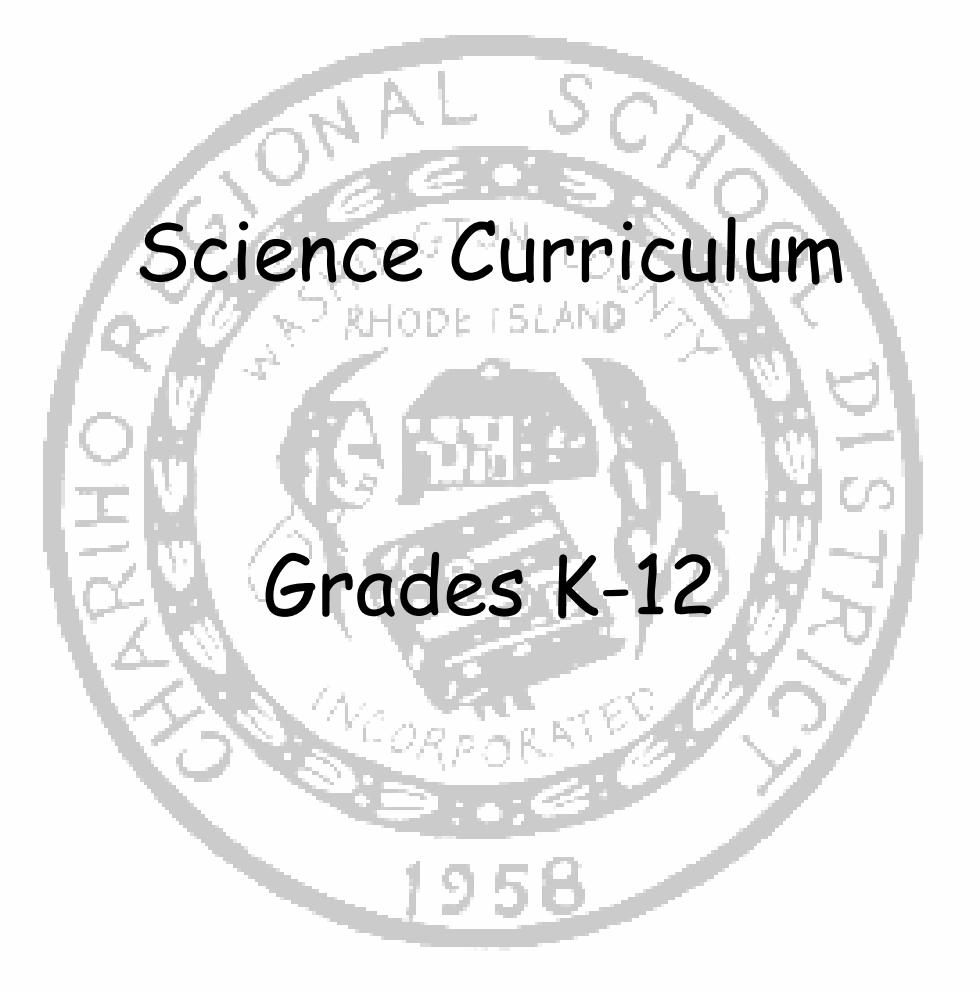
Chariho Regional School District



Science Curriculum

Grades K-12

August 17,2010

(revised December 21, 2010)

Chariho Regional School District
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Grades K-12

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Epistemological Foundations

The Chariho Regional School District believes that students learn best when they are actively engaged in and personally responsible for the learning process. Students need a safe and positive environment in which to talk purposefully about learning, to experience learning, and to observe learning. Learning is enhanced when students have an interest in and choice about what they learn. Students should be engaged in meaningful learning experiences that match their developmental status.

New learning builds on previous knowledge through a process that is challenging and rigorous. That process must encourage students to problem-solve and to think originally, critically, and creatively. Thinking and problem-solving are closely linked to a demanding core of content knowledge. Learning is most quickly assimilated when connected to student goals, when students evaluate their own work and learning habits, and when instruction appeals to a variety of learning modalities and talents.

In an environment of high expectations, sustained and directed student effort and expert teaching practices determine the extent of learning. Our schools and District will organize to encourage and support both.

Science Curriculum

INTRODUCTION

The Chariho Regional School District recognizes the need to reform the science curriculum so that it serves to communicate a clear and unified vision of teaching and learning for educators, students, and the community. This curriculum aligns with the Rhode Island Grade Span Expectations which are derived from The American Association for the Advancement of Science Project 2061 Benchmarks for Science Literacy and reflect current best practice in science teaching. This curriculum strives to coordinate physical, life, and earth/space sciences, with scientific inquiry skills to ensure continuity across the grade levels.

The goal of this curriculum is to provide all students with a basic scientific knowledge and to allow them "to make informed decisions as citizens about crucial science issues: environmental issues, energy issues, spending issues, and ethical issues" (Conn 30).

District Mission

The Chariho Regional School District ensures that all students meet high academic standards and are prepared for lifelong learning and productive global citizenship.

District Vision

With a commitment to continuous improvement, the District's highly-qualified staff engages with students in state-of-the-art facilities to master challenging content, to promote creativity, and to foster critical thinking. The District is recognized by the community as its greatest asset.

District Beliefs

We believe that high academic standards and research informed decision making are critical…

All students can learn and meet or exceed rigorous standards.
All students at every level must be engaged in rigorous and challenging academic experiences.
Rigorous academic standards are the foundation of this school district.
Instructional and program decisions must be data-informed and research-based.
Learning is a continuous lifelong process.
Schools must prepare students to be creative and critical thinkers, problem solvers, and effective communicators.
The physical, social, and emotional wellness of every child is necessary for optimum learning.

We believe that the larger community must be fully engaged in the learning process…

Education is a shared responsibility of students, parents, staff, and the community.
Students thrive when supported, nurtured, and engaged by the community.
In an environment that emphasizes school safety, everyone must be treated with kindness, dignity, and respect.
Schools must prepare students to be team members and leaders, community contributors, and productive citizens in a global society.

Report on Knowledge Base
for
Science Education

Learning and teaching within the science curriculum are best defined by the principles found in Best Practice: New Standards for Teaching and Learning in America's Schools. To promote students' achievement of learning goals, connections between content learning and scientific application skills must be woven into every level of student learning.

- Students need opportunities to explore the significance of science in their lives.
- Science study should involve doing science, not just covering material.
- Effective, hands-on inquiry involves a series of steps that build students' investigative skills.
- Meaningful science study will aim to develop thinking, problem-solving, and attitudes of curiosity, healthy skepticism, and openness to modifying explanations.
- Science education can build a knowledge base focused on essential concepts, rather than disconnected topics or bits of information.
- Students should explore fewer topics, not skim many superficially.
- Students grow out of misconceptions and naïve theories only by actively engaging in investigation.
- Learning science means integrating reading, writing, speaking, and math.
- Students need to consider issues of application of science and technology.
- Good science teaching involves facilitation, collaborative group work and a limited, judicious use of information giving.
- Meaningful assessment of students' learning in science must promote the objectives of a good science curriculum and not undermine them.

Hallmarks of Excellence
for
Science

Desirable Features of the Curriculum

MORE	LESS
• Inquiry-based instruction • Student-centered approach • Discussion and questioning • Real world connections • Problem-solving • Investigations based on student-generated questions • Emphasis on integration of technology • Connections within scientific disciplines as well as across disciplines • Emphasis on higher order thinking skills (e.g., compare and contrast, synthesize) • Assessments that focus on scientific concepts and processes • Fewer topics studied in greater depth • Active application of science to contemporary issues • Cooperative group work • Sophistication of science topics across the grade levels	• Lecture-based instruction • Teacher-centered approach • Reliance on textbook as sole source • Isolated topics • "Cookbook" investigations • Memorization of isolated facts without connection to broader concepts • Assessments that focus solely on isolated facts • Superficial coverage of many topics • Isolation of science from the rest of the students' lives • Repetition of specific activities for similar topics across grade levels

Statement of Educational Goals
for
Science

In alignment with Chariho High School's graduation requirements and in order to transform traditional science instruction into meaningful science inquiry, all students will demonstrate the ability to:

- Acquire, analyze, and evaluate information and ideas to effectively solve problems;
- Effectively utilize literacy skills: writing, listening, speaking, reading analysis, and reading interpretation;
- Display technological literacy;
- Be self-directed learners effectively using ideas and information from various disciplines;
- Analyze problems from a global perspective and contribute to society as responsible and skilled citizens;
- Work actively and cooperatively to achieve group goals;
- Display and understanding of scientific content and process as outlined in the national standards;
- Apply their scientific knowledge to real world situations and problems.

The Chariho Regional School District Science Standards for grades K-12 are:

The American Association for the Advancement of Science Project 2061 Benchmarks for Science Literacy

I. The Nature of Science

A. The Scientific World View

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- When a science investigation is done the way it was done before, we expect to get a very similar result.
- Science investigations generally work the same way in different places

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Results of similar scientific investigations seldom turn out exactly the same. Sometimes this is because of unexpected differences in the things being investigated, sometimes because of unrealized differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations. It is not always easy to tell which.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct.
- Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
- Some scientific knowledge is very old and yet is still applicable today.

- Some matters cannot be examined usefully in a scientific way. Among them are matters that by their nature cannot be tested objectively and those that are essentially matters of morality. Science can sometimes be used to inform ethical decisions by identifying the likely consequences of particular actions but cannot be used to establish that some action is either moral or immoral.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Scientists assume that the universe is a vast single system in which the basic rules are the same everywhere. The rules may range from very simple to extremely complex, but scientists operate on the belief that the rules can be discovered by careful, systematic study.
- From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Change and continuity are persistent features of science.
- No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.

B. Scientific Inquiry

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
- Tools such as thermometers, magnifiers, rulers, or balances often give more information about things than can be obtained by just observing things without their help.
- Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.

- When people give different descriptions of the same thing, it is usually a good idea to make some fresh observations instead of just arguing about who is right.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.
- Results of scientific investigations are seldom exactly the same, but if the differences are large, it is important to try to figure out why. One reason for following directions carefully and for keeping records of one's work is to provide information on what might have caused the differences.
- Scientists' explanations about what happens in the world come partly from what they observe, partly from what they think. Sometimes scientists have different explanations for the same set of observations. That usually leads to their making more observations to resolve the differences.
- Scientists do not pay much attention to claims about how something they know about works unless the claims are backed up with evidence that can be confirmed and with a logical argument.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations.
- What people expect to observe often affects what they actually do observe. Strong beliefs about what should happen in particular circumstances can prevent them from detecting other results. Scientists know about this

danger to objectivity and take steps to try and avoid it when designing investigations and examining data. One safeguard is to have different investigators conduct independent studies of the same questions.

- New ideas in science sometimes spring from unexpected findings, and they usually lead to new investigations.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).
- Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.
- There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments. And there is agreement that progress in all fields of science depends on intelligence, hard work, imagination, and even chance.
- Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias.
- In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.
- New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators.

C. The Scientific Enterprise

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Everybody can do science and invent things and ideas.
- In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean.
- A lot can be learned about plants and animals by observing them closely, but care must be taken to know the needs of living things and how to provide for them in the classroom.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Science is an adventure that people everywhere can take part in, as they have for many centuries.
- Clear communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world.
- Doing science involves many different kinds of work and engages men and women of all ages and backgrounds.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.
- Until recently, women and racial minorities, because of restrictions on their education and employment opportunities, were essentially left out of much of the formal work of the science establishment; the remarkable few who overcame those obstacles were even then likely to have their work disregarded by the science establishment.
- No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world.
- Scientists are employed by colleges and universities, business and industry, hospitals, and many government agencies. Their places of work include offices, classrooms, laboratories, farms, factories, and natural field settings ranging from space to the ocean floor.

- In research involving human subjects, the ethics of science require that potential subjects be fully informed about the risks and benefits associated with the research and of their right to refuse to participate. Science ethics also demand that scientists must not knowingly subject coworkers, students, the neighborhood, or the community to health or property risks without their prior knowledge and consent. Because animals cannot make informed choices, special care must be taken in using them in scientific research.
- Computers have become invaluable in science because they speed up and extend people's ability to collect, store, compile, and analyze data, prepare research reports, and share data and ideas with investigators all over the world.
- Accurate record-keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions.
- Modern science is based on traditions of thought that came together in Europe about 500 years ago. People from all cultures now contribute to that tradition.
- Progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments.
- Science disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some sub-disciplines spin off to become new disciplines in their own right.
- Current ethics in science hold that research involving human subjects may be conducted only with the informed consent of the subjects, even if this constraint limits some kinds of potentially important research or influences the results. When it comes to participation in research that could pose risks to society, most

scientists believe that a decision to participate or not is a matter of personal ethics rather than professional ethics.

- Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups are about their perceived interests.
- The strongly held traditions of science, including its commitment to peer review and publication, serve to keep the vast majority of scientists well within the bounds of ethical professional behavior. Deliberate deceit is rare and likely to be exposed sooner or later by the scientific enterprise itself. When violations of these scientific ethical traditions are discovered, they are strongly condemned by the scientific community, and the violators then have difficulty regaining the respect of other scientists.
- Funding influences the direction of science by virtue of the decisions that are made on which research to support. Research funding comes from various federal government agencies, industry, and private foundations.
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II. The Nature of Mathematics

A. Patterns and Relationships

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Circles, squares, triangles, and other shapes can be found in things in nature and in things that people build.
- Patterns can be made by putting different shapes together or taking them apart.
- Things move, or can be made to move, along straight, curved, circular, back-and-forth, and jagged paths.
- Numbers can be used to count any collection of things.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Mathematics is the study of many kinds of patterns, including numbers and shapes and operations on them. Sometimes patterns are studied because they help to explain how the world works or how to solve practical problems, sometimes because they are interesting in themselves.
- Mathematical ideas can be represented concretely, graphically, and symbolically.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Usually there is no one right way to solve a mathematical problem; different methods have different advantages and disadvantages.
- Logical connections can be found between different parts of mathematics.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Mathematics is the study of any patterns or relationships, whereas natural science is concerned only with those patterns that are relevant to the observable world. Although mathematics began long ago in practical problems, it soon focused on abstractions from the material world, and then on even more abstract relationships among those abstractions.
- As in other sciences, simplicity is one of the highest values in mathematics. Some mathematicians try to identify the smallest set of rules from which many other propositions can be logically derived.
- Theories and applications in mathematical work influence each other. Sometimes a practical problem leads to the development of new mathematical theories; often mathematics developed for its own sake turns out to have practical applications.
- New mathematics continues to be invented, and connections between different parts of mathematics continue to be found.

B. Mathematics, Science, and Technology

1. Kindergarten through Grade 2

No benchmarks at this level.

2. Grades 3 through 5

No benchmarks at this level.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Mathematics is helpful in almost every kind of human endeavor-from laying bricks to prescribing medicine or drawing a face. In particular, mathematics has contributed to progress in science and technology for thousands of years and still continues to do so.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Mathematical modeling aids in technological design by simulating how a proposed system would theoretically behave.
- Mathematics and science as enterprises share many values and features: belief in order, ideals of honesty and openness, the importance of criticism by colleagues, and the essential role played by imagination.
- Mathematics provides a precise language for science and technology-to describe objects and events, to characterize relationships between variables, and to argue logically.
- Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved. In particular, the development of computer technology (which itself relies on mathematics) has generated new kinds of problems and methods of work in mathematics.
- Developments in mathematics often stimulate innovations in science and technology.

C. Mathematical Inquiry

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Numbers and shapes can be used to tell about things.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Numbers and shapes-and operations on them-help to describe and predict things about the world around us.
- In using mathematics, choices have to be made about what operations will give the best results. Results should always be judged by whether they make sense and are useful.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Mathematicians often represent things with abstract ideas, such as numbers or perfectly straight lines, and then work with those ideas alone. The "things" from which they abstract can be ideas themselves (for example, a proposition about "all equal-sided triangles" or "all odd numbers").
- When mathematicians use logical rules to work with representations of things, the results may or may not be valid for the things themselves. Using mathematics to solve a problem requires choosing what mathematics to use; probably making some simplifying assumptions, estimates, or approximations; doing computations; and then checking to see whether the answer makes sense. If an answer does not seem to make enough sense for its intended purpose, then any of these steps might have been inappropriate.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Some work in mathematics is much like a game-mathematicians choose an interesting set of rules and then play according to those rules to see what can happen. The more interesting the results, the better. The only limit on the set of rules is that they should not contradict one another.
- Much of the work of mathematicians involves a modeling cycle, which consists of three steps: (1) using abstractions to represent things or ideas, (2) manipulating the abstractions according to some logical rules, and (3) checking how well the results match the original things or ideas. If the match is not considered good enough, a new round of abstraction and manipulation may begin. The actual thinking need not go through these processes in logical order but may shift from one to another in any order.

III. The Nature of Technology

A. Technology and Science

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Tools are used to do things better or more easily and to do some things that could not otherwise be done at all. In technology, tools are used to observe, measure, and make things.

- When trying to build something or to get something to work better, it usually helps to follow directions if there are any or to ask someone who has done it before for suggestions.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Throughout all of history, people everywhere have invented and used tools. Most tools of today are different from those of the past but many are modifications of very ancient tools.
- Technology enables scientists and others to observe things that are too small or too far away to be seen without them and to study the motion of objects that are moving very rapidly or are hardly moving at all
- Measuring instruments can be used to gather accurate information for making scientific comparisons of objects and events and for designing and constructing things that will work properly.
- Technology extends the ability of people to change the world: to cut, shape, or put together materials; to move things from one place to another; and to reach farther with their hands, voices, senses, and minds. The changes may be for survival needs such as food, shelter, and defense, for communication and transportation, or to gain knowledge and express ideas.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- In earlier times, the accumulated information and techniques of each generation of workers were taught on the job directly to the next generation of workers. Today, the knowledge base for technology can be found as well in libraries of print and electronic resources and is often taught in the classroom.
- Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
- Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. But they usually have to take human values and limitations into account as well.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances.
- Mathematics, creativity, logic and originality are all needed to improve technology.
- Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs). In contrast, science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like.

C. Design and Systems

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People may not be able to actually make or do everything that they can design.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- There is no perfect design. Designs that are best in one respect (safety or ease of use, for example) may be inferior in other ways (cost or appearance). Usually some features must be sacrificed to get others. How such trade-offs are received depends upon which features are emphasized and which are down-played.
- Even a good design may fail. Sometimes steps can be taken ahead of time to reduce the likelihood of failure, but it cannot be entirely eliminated.
- The solution to one problem may create other problems.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Design usually requires taking constraints into account. Some constraints, such as gravity or the properties of the materials to be used, are unavoidable. Other constraints, including economic, political, social, ethical, and aesthetic ones, limit choices.

- All technologies have effects other than those intended by the design, some of which may have been predictable and some not. In either case, these side effects may turn out to be unacceptable to some of the population and therefore lead to conflict between groups.
- Almost all control systems have inputs, outputs, and feedback. The essence of control is comparing information about what is happening to what people want to happen and then making appropriate adjustments. This procedure requires sensing information, processing it, and making changes. In almost all modern machines, microprocessors serve as centers of performance control.
- Systems fail because they have faulty or poorly matched parts, are used in ways that exceed what was intended by the design, or were poorly designed to begin with. The most common ways to prevent failure are pretesting parts and procedures, overdesign, and redundancy.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design.
- The value of any given technology may be different for different groups of people and at different points in time.
- Complex systems have layers of controls. Some controls operate particular parts of the system and some control other controls. Even fully automatic systems require human control at some point.
- Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. The public perception of risk may depend, however, on psychological factors as well as scientific ones.
- The more parts and connections a system has, the more ways it can go wrong. Complex systems usually have components to detect, back up, bypass, or compensate for minor failures.
- To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable.

D. Issues in Technology

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People, alone or in groups, are always inventing new ways to solve problems and get work done. The tools and ways of doing things that people have invented affect all aspects of life.
- When a group of people wants to build something or try something new, they should try to figure out ahead of time how it might affect other people.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Technology has been part of life on the earth since the advent of the human species. Like language, ritual, commerce, and the arts, technology is an intrinsic part of human culture, and it both shapes society and is shaped by it. The technology available to people greatly influences what their lives are like.
- Any invention is likely to lead to other inventions. Once an invention exists, people are likely to think up ways of using it that were never imagined at first.
- Transportation, communications, nutrition, sanitation, health care, entertainment, and other technologies give large numbers of people today the goods and services that once were luxuries enjoyed only by the wealthy. These benefits are not equally available to everyone.
- Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. Other factors, such as cost, safety, appearance, environmental impact, and what will happen if the solution fails also must be considered.
- Technologies often have drawbacks as well as benefits. A technology that helps some people or organisms may hurt others-either deliberately (as weapons can) or inadvertently (as pesticides can). When harm occurs or seems likely, choices have to be made or new solutions found.
- Because of their ability to invent tools and processes, people have an enormous effect on the lives of other living things.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- The human ability to shape the future comes from a capacity for generating knowledge and developing new technologies-and for communicating ideas to others.

- Technology cannot always provide successful solutions for problems or fulfill every human need.
- Throughout history, people have carried out impressive technological feats, some of which would be hard to duplicate today even with modern tools. The purposes served by these achievements have sometimes been practical, sometimes ceremonial.
- Technology has strongly influenced the course of history and continues to do so. It is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications that have radically changed how people live.
- New technologies increase some risks and decrease others. Some of the same technologies that have improved the length and quality of life for many people have also brought new risks.
- Rarely are technology issues simple and one-sided. Relevant facts alone, even when known and available, usually do not settle matters entirely in favor of one side or another. That is because the contending groups may have different values and priorities. They may stand to gain or lose in different degrees, or may make very different predictions about what the future consequences of the proposed action will be.
- Societies influence what aspects of technology are developed and how these are used. People control technology (as well as science) and are responsible for its effects.

4. <u>Grades 9 through 12</u>

By the end of the 12th grade, students should know that:

- Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.
- Technological knowledge is not always as freely shared as scientific knowledge unrelated to technology. Some scientists and engineers are comfortable working in situations in which some secrecy is required, but others prefer not to do so. It is generally regarded as a matter of individual choice and ethics, not one of professional ethics.
- In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits. What alternative ways are there to achieve the same ends,

and how do the alternatives compare to the plan being put forward? Who benefits and who suffers? What are the financial and social costs, do they change over time, and who bears them? What are the risks associated with using (or not using) the new technology, how serious are they, and who is in jeopardy? What human, material, and energy resources will be needed to build, install, operate, maintain, and replace the new technology, and where will they come from? How will the new technology and its waste products be disposed of and at what costs?

- The human species has a major impact on other species in many ways: reducing the amount of the earth's surface available to those other species, interfering with their food sources, changing the temperature and chemical composition of their habitats, introducing foreign species into their ecosystems, and altering organisms directly through selective breeding and genetic engineering.
- Human inventiveness has brought new risks as well as improvements to human existence.

IV. The Physical Setting

A. The Universe

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- There are more stars in the sky than anyone can easily count, but they are not scattered evenly, and they are not all the same in brightness or color.
- The sun can be seen only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. The sun, moon, and stars all appear to move slowly across the sky.
- The moon looks a little different every day, but looks the same again about every four weeks.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- The patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons.

- Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.
- Planets change their positions against the background of stars.
- The earth is one of several planets that orbit the sun, and the moon orbits around the earth.
- Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- The sun is a medium-sized star located near the edge of a disk-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot.
- The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past.
- Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The earth is orbited by one moon, many artificial satellites, and debris.
- Large numbers of chunks of rock orbit the sun. Some of those that the earth meets in its yearly orbit around the sun glow and disintegrate from friction as they plunge through the atmosphere-and sometimes impact the ground. Other chunks of rocks mixed with ice have long, off-center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen material from their surfaces and pushes it into a long, illuminated tail.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The stars differ from each other in size, temperature, and age, but they appear to be made up of the same elements that are found on the earth and to behave according to the same physical principles. Unlike the sun, most stars are in systems of two or more stars orbiting around one another.
- On the basis of scientific evidence, the universe is estimated to be over ten billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass. Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. Eventually, some stars exploded, producing clouds of heavy elements from which other stars and planets could later condense. The process of star formation and destruction continues.
- Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed.
- Mathematical models and computer simulations are used in studying evidence from many sources in order to form a scientific account of the universe.

B. The Earth

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Some events in nature have a repeating pattern. The weather changes some from day to day, but things such as temperature and rain (or snow) tend to be high, low, or medium in the same months every year.
- Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.
- Water left in an open container disappears, but water in a closed container does not disappear.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Things on or near the earth are pulled toward it by the earth's gravity.
- Like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day.
- When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.
- Air is a substance that surrounds us, takes up space, and whose movement we feel as wind.

3. <u>Grades 6 through 8</u>

By the end of the 8th grade, students should know that:

- We live on a relatively small planet, the third from the sun in the only system of planets definitely known to exist (although other, similar systems may be discovered in the universe).
- The earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from the earth's.
- Everything on or anywhere near the earth is pulled toward the earth's center by gravitational force.
- Because the earth turns daily on an axis that is tilted relative to the plane of the earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the earth during the year. The difference in heating of the earth's surface produces the planet's seasons and weather patterns.
- The moon's orbit around the earth once in about 28 days changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth-the phases of the moon.
- Climates have sometimes changed abruptly in the past as a result of changes in the earth's crust, such as volcanic eruptions or impacts of huge rocks from space. Even relatively small changes in atmospheric or ocean content can have widespread effects on climate if the change lasts long enough.
- The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, condenses into rain or snow, and falls again to

the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the ocean.

- Fresh water, limited in supply, is essential for life and also for most industrial processes. Rivers, lakes, and groundwater can be depleted or polluted, becoming unavailable or unsuitable for life.
- Heat energy carried by ocean currents has a strong influence on climate around the world.
- Some minerals are very rare and some exist in great quantities, but-for practical purposes-the ability to recover them is just as important as their abundance. As minerals are depleted, obtaining them becomes more difficult. Recycling and the development of substitutes can reduce the rate of depletion but may also be costly.
- The benefits of the earth's resources-such as fresh water, air, soil, and trees-can be reduced by using them wastefully or by deliberately or inadvertently destroying them. The atmosphere and the oceans have a limited capacity to absorb wastes and recycle materials naturally. Cleaning up polluted air, water, or soil or restoring depleted soil, forests, or fishing grounds can be very difficult and costly.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Life is adapted to conditions on the earth, including the force of gravity that enables the planet to retain an adequate atmosphere, and an intensity of radiation from the sun that allows water to cycle between liquid and vapor.
- Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans, and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall-and such circulation, influenced by the rotation of the earth, produces winds and ocean currents.

C. Processes that Shape the Earth

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

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

- Change is something that happens to many things.
- Animals and plants sometimes cause changes in their surroundings.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Waves, wind, water, and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers.
- Rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock, partly from plant remains-and also contains many living organisms.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- The interior of the earth is hot. Heat flow and movement of material within the earth cause earthquakes and volcanic eruptions and create mountains and ocean basins. Gas and dust from large volcanoes can change the atmosphere.
- Some changes in the earth's surface are abrupt (such as earthquakes and volcanic eruptions) while other changes happen very slowly (such as uplift and wearing down of mountains). The earth's surface is shaped in part by the motion of water and wind over very long times, which act to level mountain ranges.
- Sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by dissolved minerals to form solid rock again.
- Sedimentary rock buried deep enough may be reformed by pressure and heat, perhaps melting and re-crystallizing into different kinds of rock. These re-formed rock layers may be forced up again to become land surface and even mountains. Subsequently, this new rock too will erode. Rock bears evidence of the minerals, temperatures, and forces that created it.
- Thousands of layers of sedimentary rock confirm the long history of the changing surface of the earth and the changing life forms whose remains are found in successive layers. The youngest layers are not always found on top, because of folding, breaking, and uplift of layers.

- Although weathered rock is the basic component of soil, the composition and texture of soil and its fertility and resistance to erosion are greatly influenced by plant roots and debris, bacteria, fungi, worms, insects, rodents, and other organisms.
- Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Plants alter the earth's atmosphere by removing carbon dioxide from it, using the carbon to make sugars and releasing oxygen. This process is responsible for the oxygen content of the air.
- The formation, weathering, sedimentation, and reformation of rock constitute a continuing "rock cycle" in which the total amount of material stays the same as its forms change.
- The slow movement of material within the earth results from heat flowing out from the deep interior and the action of gravitational forces on regions of different density.
- The solid crust of the earth-including both the continents and the ocean basins-consists of separate plates that ride on a denser, hot, gradually deformable layer of the earth. The crust sections move very slowly, pressing against one another in some places, pulling apart in other places. Ocean-floor plates may slide under continental plates, sinking deep into the earth. The surface layers of these plates may fold, forming mountain ranges.
- Earthquakes often occur along the boundaries between colliding plates, and molten rock from below creates pressure that is released by volcanic eruptions, helping to build up mountains. Under the ocean basins, molten rock may well up between separating plates to create new ocean floor. Volcanic activity along the ocean floor may form undersea mountains, which can thrust above the ocean's surface to become islands.

D. The Structure of Matter

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Objects can be described in terms of the materials they are made of (clay, cloth, paper, etc.) and their physical properties (color, size, shape, weight, texture, flexibility, etc.).

- Things can be done to materials to change some of their properties, but not all materials respond the same way to what is done to them.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions.
- No matter how parts of an object are assembled, the weight of the whole object made is always the same as the sum of the parts; and when a thing is broken into parts, the parts have the same total weight as the original thing.
- Materials may be composed of parts that are too small to be seen without magnification.
- When a new material is made by combining two or more materials, it has properties that are different from the original materials. For that reason, a lot of different materials can be made from a small number of basic kinds of materials.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.
- Equal volumes of different substances usually have different weights.
- Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.
- The temperature and acidity of a solution influence reaction rates. Many substances dissolve in water, which may greatly facilitate reactions between them.

- Scientific ideas about elements were borrowed from some Greek philosophers of 2,000 years earlier, who believed that everything was made from four basic substances: air, earth, fire, and water. It was the combinations of these "elements" in different proportions that gave other substances their observable properties. The Greeks were wrong about those four, but now over 100 different elements have been identified, some rare and some plentiful, out of which everything is made. Because most elements tend to combine with others, few elements are found in their pure form.
- There are groups of elements that have similar properties, including highly reactive metals, less-reactive metals, highly reactive nonmetals (such as chlorine, fluorine, and oxygen), and some almost completely non-reactive gases (such as helium and neon). An especially important kind of reaction between substances involves combination of oxygen with something else-as in burning or rusting. Some elements don't fit into any of the categories; among them are carbon and hydrogen, essential elements of living matter.
- No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same.

4. <u>Grades 9 through 12</u>

By the end of the 12th grade, students should know that:

- Atoms are made of a positive nucleus surrounded by negative electrons. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms form bonds to other atoms by transferring or sharing electrons.
- The nucleus, a tiny fraction of the volume of an atom, is composed of protons and neutrons, each almost two thousand times heavier than an electron. The number of positive protons in the nucleus determines what an atom's electron configuration can be and so defines the element. In a neutral atom, the number of electrons equals the number of protons. But an atom may acquire an unbalanced charge by gaining or losing electrons.
- Neutrons have a mass that is nearly identical to that of protons, but neutrons have no electric charge. Although neutrons have little effect on how an atom interacts with others, they do affect the mass and stability of the

nucleus. Isotopes of the same element have the same number of protons (and therefore of electrons) but differ in the number of neutrons.

- The nucleus of radioactive isotopes is unstable and spontaneously decays, emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate. This predictability of decay rate allows radioactivity to be used for estimating the age of materials that contain radioactive substances.
- Scientists continue to investigate atoms and have discovered even smaller constituents of which neutrons and protons are made.
- When elements are listed in order by the masses of their atoms, the same sequence of properties appears over and over again in the list.
- Atoms often join with one another in various combinations in distinct molecules or in repeating three-dimensional crystal patterns. An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.
- The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others.
- The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others.

E. Energy Transformations

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

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

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Things that give off light often also give off heat. Heat is produced by mechanical and electrical machines, and any time one thing rubs against something else.

- When warmer things are put with cooler ones, the warm ones lose heat and the cool ones gain it until they are all at the same temperature. A warmer object can warm a cooler one by contact or at a distance.
- Some materials conduct heat much better than others. Poor conductors can reduce heat loss.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Energy cannot be created or destroyed, but only changed from one form into another.
- Most of what goes on in the universe-from exploding stars and biological growth to the operation of machines and the motion of people-involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation.
- Heat can be transferred through materials by the collisions of atoms or across space by radiation. If the material is fluid, currents will be set up in it that aid the transfer of heat.
- Energy appears in different forms. Heat energy is in the disorderly motion of molecules; chemical energy is in the arrangement of atoms; mechanical energy is in moving bodies or in elastically distorted shapes; gravitational energy is in the separation of mutually attracting masses.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount.
- Heat energy in a material consists of the disordered motions of its atoms or molecules. In any interactions of atoms or molecules, the statistical odds are that they will end up with less order than they began-that is, with the heat energy spread out more evenly. With huge numbers of atoms and molecules, the greater disorder is almost certain.
- Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with it.
- Different energy levels are associated with different configurations of atoms and molecules. Some changes of configuration require an input of energy whereas others release energy.

- When energy of an isolated atom or molecule changes, it does so in a definite jump from one value to another, with no possible values in between. The change in energy occurs when radiation is absorbed or emitted, so the radiation also has distinct energy values. As a result, the light emitted or absorbed by separate atoms or molecules (as in a gas) can be used to identify what the substance is.
- Energy is released whenever the nuclei of very heavy atoms, such as uranium or plutonium, split into middleweight ones, or when very light nuclei, such as those of hydrogen and helium, combine into heavier ones. The energy released in each nuclear reaction is very much greater than the energy given off in each chemical reaction.

F. Motion

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.
- The way to change how something is moving is to give it a push or a pull.
- Things that make sound vibrate.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have.
- How fast things move differs greatly. Some things are so slow that their journey takes a long time; others move too fast for people to even see them.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors.
- Something can be "seen" when light waves emitted or reflected by it enter the eye-just as something can be "heard" when sound waves from it enter the ear.

- An unbalanced force acting on an object changes its speed or direction of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center.
- Vibrations in materials set up wavelike disturbances that spread away from the source. Sound and earthquake waves are examples. These and other waves move at different speeds in different materials.
- Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation-visible light. Differences of wavelength within that range are perceived as differences in color.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The change in motion of an object is proportional to the applied force and inversely proportional to the mass.
- All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion.
- Accelerating electric charges produce electromagnetic waves around them. A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. In empty space, all electromagnetic waves move at the same speed-the "speed of light."
- Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.
- The observed wavelength of a wave depends upon the relative motion of the source and the observer. If either is moving toward the other, the observed wavelength is shorter; if either is moving away, the wavelength is longer. Because the light seen from almost all distant galaxies has longer wavelengths than comparable light here on earth, astronomers believe that the whole universe is expanding.
- Waves can superpose on one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. The energy of waves (like any form of energy) can be changed into other forms of energy.

G. Forces of Nature

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Things near the earth fall to the ground unless something holds them up.

- Magnets can be used to make some things move without being touched.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- The earth's gravity pulls any object toward it without touching it.
- Without touching them, a magnet pulls on all things made of iron and either pushes or pulls on other magnets.
- Without touching them, material that has been electrically charged pulls on all other materials and may either push or pull other charged materials.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at least one of the objects has a lot of mass.
- The sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.
- Electric currents and magnets can exert a force on each other.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Gravitational force is an attraction between masses. The strength of the force is proportional to the masses and weakens rapidly with increasing distance between them.
- Electromagnetic forces acting within and between atoms are vastly stronger than the gravitational forces acting between the atoms. At the atomic level, electric forces between oppositely charged electrons and protons hold atoms and molecules together and thus are involved in all chemical reactions. On a larger scale, these forces hold solid and liquid materials together and act between objects when they are in contact-as in sticking or sliding friction.
- There are two kinds of charges-positive and negative. Like charges repel one another, opposite charges attract. In materials, there are almost exactly equal proportions of positive and negative charges, making the materials as a whole electrically neutral. Negative charges, being associated with electrons, are far more mobile in

materials than positive charges are. A very small excess or deficit of negative charges in a material produces noticeable electric forces.

- Different kinds of materials respond differently to electric forces. In conducting materials such as metals, electric charges flow easily, whereas in insulating materials such as glass, they can move hardly at all. At very low temperatures, some materials become superconductors and offer no resistance to the flow of current. In between these extremes, semiconducting materials differ greatly in how well they conduct, depending on their exact composition.
- Magnetic forces are very closely related to electric forces and can be thought of as different aspects of a single electromagnetic force. Moving electric charges produce magnetic forces and moving magnets produce electric forces. The interplay of electric and magnetic forces is the basis for electric motors, generators, and many other modern technologies, including the production of electromagnetic waves.
- The forces that hold the nucleus of an atom together are much stronger than the electromagnetic force. That is why such great amounts of energy are released from the nuclear reactions in the sun and other stars.

V. The Living Environment

A. Diversity of Life

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Some animals and plants are alike in the way they look and in the things they do, and others are very different from one another.
- Plants and animals have features that help them live in different environments.
- Stories sometimes give plants and animals attributes they really do not have.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group.
- Features used for grouping depend on the purpose of the grouping.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods. Some kinds of organisms, many of them microscopic, cannot be neatly classified as either plants or animals.
- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.
- Similarities among organisms are found in internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.
- For sexually reproducing organisms, a species comprises all organisms that can mate with one another to produce fertile offspring.
- All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions, and a great diversity of species increases the chance that at least some living things will survive in the face of large changes in the environment.
- The degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification based on anatomical similarities.

B. Heredity

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- There is variation among individuals of one kind within a population.

- Offspring are very much, but not exactly, like their parents and like one another.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Some likenesses between children and parents, such as eye color in human beings, or fruit or flower color in plants, are inherited. Other likenesses, such as people's table manners or carpentry skills, are learned.
- For offspring to resemble their parents there must be a reliable way to transfer information from one generation to the next.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- In some kinds of organisms, all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent.
- In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male. As the fertilized egg, carrying genetic information from each parent, multiplies to form the complete organism with about a trillion cells, the same genetic information is copied in each cell.
- New varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious.
- The sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents.
- The information passed from parents to offspring is coded in DNA molecules.
- Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.

- Gene mutations can be caused by such things as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring; if they occur in other cells, they can be passed on to descendant cells only. The experiences an organism has during its lifetime can affect its offspring only if the genes in its own sex cells are changed by the experience.
- The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different parts of the instructions are used in different types of cells, influenced by the cell's environment and past history.

C. Cells

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Magnifiers help people see things they could not see without them.
- Most living things need water, food, and air.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Some living things consist of a single cell. Like familiar organisms, they need food, water, and air; a way to dispose of waste; and an environment they can live in.
- Microscopes make it possible to see that living things are made mostly of cells. Some organisms are made of a collection of similar cells that benefit from cooperating. Some organisms' cells vary greatly in appearance and perform very different roles in the organism.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.
- Cells repeatedly divide to make more cells for growth and repair. Various organs and tissues function to serve the needs of cells for food, air, and waste removal.

- Within cells, many of the basic functions of organisms-such as extracting energy from food and getting rid of waste-are carried out. The way in which cells function is similar in all living organisms.
- About two thirds of the weight of cells is accounted for by water, which gives cells many of their properties.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape and, for animal cells, movement.
- Within every cell are specialized parts for the transport of materials, energy transfer, protein building, waste disposal, information feedback, and even movement. In addition, most cells in multicellular organisms perform some special functions that others do not.
- The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino-acid molecules. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes is a consequence of attractions between the chain's parts.
- The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms. Before a cell divides, the instructions are duplicated so that each of the two new cells gets all the necessary information for carrying on.
- Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.
- Gene mutation in a cell can result in uncontrolled cell division, called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.
- Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules. Even small changes in acidity can alter the molecules and how they interact. Both single cells and multicellular organisms have molecules that help to keep the cell's acidity within a narrow range.

- A living cell is composed of a small number of chemical elements mainly carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur. Carbon atoms can easily bond to several other carbon atoms in chains and rings to form large and complex molecules.

D. Interdependence of Life

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting.
- Living things are found almost everywhere in the world. There are somewhat different kinds in different places.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- For any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.
- Insects and various other organisms depend on dead plant and animal material for food.
- Organisms interact with one another in various ways besides providing food. Many plants depend on animals for carrying their pollen to other plants or for dispersing their seeds.
- Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful.
- Most microorganisms do not cause disease, and many are beneficial.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- In all environments-freshwater, marine, forest, desert, grassland, mountain, and others-organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions.
- Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one.
- Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution.
- Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

E. Flow of Matter and Energy

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Plants and animals both need to take in water, and animals need to take in food. In addition, plants need light.
- Many materials can be recycled and used again, sometimes in different forms.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Almost all kinds of animals' food can be traced back to plants.
- Some source of "energy" is needed for all organisms to stay alive and grow.
- Over the whole earth, organisms are growing, dying, and decaying, and new organisms are being produced by the old ones.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Food provides molecules that serve as fuel and building material for all organisms. Plants use the energy in light to make sugars out of carbon dioxide and water. This food can be used immediately for fuel or materials or it

may be stored for later use. Organisms that eat plants break down the plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.

- Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change.
- Energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- At times, environmental conditions are such that plants and marine organisms grow faster than decomposers can recycle them back to the environment. Layers of energy-rich organic material have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. By burning these fossil fuels, people are passing most of the stored energy back into the environment as heat and releasing large amounts of carbon dioxide.
- The amount of life any environment can support is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow and reduce the fertility of the land.
- The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.

F. Evolution of Life

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Different plants and animals have external features that help them thrive in different kinds of places.
- Some kinds of organisms that once lived on earth have completely disappeared, although they were something like others that are alive today.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Individuals of the same kind differ in their characteristics, and sometimes the differences give individuals an advantage in surviving and reproducing.
- Fossils can be compared to one another and to living organisms according to their similarities and differences. Some organisms that lived long ago are similar to existing organisms, but some are quite different.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors.
- Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.
- Many thousands of layers of sedimentary rock provide evidence for the long history of the earth and for the long history of changing life forms whose remains are found in the rocks. More recently deposited rock layers are more likely to contain fossils resembling existing species.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The basic idea of biological evolution is that the earth's present-day species developed from earlier, distinctly different species.
- Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another.
- Natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.

- Heritable characteristics can be observed at molecular and whole-organism levels-in structure, chemistry, or behavior. These characteristics strongly influence what capabilities an organism will have and how it will react, and therefore influence how likely it is to survive and reproduce.
- New heritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells. Changes in other cells of an organism cannot be passed on to the next generation.
- Natural selection leads to organisms that are well suited for survival in particular environments. Chance alone can result in the persistence of some heritable characteristics having no survival or reproductive advantage or disadvantage for the organism. When an environment changes, the survival value of some inherited characteristics may change.
- The theory of natural selection provides a scientific explanation for the history of life on earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.
- Life on earth is thought to have begun as simple, one-celled organisms about 4 billion years ago. During the first 2 billion years, only single-cell microorganisms existed, but once cells with nuclei developed about a billion years ago, increasingly complex multi-cellular organisms evolved.
- Evolution builds on what already exists, so the more variety there is, the more there can be in the future. But evolution does not necessitate long-term progress in some set direction. Evolutionary changes appear to be like the growth of a bush: Some branches survive from the beginning with little or no change, many die out altogether, and others branch repeatedly, sometimes giving rise to more complex organisms.

VI. The Human Organism

A. Human Identity

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People have different external features, such as the size, shape, and color of hair, skin, and eyes, but they are more like one another than like other animals.
- People need water, food, air, waste removal, and a particular range of temperatures in their environment, just as other animals do.

- People tend to live in families and communities in which individuals have different roles.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Unlike in human beings, behavior in insects and many other species is determined almost entirely by biological inheritance.
- Human beings have made tools and machines to sense and do things that they could not otherwise sense or do at all, or as quickly, or as well.
- Artifacts and preserved remains provide some evidence of the physical characteristics and possible behavior of human beings who lived a very long time ago.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Like other animals, human beings have body systems for obtaining and providing energy, defense, reproduction, and the coordination of body functions.
- Human beings have many similarities and differences. The similarities make it possible for human beings to reproduce and to donate blood and organs to one another throughout the world. Their differences enable them to create diverse social and cultural arrangements and to solve problems in a variety of ways.
- Fossil evidence is consistent with the idea that human beings evolved from earlier species.
- Specialized roles of individuals within other species are genetically programmed, whereas human beings are able to invent and modify a wider range of social behavior.
- Human beings use technology to match or excel many of the abilities of other species. Technology has helped people with disabilities survive and live more conventional lives.
- Technologies having to do with food production, sanitation, and disease prevention have dramatically changed how people live and work and have resulted in rapid increases in the human population.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The similarity of human DNA sequences and the resulting similarity in cell chemistry and anatomy identify human beings as a single species.

- Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. No other species uses such technologies.

B. Human Development

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- All animals have offspring, usually with two parents involved. People may prevent some animals from producing offspring.
- A human baby grows inside its mother until its birth. Even after birth, a human baby is unable to care for itself, and its survival depends on the care it receives from adults.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- It takes about 9 months for a human embryo to develop. Embryos are nourished by the mother, so substances she takes in will affect how well or poorly the baby develops.
- Human beings live longer than most other animals, but all living things die.
- There is a usual sequence of stages in physical and mental development in human beings, although individuals differ in exactly when they reach each stage.
- People are usually able to have children before they are able to care for them properly.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Fertilization occurs when sperm cells from a male's testes are deposited near an egg cell from the female ovary, and one of the sperm cells enters the egg cell. Most of the time, by chance or design, a sperm never arrives or an egg isn't available.
- Contraception measures may incapacitate sperm, block their way to the egg, prevent the release of eggs, or prevent the fertilized egg from implanting successfully.
- Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and function to form the basic tissues of an embryo. During the first three months of pregnancy, organs begin to form. During the second three months, all organs and body features develop. During the last three months, the

organs and features mature enough to function well after birth. Patterns of human development are similar to those of other vertebrates.

- The developing embryo-and later the newborn infant-encounters many risks from faults in its genes, its mother's inadequate diet, her cigarette smoking or use of alcohol or other drugs, or from infection. Inadequate child care may lead to lower physical and mental ability.
- Various body changes occur as adults age. Muscles and joints become less flexible, bones and muscles lose mass, energy levels diminish, and the senses become less acute. Women stop releasing eggs and hence can no longer reproduce. The length and quality of human life are influenced by many factors, including sanitation, diet, medical care, sex, genes, environmental conditions, and personal health behaviors.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- As successive generations of an embryo's cells form by division, small differences in their immediate environments cause them to develop slightly differently, by activating or inactivating different parts of the DNA information.
- Using artificial means to prevent or facilitate pregnancy raises questions of social norms, ethics, religious beliefs, and even politics.
- The very long period of human development (compared to that of other species) is associated with the prominent role of the brain in human evolution. The ability to learn persists throughout life and may improve as people build a base of ideas and come to understand how to learn well. Human mental abilities that apparently evolved for survival are used for newly invented cultural purposes such as art, literature, ritual, and games.
- The development and use of technologies to maintain, prolong, sustain, or terminate life raise social, moral, ethical, and legal issues.

C. Basic Functions

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- The human body has parts that help it seek, find, and take in food when it feels hunger-eyes and noses for detecting food, legs to get to it, arms to carry it away, and a mouth to eat it.

- Senses can warn individuals about danger; muscles help them to fight, hide, or get out of danger.
- The brain enables human beings to think and sends messages to other body parts to help them work properly.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- From food, people obtain energy and materials for body repair and growth. The indigestible parts of food are eliminated.
- By breathing, people take in the oxygen they need to live.
- Skin protects the body from harmful substances and other organisms and from drying out.
- The brain gets signals from all parts of the body telling what is going on there. The brain also sends signals to parts of the body to influence what they do.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Organs and organ systems are composed of cells and help to provide all cells with basic needs.
- For the body to use food for energy and building materials, the food must first be digested into molecules that are absorbed and transported to cells.
- To burn food for the release of energy stored in it, oxygen must be supplied to cells, and carbon dioxide removed. Lungs take in oxygen for the combustion of food and they eliminate the carbon dioxide produced. The urinary system disposes of dissolved waste molecules, the intestinal tract removes solid wastes, and the skin and lungs rid the body of heat energy. The circulatory system moves all these substances to or from cells where they are needed or produced, responding to changing demands.
- Specialized cells and the molecules they produce identify and destroy microbes that get inside the body.
- Hormones are chemicals from glands that affect other body parts. They are involved in helping the body respond to danger and in regulating human growth, development, and reproduction.
- Interactions among the senses, nerves, and brain make possible the learning that enables human beings to cope with changes in their environment.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The immune system is designed to protect against microscopic organisms and foreign substances that enter from outside the body and against some cancer cells that arise within.
- The nervous system works by electrochemical signals in the nerves and from one nerve to the next. The hormonal system exerts its influences by chemicals that circulate in the blood. These two systems also affect each other in coordinating body systems.
- Communication between cells is required to coordinate their diverse activities. Some cells secrete substances that spread only to nearby cells. Others secrete hormones, molecules that are carried in the bloodstream to widely distributed cells that have special receptor sites to which they attach. Along nerve cells, electrical impulses carry information much more rapidly than is possible by diffusion or blood flow. Some drugs mimic or block the molecules involved in transmitting nerve or hormone signals and therefore disturb normal operations of the brain and body.
- Reproduction is necessary for the survival of any species. Sexual behavior depends strongly on cultural, personal, and biological factors.

D. Learning

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People use their senses to find out about their surroundings and themselves. Different senses give different information. Sometimes a person can get different information about the same thing by moving closer to it or further away from it.
- Some of the things people do, like playing soccer, reading, and writing, must be deliberately learned. Practicing helps people to improve. How well one learns sometimes depends on how one does it and *how often* and *how hard* one tries to learn.
- People can learn from each other by telling and listening, showing and watching, and imitating what others do.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Human beings have different interests, motivations, skills, and talents.
- Human beings can use the memory of their past experiences to make judgments about new situations.

- Many skills can be practiced until they become automatic.
- Human beings tend to repeat behaviors that feel good or have pleasant consequences and avoid behaviors that feel bad or have unpleasant consequences.
- Learning means using what one already knows to make sense out of new experiences or information, not just storing the new information in one's head.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Some animal species are limited to a repertoire of genetically determined behaviors; others have more complex brains and can learn a wide variety of behaviors. All behavior is affected by both inheritance and experience.
- The level of skill a person can reach in any particular activity depends on innate abilities, the amount of practice, and the use of appropriate learning technologies.
- Human beings can detect a tremendous range of visual and olfactory stimuli. The strongest stimulus they can tolerate may be more than a trillion times as intense as the weakest they can detect. Still, there are many kinds of signals in the world that people cannot detect directly.
- Attending closely to any one input of information usually reduces the ability to attend to others at the same time.
- Learning often results from two perceptions or actions occurring at about the same time. The more often the same combination occurs, the stronger the mental connection between them is likely to be. Occasionally a single vivid experience will connect two things permanently in people's minds.
- Language and tools enable human beings to learn complicated and varied things from others.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Differences in the behavior of individuals arise from the interaction of heredity and experience-the effect of each depends on what the other is. Even instinctive behavior may not develop well if the individual is exposed to abnormal conditions.

- The expectations, moods, and prior experiences of human beings can affect how they interpret new perceptions or ideas. People tend to ignore evidence that challenges their beliefs and to accept evidence that supports them. The context in which something is learned may limit the contexts in which the learning can be used.
- Human thinking involves the interaction of ideas, and ideas about ideas. People can produce many associations internally without receiving information from their senses.

E. Physical Health

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Eating a variety of healthful foods and getting enough exercise and rest help people to stay healthy.
- Some things people take into their bodies from the environment can hurt them.
- Some diseases are caused by germs, some are not. Diseases caused by germs may be spread by people who have them. Washing one's hands with soap and water reduces the number of germs that can get into the body or that can be passed on to other people.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Food provides energy and materials for growth and repair of body parts. Vitamins and minerals, present in small amounts in foods, are essential to keep everything working well. As people grow up, the amounts and kinds of food and exercise needed by the body may change.
- Tobacco, alcohol, other drugs, and certain poisons in the environment (pesticides, lead) can harm human beings and other living things.
- If germs are able to get inside one's body, they may keep it from working properly. For defense against germs, the human body has tears, saliva, skin, some blood cells, and stomach secretions. A healthy body can fight most germs that do get inside. However, there are some germs that interfere with the body's defenses.
- There are some diseases that human beings can catch only once. After they've recovered they don't get sick from them again. There are many diseases that can be prevented by vaccination, so that people don't catch them even once.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- The amount of food energy (calories) a person requires varies with body weight, age, sex, activity level, and natural body efficiency. Regular exercise is important to maintain a healthy heart/lung system, good muscle tone, and bone strength.
- Toxic substances, some dietary habits, and some personal behavior may be bad for one's health. Some effects show up right away, others may not show up for many years. Avoiding toxic substances, such as tobacco, and changing dietary habits to reduce the intake of such things as animal fat increases the chances of living longer.
- Viruses, bacteria, fungi, and parasites may infect the human body and interfere with normal body functions. A person can catch a cold many times because there are many varieties of cold viruses that cause similar symptoms.
- White blood cells engulf invaders or produce antibodies that attack them or mark them for killing by other white cells. The antibodies produced will remain and can fight off subsequent invaders of the same kind.
- The environment may contain dangerous levels of substances that are harmful to human beings. Therefore, the good health of individuals requires monitoring the soil, air, and water and taking steps to keep them safe.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Some allergic reactions are caused by the body's immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body's own cells.
- Faulty genes can cause body parts or systems to work poorly. Some genetic diseases appear only when an individual has inherited a certain faulty gene from both parents.
- New medical techniques, efficient health care delivery systems, improved sanitation, and a fuller understanding of the nature of disease give today's human beings a better chance of staying healthy than their forebears had. Conditions now are very different from the conditions in which the species evolved. But some of the differences may not be good for human health.
- Some viral diseases, such as AIDS, destroy critical cells of the immune system, leaving the body unable to deal with multiple infection agents and cancerous cells.

F. Mental Health

1. Kindergarten through Grade 2

- By the end of the 2nd grade, students should know that:
- People have many different feelings-sadness, joy, anger, fear, etc.-about events, themselves, and other people.
- People react to personal problems in different ways. Some ways are more likely to be helpful than others.
- Talking to someone (a friend, relative, teacher, or counselor) may help people understand their feelings and problems and what to do about them.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Different individuals handle their feelings differently, and sometimes they have different feelings in the same situation.
- Often human beings don't understand why others act the way they do, and sometimes they don't understand their own behavior and feelings.
- Physical health can affect people's emotional well-being and vice versa.
- One way to respond to a strong feeling, either pleasant or unpleasant, is to think about what caused it and then consider whether to seek out or avoid similar situations.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Individuals differ greatly in their ability to cope with stressful situations. Both external and internal conditions (chemistry, personal history, values) influence how people behave.
- Often people react to mental distress by denying that they have any problem. Sometimes they don't know why they feel the way they do, but with help they can sometimes uncover the reasons.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Stresses are especially difficult for children to deal with and may have long-lasting effects.
- Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptibility to psychological disturbances.
- Reactions of other people to an individual's emotional disturbance may increase its effects.

- Human beings differ greatly in how they cope with emotions and may therefore puzzle one another.
- Ideas about what constitutes good mental health and proper treatment for abnormal mental states vary from one culture to another and from one time period to another.

VII. Human Society

A. Cultural Effects on Behavior

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People are alike in many ways and different in many ways.
- Different families or classrooms have different rules and patterns of behavior. Some behaviors are not accepted in most families or schools.
- People often choose to dress, talk, and act like their friends, do the same things they do, and have the same kinds of things they have. They also often choose to do certain things their own way.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- People can learn about others from direct experience, from the mass communications media, and from listening to other people talk about their work and their lives. People also sometimes imitate people-or characters-in the media.
- People tend to feel uncomfortable with other people who dress, talk, or act very differently from themselves. What is considered to be acceptable human behavior varies from culture to culture and from one time period to another, but there are some behaviors that are unacceptable in almost all cultures, past and present.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Each culture has distinctive patterns of behavior, usually practiced by most of the people who grow up in it.
- Within a large society, there may be many groups, with distinctly different subcultures associated with region, ethnic origin, or social class.

- Although within any society there is usually broad general agreement on what behavior is unacceptable, the standards used to judge behavior vary for different settings and different subgroups, and they may change with time and different political and economic conditions. Moreover, the punishments vary widely among, and even within, different societies.
- Technology, especially in transportation and communication, is increasingly important in spreading ideas, values, and behavior patterns within a society and among different societies. New technology can change cultural values and social behavior.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Cultural beliefs strongly influence the values and behavior of the people who grow up in the culture, often without their being fully aware of it. Response to these influences varies among individuals.
- The ways that unacceptable social behavior is punished depend partly on beliefs about the purposes of punishment and about its effectiveness. Effectiveness is difficult to test scientifically because circumstances vary greatly and because legal and ethical barriers interfere.
- Social distinctions are a part of every culture, but take many different forms, ranging from rigid classes based solely on parentage to gradations based on the acquisition of skill, wealth, or education. Differences in speech, dress, behavior, or physical features are often taken by people to be signs of social class. The difficulty of moving from one social class to another varies greatly with time, place, and economic circumstances.
- Heredity, culture, and personal experience interact in shaping human behavior. Their relative importance in most circumstances is not clear.

B. Group Behavior

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People belong to some groups by birth and belong to some groups because they join them.
- The way people act is often influenced by the groups to which they belong.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- People often like or dislike other people because of membership in or exclusion from a particular social group. Individuals tend to support members of their own group and perceive them as being like themselves.
- Different groups have different expectations for how their members should act. Sometimes the rules are written down and strictly enforced, sometimes they are just understood from example.
- When acting together, members of a group and even people in a crowd sometimes do and say things, good or bad, that they would not do or say on their own.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Affiliation with a group can increase the power of members through pooled resources and concerted action. Joining a group often has personal advantages, such as companionship, a sense of identity, and recognition by others inside and outside the group. Group identity may create a feeling of superiority, which increases group cohesion but may also entail hostility toward other groups.
- People sometimes react to all members of a group as though they were the same and perceive in their behavior only those qualities that fit preconceptions of the group. Such stereotyping leads to uncritical judgments, such as showing blind respect for members of some groups and equally blind disrespect for members of other groups.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The behavior of a group may not be predictable from an understanding of each of its members.
- Social organizations may serve business, political, or social purposes beyond those for which they officially exist, including unstated ones such as excluding certain categories of people from activities.

C. Social Change

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Changes happen in everyone's life, sometimes suddenly, more often slowly. People cannot control some changes, but they can usually learn to cope with them.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Although rules at home, school, church, and in the community stay mostly the same, sometimes they change. Changes in social arrangements happen because some rules do not work or new people are involved or outside circumstances change.
- Rules and laws can sometimes be changed by getting most of the people they affect to agree to change them.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Some aspects of family and community life are the same now as they were a generation ago, but some aspects are very different. What is taught in school and school policies toward student behavior have changed over the years in response to family and community pressures.
- By the way they depict the ideas and customs of one culture, communications media may stimulate changes in others.
- Migration, conquest, and natural disasters have been major factors in causing social and cultural change.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The size and rate of growth of the human population in any location is affected by economic, political, religious, technological, and environmental factors. Some of these factors, in turn, are influenced by the size and rate of growth of the population.
- The decisions of one generation both provide and limit the range of possibilities open to the next generation.
- Mass media, migrations, and conquest affect social change by exposing one culture to another. Extensive borrowing among cultures has led to the virtual disappearance of some cultures but only modest change in others.
- To various degrees, governments try to bring about social change or to impede it through policies, laws, incentives, or direct coercion. Sometimes such efforts achieve their intended results and sometimes they do not.

D. Social Trade-Offs

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Getting something one wants may mean giving up something in return.
- Different people may make different choices for different reasons.
- Choices have consequences, some of which are more serious than others.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- In making decisions, it helps to take time to consider the benefits and drawbacks of alternatives.
- In making decisions, benefits and drawbacks of alternatives can be taken into account more effectively if the people who will be affected are involved.
- Sometimes social decisions have unexpected consequences, no matter how carefully the decisions are made.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- There are tradeoffs that each person must consider in making choices-about personal popularity, health, family relations, and education, for example-that often have life-long consequences.
- One common aspect of all social tradeoffs pits personal benefit and the rights of the individual, on one side, against the social good and the rights of society, on the other.
- Tradeoffs are not always between desirable possibilities. Sometimes social and personal tradeoffs require accepting an unwanted outcome to avoid some other unwanted one.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Benefits and costs of proposed choices include consequences that are long-term as well as short-term, and indirect as well as direct. The more remote the consequences of a personal or social decision, the harder it usually is to take them into account in considering alternatives. But benefits and costs may be difficult to estimate.
- In deciding among alternatives, a major question is who will receive the benefits and who (not necessarily the same people) will bear the costs.

- Social tradeoffs are often generational. The cost of benefits received by one generation may fall on subsequent generations. Also, the cost of a social trade-off is sometimes borne by one generation although the benefits are enjoyed by their descendants.

E. Political and Economic Systems

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Money can buy things that people need or want. People earn money by working at a job making or growing things, selling things, or doing things to help other people.
- Everyone wants to be treated fairly, and some rules can help to do that.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- People tend to live together in groups and therefore have to have ways of deciding who will do what.
- Services that everyone gets, such as schools, libraries, parks, mail service, and police and fire protection, are usually provided by government.
- There are not enough resources to satisfy all of the desires of all people, and so there has to be some way of deciding who gets what.
- Some jobs require more (or more expensive) training than others, some involve more risk, and some pay better.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Government provides some goods and services through its own agencies and some through contracts with private individuals or businesses. To pay for the goods and services, government must obtain money by taxing people or by borrowing the money.
- Government leaders come into power by election, appointment, or force.
- However they are formed, governments usually have most of the power to make, interpret, and enforce the rules and decisions that determine how a community, state, or nation will be run. Many of the rules established by governments are designed to reduce social conflict. The rules affect a wide range of human affairs, from marriage and education to scientific research and commerce.

- In a central-planning model, a single authority, usually a national government, decides what to produce, how to produce it, and for whom. In a free-market model, consumers and producers (individually or in organizations) make these decisions based on what they believe will benefit themselves. No real-world economy is a pure example of either model; all economies have some features of each kind.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- In the free-market model, the control of production and consumption is mainly in private hands. The best allocation of resources is believed to be achieved by individuals and organizations competing in the marketplace. Individual initiative, talent, and hard work are expected to be rewarded with success and wealth. Government's role is primarily to protect political and economic freedoms for society as a whole-even at the cost of some individual or group material benefits.
- In the central-planning model, production and consumption are controlled by the government. The best allocation of resources is thought to be achieved through government planning by experts. Dedication to the good of the society as a whole is expected to motivate initiative, talent, and hard work. The main purpose of government is to promote comparable welfare for all individuals and groups-even at the cost of some individual and group freedoms.
- In practice, countries make compromises with regard to economic models. Central planning has to allow for some individual initiative, and markets have to provide some protection for unsuccessful competitors. The countries of the world use elements of both systems and are neither purely free-market nor entirely centrally controlled. Countries change, some adopting more free-market policies and practices, others more central-planning ones, and still others doing some of each.

F. Social Conflict

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Disagreements are common, even between family members or friends. Some ways of dealing with them work better than others. People who are not involved in an argument may be helpful in solving it.

- Rules at home, at school, and in the community let individuals know what to expect and so can reduce the number of disputes.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Communicating the different points of view in a dispute can often help people to find a satisfactory compromise.
- Resolving a conflict by force rather than compromise can lead to more problems.
- One person's exercise of freedom may conflict with the freedom of others. Rules can help to resolve conflicting freedoms.
- If a conflict cannot be settled by compromise, it may be decided by a vote-if everyone agrees to accept the results.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Being a member of a group can increase an individual's social power or hostile actions against other groups or individuals. It may also subject that person to the hostility of people who are outside the group.
- Most groups have formal or informal procedures for arbitrating disputes among their members.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Conflict between people or groups arises from competition over ideas, resources, power, and status. Social change, or the prospect of it, promotes conflict because social, economic, and political changes usually benefit some groups more than others. That, of course, is also true of the status quo.
- Conflicts are especially difficult to resolve in situations in which there are few choices and little room for compromise. Some informal ways of responding to conflict-use of pamphlets, demonstrations, cartoons, etc.-may sometimes reduce tensions and lead to compromise but at other times they may be inflammatory and make agreement more difficult to reach.
- Conflict within a group may be reduced by conflict between it and other groups.
- Intergroup conflict does not necessarily end when one segment of society gets a decision in its favor, for the "losers" may then work all the harder to reverse, modify, or circumvent the change. Even when the majority of

the people in a society agree on a social decision, the minority who disagree must be protected from oppression, just as the majority may need protection against unfair retaliation from the minority.

G. Global Interdependence

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- For many things they need, people rely on others who are not part of the family and maybe not even part of their local community.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Many of the things people eat and wear come from other countries, and people in those countries use things from this country. Trade occurs between nations, between different people, and between regions in the same nation. Decisions made in one country about what is produced there may have an effect on other countries.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Trade between nations occurs when natural resources are unevenly distributed and the costs of production are very different in different countries. A nation has a trade opportunity whenever it can create more of a product or service at lower cost than another.
- The major ways to promote economic health are to encourage technological development, to increase the quantity or quality of a nation's productive resources-more or better-trained workers, better equipment and methods-and to engage in trade with other nations.
- The purpose of treaties being negotiated directly between individual countries or by international organizations is to bring about cooperation among countries.
- Scientists are linked to other scientists worldwide both personally and through international scientific organizations.
- The global environment is affected by national policies and practices relating to energy use, waste disposal, ecological management, manufacturing, and population.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The wealth of a country depends partly on the effort and skills of its workers, its natural resources, and the capital and technology available to it. It also depends on the balance between how much its products are sought by other nations and how much of other nations' products it seeks. Even if a country could produce everything it needs for itself, it would still benefit from trade with other countries.
- Because of increasing international trade, the domestic products of any country may be made up in part by parts made in other countries. The international trade picture is often complicated by political motivations taking priority over economic ones.
- Migration across borders, temporary and permanent, legal and illegal, plays a major role in the availability and distribution of labor in many nations. It can bring both economic benefits and political problems.
- The growing interdependence of world social, economic, and ecological systems does not always bring greater worldwide stability and often increases the costs of conflict.

VIII. The Designed World

A. Agriculture

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Most food comes from farms either directly as crops or as the animals that eat the crops. To grow well, plants need enough warmth, light, and water. Crops also must be protected from weeds and pests that can harm them.
- Part of a crop may be lost to pests or spoilage.
- A crop that is fine when harvested may spoil before it gets to consumers.
- Machines improve what people get from crops by helping in planting and harvesting, in keeping food fresh by packaging and cooling, and in moving it long distances from where it is grown to where people live.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Some plant varieties and animal breeds have more desirable characteristics than others, but some may be more difficult or costly to grow. The kinds of crops that can grow in an area depend on the climate and soil. Irrigation and fertilizers can help crops grow in places where there is too little water or the soil is poor.
- The damage to crops caused by rodents, weeds, and insects can be reduced by using poisons, but their use may harm other plants or animals as well, and pests tend to develop resistance to poisons.
- Heating, salting, smoking, drying, cooling, and airtight packaging are ways to slow down the spoiling of food by microscopic organisms. These methods make it possible for food to be stored for long intervals before being used.
- Modern technology has increased the efficiency of agriculture so that fewer people are needed to work on farms than ever before.
- Places too cold or dry to grow certain crops can obtain food from places with more suitable climates. Much of the food eaten by Americans comes from other parts of the country and other places in the world.

3. <u>Grades 6 through 8</u>

By the end of the 8th grade, students should know that:

- Early in human history, there was an agricultural revolution in which people changed from hunting and gathering to farming. This allowed changes in the division of labor between men and women and between children and adults, and the development of new patterns of government.
- People control the characteristics of plants and animals they raise by selective breeding and by preserving varieties of seeds (old and new) to use if growing conditions change.
- In agriculture, as in all technologies, there are always trade-offs to be made. Getting food from many different places makes people less dependent on weather in any one place, yet more dependent on transportation and communication among far-flung markets. Specializing in one crop may risk disaster if changes in weather or increases in pest populations wipe out that crop. Also, the soil may be exhausted of some nutrients, which can be replenished by rotating the right crops.
- Many people work to bring food, fiber, and fuel to US markets. With improved technology, only a small fraction of workers in the United States actually plant and harvest the products that people use. Most workers are engaged in processing, packaging, transporting, and selling what is produced.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- New varieties of farm plants and animals have been engineered by manipulating their genetic instructions to produce new characteristics.
- Government sometimes intervenes in matching agricultural supply to demand in an attempt to ensure a stable, high-quality, and inexpensive food supply. Regulations are often also designed to protect farmers from abrupt changes in farming conditions and from competition by farmers in other countries.
- Agricultural technology requires tradeoffs between increased production and environmental harm and between efficient production and social values. In the past century, agricultural technology led to a huge shift of population from farms to cities and a great change in how people live and work.

B. Materials and Manufacturing

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Some kinds of materials are better than others for making any particular thing. Materials that are better in some ways (such as stronger or cheaper) may be worse in other ways (heavier or harder to cut).
- Several steps are usually involved in making things.
- Tools are used to help make things, and some things cannot be made at all without tools. Each kind of tool has a special purpose.
- Some materials can be used over again.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Naturally occurring materials such as wood, clay, cotton, and animal skins may be processed or combined with other materials to change their properties.
- Through science and technology, a wide variety of materials that do not appear in nature at all have become available, ranging from steel to nylon to liquid crystals.
- Discarded products contribute to the problem of waste disposal. Sometimes it is possible to use the materials in them to make new products, but materials differ widely in the ease with which they can be recycled.

- Through mass production, the time required to make a product and its cost can be greatly reduced. Although many things are still made by hand in some parts of the world, almost everything in the most technologically developed countries is now produced using automatic machines. Even automatic machines require human supervision.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- The choice of materials for a job depends on their properties and on how they interact with other materials. Similarly, the usefulness of some manufactured parts of an object depends on how well they fit together with the other parts.
- Manufacturing usually involves a series of steps, such as designing a product, obtaining and preparing raw materials, processing the materials mechanically or chemically, and assembling, testing, inspecting, and packaging. The sequence of these steps is also often important.
- Modern technology reduces manufacturing costs, produces more uniform products, and creates new synthetic materials that can help reduce the depletion of some natural resources.
- Automation, including the use of robots, has changed the nature of work in most fields, including manufacturing. As a result, high-skill, high-knowledge jobs in engineering, computer programming, quality control, supervision, and maintenance are replacing many routine, manual-labor jobs. Workers therefore need better learning skills and flexibility to take on new and rapidly changing jobs.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently.
- Waste management includes considerations of quantity, safety, degradability, and cost. It requires social and technological innovations, because waste-disposal problems are political and economic as well as technical.
- Scientific research identifies new materials and new uses of known materials.

- Increased knowledge of the molecular structure of materials helps in the design and synthesis of new materials for special purposes.

C. Energy Sources and Use

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People can save money by turning off machines when they are not using them.
- People burn fuels such as wood, oil, coal, or natural gas, or use electricity to cook their food and warm their houses.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Moving air and water can be used to run machines.
- The sun is the main source of energy for people and they use it in various ways. The energy in fossil fuels such as oil and coal comes from the sun indirectly, because the fuels come from plants that grew long ago.
- Some energy sources cost less than others and some cause less pollution than others.
- People try to conserve energy in order to slow down the depletion of energy resources and/or to save money.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Energy can change from one form to another, although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others.
- Different ways of obtaining, transforming, and distributing energy have different environmental consequences.
- In many instances, manufacturing and other technological activities are performed at a site close to an energy source. Some forms of energy are transported easily, others are not.
- Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. Moreover, electricity is used to distribute energy quickly and conveniently to distant locations.

- Energy from the sun (and the wind and water energy derived from it) is available indefinitely. Because the flow of energy is weak and variable, very large collection systems are needed. Other sources don't renew or renew only slowly.
- Different parts of the world have different amounts and kinds of energy resources to use and use them for different purposes.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- A central factor in technological change has been how hot a fire could be made. The discovery of new fuels, the design of better ovens and furnaces, and the forced delivery of air or pure oxygen have progressively increased the available temperature. Lasers are a new tool for focusing radiation energy with great intensity and control.
- At present, all fuels have advantages and disadvantages so that society must consider the tradeoffs among them.
- Nuclear reactions release energy without the combustion products of burning fuels, but the radioactivity of fuels and by-products poses other risks, which may last for thousands of years.
- Industrialization brings an increased demand for and use of energy. Such usage contributes to the high standard of living in the industrially developing nations but also leads to more rapid depletion of the earth's energy resources and to environmental risks associated with the use of fossil and nuclear fuels.
- Decisions to slow the depletion of energy sources through efficient technology can be made at many levels, from personal to national, and they always involve tradeoffs of economic costs and social values.

D. Communication

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Information can be sent and received in many different ways. Some allow answering back and some do not. Each way has advantages and disadvantages.
- Devices can be used to send and receive messages quickly and clearly.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- People have always tried to communicate with one another. Signed and spoken language was one of the first inventions. Early forms of recording messages used markings on materials such as wood or stone.
- Communication involves coding and decoding information. In any language, both the sender and the receiver have to know the same code, which means that secret codes can be used to keep communication private.
- People have invented devices, such as paper and ink, engraved plastic disks, and magnetic tapes, for recording information. These devices enable great amounts of information to be stored and retrieved-and be sent to one or many other people or places.
- Communication technologies make it possible to send and receive information more and more reliably, quickly, and cheaply over long distances.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Errors can occur in coding, transmitting, or decoding information, and some means of checking for accuracy is needed. Repeating the message is a frequently used method.
- Information can be carried by many media, including sound, light, and objects. In this century, the ability to code information as electric currents in wires, electromagnetic waves in space, and light in glass fibers has made communication millions of times faster than is possible by mail or sound.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Almost any information can be transformed into electrical signals. A weak electrical signal can be used to shape a stronger one, which can control other signals of light, sound, mechanical devices, or radio waves.
- The quality of communication is determined by the strength of the signal in relation to the noise that tends to obscure it. Communication errors can be reduced by boosting and focusing signals, shielding the signal from internal and external noise, and repeating information, but all of these increase costs. Digital coding of information (using only 1's and 0's) makes possible more reliable transmission of information.
- As technologies that provide privacy in communication improve, so do those for invading privacy.

E. Information Processing

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- There are different ways to store things so they can be easily found later.
- Letters and numbers can be used to put things in a useful order.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Computers are controlled partly by how they are wired and partly by special instructions called programs that are entered into a computer's memory. Some programs stay permanently in the machine but most are coded on disks and transferred into and out of the computer to suit the user.
- Computers can be programmed to store, retrieve, and perform operations on information. These operations include mathematical calculations, word processing, diagram drawing, and the modeling of complex events.
- Mistakes can occur when people enter programs or data into a computer. Computers themselves can make errors in information processing because of defects in their hardware or software.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Most computers use digital codes containing only two symbols, 0 and 1, to perform all operations. Continuous signals must be transformed into digital codes before they can be processed by a computer.
- What use can be made of a large collection of information depends upon how it is organized. One of the values of computers is that they are able, on command, to reorganize information in a variety of ways, thereby enabling people to make more and better uses of the collection.
- Computer control of mechanical systems can be much quicker than human control. In situations where events happen faster than people can react, there is little choice but to rely on computers. Most complex systems still require human oversight, however, to make certain kinds of judgments about the readiness of the parts of the system (including the computers) and the system as a whole to operate properly, to react to unexpected failures, and to evaluate how well the system is serving its intended purposes.
- An increasing number of people work at jobs that involve processing or distributing information. Because computers can do these tasks faster and more reliably, they have become standard tools both in the workplace and at home.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Computer modeling explores the logical consequences of a set of instructions and a set of data. The instructions and data input of a computer model try to represent the real world so the computer can show what would actually happen. In this way, computers assist people in making decisions by simulating the consequences of different possible decisions.
- Redundancy can reduce errors in storing or processing information but increases costs.
- Miniaturization of information-processing hardware can increase processing speed and portability, reduce energy use, and lower cost. Miniaturization is made possible through higher-purity materials and more precise fabrication technology.

F. Health Technology

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Vaccinations and other scientific treatments protect people from getting certain diseases, and different kinds of medicines may help those who do become sick to recover.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- There are normal ranges for body measurements-including temperature, heart rate, and what is in the blood and urine-that help to tell when people are well. Tools, such as thermometers and x-ray machines, provide us clues about what is happening inside the body.
- Technology has made it possible to repair and sometimes replace some body parts.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Sanitation measures such as the use of sewers, landfills, quarantines, and safe food handling are important in controlling the spread of organisms that cause disease. Improving sanitation to prevent disease has contributed more to saving human life than any advance in medical treatment.

- The ability to measure the level of substances in body fluids has made it possible for physicians to make comparisons with normal levels, make very sophisticated diagnoses, and monitor the effects of the treatments they prescribe.
- It is becoming increasingly possible to manufacture chemical substances such as insulin and hormones that are normally found in the body. They can be used by individuals whose own bodies cannot produce the amounts required for good health.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Owing to the large amount of information that computers can process, they are playing an increasingly larger role in medicine. They are used to analyze data and to keep track of diagnostic information about individuals and statistical information on the distribution and spread of various maladies in populations.
- Almost all body substances and functions have daily or longer cycles. These cycles often need to be taken into account in interpreting normal ranges for body measurements, detecting disease, and planning treatment of illness. Computers aid in detecting, analyzing, and monitoring these cycles.
- Knowledge of genetics is opening whole new fields of health care. In diagnosis, mapping of genetic instructions in cells makes it possible to detect defective genes that may lead to poor health. In treatment, substances from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.
- Inoculations use weakened germs (or parts of them) to stimulate the body's immune system to react. This reaction prepares the body to fight subsequent invasions by actual germs of that type. Some inoculations last for life.
- Knowledge of molecular structure and interactions aids in synthesizing new drugs and predicting their effects.
- The diagnosis and treatment of mental disorders are improving but not as rapidly as for physical health. Techniques for detecting and diagnosing these disorders include observation of behavior, in-depth interviews, and measurements of body chemistry. Treatments range from discussing problems to affecting the brain directly with chemicals, electric shock, or surgery.
- Biotechnology has contributed to health improvement in many ways, but its cost and application have led to a variety of controversial social and ethical issues.

IX. The Mathematical World

A. Numbers

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Numbers can be used to count things, place them in order, or name them.
- Sometimes in sharing or measuring there is a need to use numbers *between* whole numbers.
- It is possible (and often useful) to estimate quantities without knowing them exactly.
- Simple graphs can help to tell about observations.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- The meaning of numerals in many-digit numbers depends on their positions.
- In some situations, "0" means none of something, but in others it may be just the label of some point on a scale.
- When people care about what is being counted or measured, it is important for them to say what the units are (three degrees Fahrenheit is different from three centimeters, three miles from three miles per hour).
- Measurements are always likely to give slightly different numbers, even if what is being measured stays the same.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- There have been systems for writing numbers other than the Arabic system of place values based on tens. The very old Roman numerals are now used only for dates, clock faces, or ordering chapters in a book. Numbers based on 60 are still used for describing time and angles.
- A number line can be extended on the other side of zero to represent *negative numbers*. Negative numbers allow subtraction of a bigger number from a smaller number to make sense, and are often used when something can be measured on either side of some reference point (time, ground level, temperature, and budget).
- Numbers can be written in different forms, depending on how they are being used. How fractions or decimals based on *measured* quantities should be written depends on how precise the measurements are and how precise an answer is needed.

- The operations + and - are inverses of each other-one undoes what the other does; likewise x and ÷.
- The expression *a/b* can mean different things: *a* parts of size *1/b* each, *a* divided by *b*, or *a* compared to *b*.
- Numbers can be represented by using sequences of only two symbols (such as 1 and 0, on and off); computers work this way.
- Computations (as on calculators) can give more digits than make sense or are useful.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Comparison of numbers of very different size can be made approximately by expressing them as nearest powers of 10.
- Numbers can be written with bases different from ten (which people probably use because of their 10 fingers). The simplest base, 2, uses just two symbols (1 and 0, or on and off).
- When calculations are made with measurements, a small error in the measurements may lead to a large error in the results.
- The effects of uncertainties in measurements on a computed result can be estimated.

B. Symbolic Relationships

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Similar patterns may show up in many places in nature and in the things people make.
- Sometimes changing one thing causes changes in something else. In some situations, changing the same thing in the same way usually has the same result.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Mathematical statements using symbols may be true only when the symbols are replaced by certain numbers.
- Tables and graphs can show how values of one quantity are related to values of another.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- An equation containing a variable may be true for just one value of the variable.

- Mathematical statements can be used to describe how one quantity changes when another changes. Rates of change can be computed from differences in magnitudes and vice versa.
- Graphs can show a variety of possible relationships between two variables. As one variable increases uniformly, the other may do one of the following: increase or decrease steadily, increase or decrease faster and faster, get closer and closer to some limiting value, reach some intermediate maximum or minimum, alternately increase and decrease indefinitely, increase or decrease in steps, or do something different from any of these.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- In some cases, the more of something there is, the more rapidly it may change (as the number of births is proportional to the size of the population). In other cases, the rate of change of something depends on how much there is of something else (as the rate of change of speed is proportional to the amount of force acting).
- Symbolic statements can be manipulated by rules of mathematical logic to produce other statements of the same relationship, which may show some interesting aspect more clearly. Symbolic statements can be combined to look for values of variables that will satisfy all of them at the same time.
- Any mathematical model, graphic or algebraic, is limited in how well it can represent how the world works. The usefulness of a mathematical model for predicting may be limited by uncertainties in measurements, by neglect of some important influences, or by requiring too much computation.
- Tables, graphs, and symbols are alternative ways of representing data and relationships that can be translated from one to another.
- When a relationship is represented in symbols, numbers can be substituted for all but one of the symbols and the possible value of the remaining symbol computed. Sometimes the relationship may be satisfied by one value, sometimes more than one, and sometimes maybe not at all.
- The reasonableness of the result of a computation can be estimated from what the inputs and operations are.

C. Shapes

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Shapes such as circles, squares, and triangles can be used to describe many things that can be seen.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Length can be thought of as unit lengths joined together, area as a collection of unit squares, and volume as a set of unit cubes.
- If 0 and 1 are located on a line, any other number can be depicted as a position on the line.
- Graphical display of numbers may make it possible to spot patterns that are not otherwise obvious, such as comparative size and trends.
- Many objects can be described in terms of simple plane figures and solids. Shapes can be compared in terms of concepts such as parallel and perpendicular, congruence and similarity, and symmetry. Symmetry can be found by reflection, turns, or slides.
- Areas of irregular shapes can be found by dividing them into squares and triangles.
- Scale drawings show shapes and compare locations of things very different in size.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Some shapes have special properties: triangular shapes tend to make structures rigid, and round shapes give the least possible boundary for a given amount of interior area. Shapes can match exactly or have the same shape in different sizes.
- Lines can be parallel, perpendicular, or oblique.
- Shapes on a sphere like the earth cannot be depicted on a flat surface without some distortion.
- The graphic display of numbers may help to show patterns such as trends, varying rates of change, gaps, or clusters. Such patterns sometimes can be used to make predictions about the phenomena being graphed.
- It takes two numbers to locate a point on a map or any other flat surface. The numbers may be two perpendicular distances from a point, or an angle and a distance from a point.
- The scale chosen for a graph or drawing makes a big difference in how useful it is.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Distances and angles that are inconvenient to measure directly can be found from measurable distances and angles using scale drawings or formulas.
- There are formulas for calculating the surface areas and volumes of regular shapes. When the linear size of a shape changes by some factor, its area and volume change disproportionately: area in proportion to the square of the factor, and volume in proportion to its cube. Properties of an object that depend on its area or volume also change disproportionately.
- Geometric shapes and relationships can be described in terms of symbols and numbers-and vice versa. For example, the position of any point on a surface can be specified by two numbers; a graph represents all the values that satisfy an equation; and if two equations have to be satisfied at the same time, the values that satisfy them both will be found where their graphs intersect.
- Different ways to map a curved surface (like the earth's) onto a flat surface have different advantages.

D. Uncertainty

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Some things are more likely to happen that others. Some events can be predicted well and some cannot. Sometimes people aren't sure what will happen because they don't know everything that might be having an effect.
- Often a person can find out about a group of things by studying just a few of them.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Some predictions can be based on what is known about the past, assuming that conditions are pretty much the same now.
- Statistical predictions (as for rainy days, accidents) are typically better for *how many* of a group will experience something than for which members of the group will experience it-and better for *how often* something will happen than for *exactly when*.
- Summary predictions are usually more accurate for large collections of events than for just a few. Even very unlikely events may occur fairly often in very large populations.

- Spreading data out on a number line helps to see what the extremes are, where they pile up, and where the gaps are. A summary of data includes where the middle is and how much spread is around it.
- A small part of something may be special in some way and not give an accurate picture of the whole. How much a portion of something can help to estimate what the whole is like depends on how the portion is chosen. There is a danger of choosing only the data that show what is expected by the person doing the choosing.
- Events can be described in terms of being more or less likely, impossible, or certain.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- How probability is estimated depends on what is known about the situation. Estimates can be based on data from similar conditions in the past or on the assumption that all the possibilities are known.
- Probabilities are ratios and can be expressed as fractions, percentages, or odds.
- The mean, median, and mode tell different things about the middle of a data set.
- Comparison of data from two groups should involve comparing both their middles and the spreads around them.
- The larger a well-chosen sample is, the more accurately it is likely to represent the whole. But there are many ways of choosing a sample that can make it unrepresentative of the whole.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Even when there are plentiful data, it may not be obvious what mathematical model to use to make predictions from them or there may be insufficient computing power to use some models.
- When people estimate a statistic, they may also be able to say how far off the estimate might be.
- The middle of a data distribution may be misleading-when the data are not distributed symmetrically, or when there are extreme high or low values, or when the distribution is not reasonably smooth.
- The way data are displayed can make a big difference in how they are interpreted.
- Both percentages and actual numbers have to be taken into account in comparing different groups; using either category by itself could be misleading.
- Considering whether two variables are correlated requires inspecting their distributions, such as in two-way tables or scatter plots. A believable correlation between two variables doesn't mean that one causes the other;

perhaps some other variable causes them both or the correlation might be attributable to chance alone. A true correlation means that differences in one variable imply differences in the other when all other things are equal.

- For a well-chosen sample, the size of the sample is much more important than the size of the population. To avoid intentional or unintentional bias, samples are usually selected by some random system.
- A physical or mathematical model can be used to estimate the probability of real-world events.

E. Reasoning

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- People are more likely to believe your ideas if you can give good reasons for them.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- One way to make sense of something is to think how it is like something more familiar.
- Reasoning can be distorted by strong feelings.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Some aspects of reasoning have fairly rigid rules for what makes sense; other aspects don't. If people have rules that always hold, and good information about a particular situation, then logic can help them to figure out what is true about it. This kind of reasoning requires care in the use of key words such as *if*, *and*, *not*, *or*, *all*, and *some*. Reasoning by similarities can suggest ideas but can't prove them one way or the other.
- Practical reasoning, such as diagnosing or troubleshooting almost anything, may require many-step, branching logic. Because computers can keep track of complicated logic, as well as a lot of information, they are useful in a lot of problem-solving situations.
- Sometimes people invent a general rule to explain how something works by summarizing observations. But people tend to over generalize, imagining general rules on the basis of only a few observations.
- People are using incorrect logic when they make a statement such as "If A is true, then B is true; but A isn't true, therefore B isn't true either."

- A single example can never prove that something is always true, but sometimes a single example can prove that something is not always true.
- An analogy has some likenesses to but also some differences from the real thing.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- To be convincing, an argument needs to have both true statements and valid connections among them. Formal logic is mostly about connections among statements, not about whether they are true. People sometimes use poor logic even if they begin with true statements, and sometimes they use logic that begins with untrue statements.
- Logic requires a clear distinction among reasons: A reason may be *sufficient* to get a result, but perhaps is not the only way to get there; or, a reason may be *necessary* to get the result, but it may not be enough by itself; some reasons may be both sufficient and necessary.
- Wherever a general rule comes from, logic can be used in testing how well it works. Proving a generalization to be false (just one exception will do) is easier than proving it to be true (for all possible cases). Logic may be of limited help in finding solutions to problems if one isn't sure that general rules always hold or that particular information is correct; most often, one has to deal with probabilities rather than certainties.
- Once a person believes in a general rule, he or she may be more likely to notice cases that agree with it and to ignore cases that don't. To avoid biased observations, scientific studies sometimes use observers who don't know what the results are "supposed" to be.
- Very complex logical arguments can be made from a lot of small logical steps. Computers are particularly good at working with complex logic but not all logical problems can be solved by computers. High-speed computers can examine the validity of some logical propositions for a very large number of cases, although that may not be a perfect proof.

X. Historical Perspectives

A. Displacing the Earth from the Center of the Universe

1. Grades 6 through 8

By the end of the 8th grade, students should know that:

- The motion of an object is always judged with respect to some other object or point and so the idea of absolute motion or rest is misleading.
- Telescopes reveal that there are many more stars in the night sky than are evident to the unaided eye, the surface of the moon has many craters and mountains, the sun has dark spots, and Jupiter and some other planets have their own moons.

2. Grades 9 through 12

By the end of the 12th grade, students should know that:

- People perceive that the earth is large and stationary and that all other objects in the sky orbit around it. That perception was the basis for theories of how the universe is organized that prevailed for over 2,000 years.
- Ptolemy, an Egyptian astronomer living in the second century A.D., devised a powerful mathematical model of the universe based on constant motion in perfect circles, and circles on circles. With the model, he was able to predict the motions of the sun, moon, and stars, and even of the irregular "wandering stars" now called planets.
- In the 16th century, a Polish astronomer named Copernicus suggested that all those same motions could be explained by imagining that the earth was turning around once a day and orbiting around the sun once a year. This explanation was rejected by nearly everyone because it violated common sense and required the universe to be unbelievably large. Worse, it flew in the face of the belief, universally held at the time that the earth was at the center of the universe.
- Johannes Kepler, a German astronomer who lived at about the same time as Galileo, showed mathematically that Copernicus' idea of a sun-centered system worked well if uniform circular motion was replaced with uneven (but predictable) motion along off-center ellipses.
- Using the newly invented telescope to study the sky, Galileo made many discoveries that supported the ideas of Copernicus. It was Galileo who found the moons of Jupiter, sunspots, craters and mountains on the moon, and many more stars than were visible to the unaided eye.
- Writing in Italian rather than in Latin (the language of scholars at the time), Galileo presented arguments for and against the two main views of the universe in a way that favored the newer view. That brought the issue to the educated people of the time and created political, religious, and scientific controversy.

B. Uniting the Heavens and Earth

1. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Isaac Newton created a unified view of force and motion in which motion everywhere in the universe can be explained by the same few rules. His mathematical analysis of gravitational force and motion showed that planetary orbits had to be the very ellipses that Kepler had proposed two generations earlier.
- Newton's system was based on the concepts of mass, force, and acceleration, his three laws of motion relating them, and a physical law stating that the force of gravity between any two objects in the universe depends only upon their masses and the distance between them.
- The Newtonian model made it possible to account for such diverse phenomena as tides, the orbits of planets and moons, the motion of falling objects, and the earth's equatorial bulge.
- For several centuries, Newton's science was accepted without major changes because it explained so many different phenomena, could be used to predict many physical events (such as the appearance of Halley's comet), was mathematically sound, and had many practical applications.
- Although overtaken in the 20th century by Einstein's relativity theory, Newton's ideas persist and are widely used. Moreover, his influence has extended far beyond physics and astronomy, serving as a model for other sciences and even raising philosophical questions about free will and the organization of social systems.

C. Relating Matter & Energy and Time & Space

1. Grades 9 through 12

By the end of the 12th grade, students should know that:

- As a young man, Albert Einstein, a German scientist, formulated the special theory of relativity, which brought about revolutionary changes in human understanding of nature. A decade later, he proposed the general theory of relativity, which, along with Newton's work, ranks as one of the greatest human accomplishments in all of history.
- Among the surprising ideas of special relativity is that nothing can travel faster than the speed of light, which is the same for all observers no matter how they or the light source happen to be moving.

- The special theory of relativity is best known for stating that any form of energy has mass, and that matter itself is a form of energy. The famous relativity equation, $E = mc^2$, holds that the transformation of even a tiny amount of matter will release an enormous amount of other forms of energy, in that the c in the equation stands for the immense speed of light.
- General relativity theory pictures Newton's gravitational force as a distortion of space and time.
- Many predictions from Einstein's theory of relativity have been confirmed on both atomic and astronomical scales. Still, the search continues for an even more powerful theory of the architecture of the universe.

D. Extending Time

1. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Scientific evidence indicates that some rock near the earth's surface is several billion years old. But until the 19th century, most people believed that the earth was created just a few thousand years ago.
- The idea that the earth might be vastly older than most people believed made little headway in science until the publication of *Principles of Geology* by an English scientist, Charles Lyell, early in the 19th century. The impact of Lyell's book was a result of both the wealth of observations it contained on the patterns of rock layers in mountains and the locations of various kinds of fossils, and of the careful logic he used in drawing inferences from his data.
- In formulating and presenting his theory of biological evolution, Charles Darwin adopted Lyell's belief about the age of the earth and his style of buttressing his argument with vast amounts of evidence.

E. Moving the Continents

1. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The idea of continental drift was suggested by the matching shapes of the Atlantic coasts of Africa and South America, but rejected for lack of other evidence. It just seemed absurd that anything as massive as a continent could move around.
- Early in the 20th century, Alfred Wegener, a German scientist, reintroduced the idea of moving continents, adding such evidence as the underwater shapes of the continents, the similarity of life forms and land forms in

corresponding parts of Africa and South America, and the increasing separation of Greenland and Europe. Still, very few contemporary scientists adopted his theory.

- The theory of plate tectonics was finally accepted by the scientific community in the 1960s, when further evidence had accumulated in support of it. The theory was seen to provide an explanation for a diverse array of seemingly unrelated phenomena, and there was a scientifically sound physical explanation of how such movement could occur.

F. Understanding Fire

1. Grades 6 through 8

By the end of the 8th grade, students should know that:

- From the earliest times until now, people have believed that even though millions of different kinds of material seem to exist in the world, most things must be made up of combinations of just a few basic kinds of things. There has not always been agreement, however, on what those basic kinds of things are. One theory long ago was that the basic substances were earth, water, air, and fire. Scientists now know that these are not the basic substances. But the old theory seemed to explain many observations about the world.
- Today, scientists are still working out the details of what the basic kinds of matter are and of how they combine, or can be made to combine, to make other substances.
- Experimental and theoretical work done by French scientist Antoine Lavoisier in the decade between the American and French revolutions led to the modern science of chemistry.
- Lavoisier's work was based on the idea that when materials react with each other many changes can take place but that in every case the total amount of matter afterward is the same as before. He successfully tested the concept of conservation of matter by conducting a series of experiments in which he carefully measured all the substances involved in burning, including the gases used and those given off.
- Alchemy was chiefly an effort to change base metals like lead into gold and to produce an elixir that would enable people to live forever. It failed to do that or to create much knowledge of how substances react with each other. The more scientific study of chemistry that began in Lavoisier's time has gone far beyond alchemy in understanding reactions and producing new materials.

2. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Lavoisier invented a whole new field of science based on a theory of materials, physical laws, and quantitative methods, with the conservation of matter at its core. He persuaded a generation of scientists that his approach accounted for the experimental results better than other chemical systems.
- Lavoisier's system for naming substances and describing their reactions contributed to the rapid growth of chemistry by enabling scientists everywhere to share their findings about chemical reactions with one another without ambiguity.
- John Dalton's modernization of the ancient Greek ideas of element, atom, compound, and molecule strengthened the new chemistry by providing a physical explanation for reactions that could be expressed in quantitative terms.
- While the basic ideas of Lavoisier and Dalton have survived, the advancement of chemistry since their time now makes possible an explanation of the bonding that takes place between atoms during chemical reactions in terms of the inner workings of atoms.

G. Splitting the Atom

1. Grades 6 through 8

By the end of the 8th grade, students should know that:

- The accidental discovery that minerals containing uranium darken photographic film, as light does, led to the idea of radioactivity.
- In their laboratory in France, Marie Curie and her husband, Pierre Curie, isolated two new elements that caused most of the radioactivity of the uranium mineral. They named one radium because it gave off powerful, invisible rays, and the other polonium in honor of Madame Curie's country of birth. Marie Curie was the first scientist ever to win the Nobel prize in two different fields-in physics, shared with her husband, and later in chemistry.

2. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The Curies made radium available to researchers all over the world, increasing the study of radioactivity and leading to the realization that one kind of atom may change into another kind, and so must be made up of

smaller parts. These parts were demonstrated by other scientists to be a small, dense nucleus that contains protons and neutrons and is surrounded by a cloud of electrons.

- Ernest Rutherford of New Zealand and his colleagues discovered that the heavy radio active element uranium spontaneously splits itself into a slightly lighter nucleus and a very light helium nucleus.
- Later, Austrian and German scientists showed that when uranium is struck by neutrons, it splits into two nearly equal parts plus one or two extra neutrons. Lise Meitner, an Austrian physicist, was the first to point out that if these fragments added up to less mass than the original uranium nucleus, then Einstein's special relativity theory predicted that a large amount of energy would be released. Enrico Fermi, an Italian working with colleagues in the United States, showed that the extra neutrons trigger more fissions and so create a sustained chain reaction in which a prodigious amount of energy is given off.
- A massive effort went into developing the technology for the two nuclear fission bombs used on Japan in World War II, nuclear fusion weapons that followed, and reactors for the controlled conversion of nuclear energy into electric energy. Nuclear weapons and energy remain matters of public concern and controversy.
- Radioactivity has many uses other than generating energy, including in medicine, industry, and scientific research in many different fields.

H. Explaining the Diversity of Life

1. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The scientific problem that led to the theory of natural selection was how to explain similarities within the great diversity of existing and fossil organisms.
- Prior to Charles Darwin, the most widespread belief was that all known species were created at the same time and remained unchanged throughout history. Some scientists at the time believed that features an individual acquired during its lifetime could be passed on to its offspring, and the species could thereby gradually change to fit its environment better.
- Darwin argued that only biologically inherited characteristics could be passed on to offspring. Some of these characteristics were advantageous in surviving and reproducing. The offspring would also inherit and pass on

those advantages, and over generations the aggregation of these inherited advantages would lead to a new species.

- The quick success of Darwin's book *Origin of Species*, published in the mid-1800s, came from the clear and understandable argument it made, including the comparison of natural selection to the selective breeding of animals in wide use at the time, and from the massive array of biological and fossil evidence it assembled to support the argument.
- After the publication of *Origin of Species*, biological evolution was supported by the rediscovery of the genetics experiments of an Austrian monk, Gregor Mendel, by the identification of genes and how they are sorted in reproduction, and by the discovery that the genetic code found in DNA is the same for almost all organisms.
- By the 20th century, most scientists had accepted Darwin's basic idea. Today that still holds true, although differences exist concerning the details of the process and how rapidly evolution of species takes place. People usually do not reject evolution for scientific reasons but because they dislike its implications, such as the relation of human beings to other animals, or because they prefer a biblical account of creation.

I. Discovering Germs

1. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Throughout history, people have created explanations for disease. Some have held that disease has spiritual causes, but the most persistent biological theory over the centuries was that illness resulted from an imbalance in the body fluids. The introduction of germ theory by Louis Pasteur and others in the 19th century led to the modern belief that many diseases are caused by microorganisms-bacteria, viruses, yeasts, and parasites.
- Pasteur wanted to find out what causes milk and wine to spoil. He demonstrated that spoilage and fermentation occur when microorganisms enter from the air, multiply rapidly, and produce waste products. After showing that spoilage could be avoided by keeping germs out or by destroying them with heat, he investigated animal diseases and showed that microorganisms were involved. Other investigators later showed that specific kinds of germs caused specific diseases.

- Pasteur found that infection by disease organisms-germs-caused the body to build up an immunity against subsequent infection by the same organisms. He then demonstrated that it was possible to produce vaccines that would induce the body to build immunity to a disease without actually causing the disease itself.
- Changes in health practices have resulted from the acceptance of the germ theory of disease. Before germ theory, illness was treated by appeals to supernatural powers or by trying to adjust body fluids through induced vomiting, bleeding, or purging. The modern approach emphasizes sanitation, the safe handling of food and water, the pasteurization of milk, quarantine, and aseptic surgical techniques to keep germs out of the body; vaccinations to strengthen the body's immune system against subsequent infection by the same kind of microorganisms; and antibiotics and other chemicals and processes to destroy microorganisms.
- In medicine, as in other fields of science, discoveries are sometimes made unexpectedly, even by accident. But knowledge and creative insight are usually required to recognize the meaning of the unexpected.

J. Harnessing Power

1. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Until the 1800s, most manufacturing was done in homes, using small, handmade machines that were powered by muscle, wind, or running water. New machinery and steam engines to drive them made it possible to replace craftsmanship with factories, using fuels as a source of energy. In the factory system, workers, materials, and energy could be brought together efficiently.
- The invention of the steam engine was at the center of the Industrial Revolution. It converted the chemical energy stored in wood and coal, which were plentiful, into mechanical work. The steam engine was invented to solve the urgent problem of pumping water out of coal mines. As improved by James Watt, it was soon used to move coal, drive manufacturing machinery, and power locomotives, ships, and even the first automobiles.

2. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The Industrial Revolution happened first in Great Britain because that country made practical use of science, had access by sea to world resources and markets, and had an excess of farm workers willing to become factory workers.

- The Industrial Revolution increased the productivity of each worker but it also increased child labor and unhealthy working conditions, and it gradually destroyed the craft tradition. The economic imbalances of the Industrial Revolution led to a growing conflict between factory owners and workers and contributed to the main political ideologies of the 20th century.
- The Industrial Revolution is still underway as electric, electronic, and computer technologies change patterns of work and bring with them economic and social consequences.

XI. Common Themes

A. Systems

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Most things are made of parts.
- Something may not work if some of its parts are missing.
- When parts are put together, they can do things that they couldn't do by themselves

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- In something that consists of many parts, the parts usually influence one another.
- Something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched, or misconnected.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- A system can include processes as well as things.
- Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.

- Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts.
- Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. In defining a system, it is important to specify its boundaries and subsystems, indicate its relation to other systems, and identify what its input and its output are expected to be.
- The successful operation of a designed system usually involves feedback. The feedback of output from some parts of a system to input of other parts can be used to encourage what is going on in a system, discourage it, or reduce its discrepancy from some desired value. The stability of a system can be greater when it includes appropriate feedback mechanisms.
- Even in some very simple systems, it may not always be possible to predict accurately the result of changing some part or connection.

B. Models

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Many of the toys children play with are like real things only in some ways. They are not the same size, are missing many details, or are not able to do all of the same things.
- A model of something is different from the real thing but can be used to learn something about the real thing.
- One way to describe something is to say how it is like something else.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Seeing how a model works after changes are made to it may suggest how the real thing would work if the same were done to it.

- Geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and stories can be used to represent objects, events, and processes in the real world, although such representations can never be exact in every detail.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.
- Mathematical models can be displayed on a computer and then modified to see what happens.
- Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose. The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation. A mathematical model may give insight about how something really works or may fit observations very well without any intuitive meaning.
- Computers have greatly improved the power and use of mathematical models by performing computations that are very long, very complicated, or repetitive. Therefore computers can show the consequences of applying complex rules or of changing the rules. The graphic capabilities of computers make them useful in the design and testing of devices and structures and in the simulation of complicated processes.
- The usefulness of a model can be tested by comparing its predictions to actual observations in the real world. But a close match does not necessarily mean that the model is the only "true" model or the only one that would work.

C. Constancy and Change

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Things change in some ways and stay the same in some ways.
- People can keep track of some things, seeing where they come from and where they go.
- Things can change in different ways, such as in size, weight, color, and movement. Some small changes can be detected by taking measurements.
- Some changes are so slow or so fast that they are hard to see.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Some features of things may stay the same even when other features change. Some patterns look the same when they are shifted over, or turned, or reflected, or seen from different directions.
- Things change in steady, repetitive, or irregular ways-or sometimes in more than one way at the same time. Often the best way to tell which kinds of change are happening is to make a table or graph of measurements.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Physical and biological systems tend to change until they become stable and then remain that way unless their surroundings change.
- A system may stay the same because nothing is happening or because things are happening but exactly counterbalance one another.
- Many systems contain feedback mechanisms that serve to keep changes within specified limits.
- Symbolic equations can be used to summarize how the quantity of something changes over time or in response to other changes.
- Symmetry (or the lack of it) may determine properties of many objects, from molecules and crystals to organisms and designed structures.
- Cycles, such as the seasons or body temperature, can be described by their cycle length or frequency, what their highest and lowest values are, and when these values occur. Different cycles range from many thousands of years down to less than a billionth of a second.

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- A system in equilibrium may return to the same state of equilibrium if the disturbances it experiences are small. But large disturbances may cause it to escape that equilibrium and eventually settle into some other state of equilibrium.
- Along with the theory of atoms, the concept of the conservation of matter led to revolutionary advances in chemical science. The concept of conservation of energy is at the heart of advances in fields as diverse as the study of nuclear particles and the study of the origin of the universe.
- Things can change in detail but remain the same in general (the players change, but the team remains; cells are replaced, but the organism remains). Sometimes counterbalancing changes are necessary for a thing to retain its essential constancy in the presence of changing conditions.
- Graphs and equations are useful (and often equivalent) ways for depicting and analyzing patterns of change.
- In many physical, biological, and social systems, changes in one direction tend to produce opposing (but somewhat delayed) influences, leading to repetitive cycles of behavior.
- In evolutionary change, the present arises from the materials and forms of the past, more or less gradually, and in ways that can be explained.
- Most systems above the molecular level involve so many parts and forces and are so sensitive to tiny differences in conditions that their precise behavior is unpredictable, even if all the rules for change are known. Predictable or not, the precise future of a system is not completely determined by its present state and circumstances but also depends on the fundamentally uncertain outcomes of events on the atomic scale.

D. Scale

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should know that:

- Things in nature and things people make have very different sizes, weights, ages, and speeds.

2. Grades 3 through 5

By the end of the 5th grade, students should know that:

- Almost anything has limits on how big or small it can be.
- Finding out what the biggest and the smallest possible values of something are is often as revealing as knowing what the usual value is.

3. Grades 6 through 8

By the end of the 8th grade, students should know that:

- Properties of systems that depend on volume, such as capacity and weight, change out of proportion to properties that depend on area, such as strength or surface processes.
- As the complexity of any system increases, gaining an understanding of it depends increasingly on summaries, such as averages and ranges, and on descriptions of typical examples of that system

4. Grades 9 through 12

By the end of the 12th grade, students should know that:

- Representing large numbers in terms of powers of ten makes it easier to think about them and to compare things that are greatly different.
- Because different properties are not affected to the same degree by changes in scale, large changes in scale typically change the way that things work in physical, biological, or social systems.
- As the number of parts of a system increases, the number of possible interactions between pairs of parts increases much more rapidly.

XII. Habits of Mind

A. Values and Attitudes

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should:

- Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.

2. Grades 3 through 5

By the end of the 5th grade, students should:

- Keep records of their investigations and observations and not change the records later.
- Offer reasons for their findings and consider reasons suggested by others.

3. Grades 6 through 8

By the end of the 8th grade, students should:

- Know why it is important in science to keep honest, clear, and accurate records.
- Know that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.
- Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct.

4. Grades 9 through 12

By the end of the 12th grade, students should:

- Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out; exhibit those traits in their own lives and value them in others.
- View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.

B. Computation and Estimation

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should be able to:

- Use whole numbers and simple, everyday fractions in ordering, counting, identifying, measuring, and describing things and experiences.
- Readily give the sums and differences of single-digit numbers in familiar contexts where the operation makes sense to them and they can judge the reasonableness of the answer.
- Give rough estimates of numerical answers to problems before doing them formally.
- Explain to other students how they go about solving numerical problems.
- Make quantitative estimates of familiar lengths, weights, and time intervals and check them by measurements.

2. Grades 3 through 5

By the end of the 5th grade, students should be able to:

- Add, subtract, multiply, and divide whole numbers mentally, on paper, and with a calculator.
- Use fractions and decimals, translating when necessary between decimals and commonly encountered fractions-halves, thirds, fourths, fifths, tenths, and hundredths (but not sixths, sevenths, etc.).
- Judge whether measurements and computations of quantities such as length, area, volume, weight, or time are reasonable in a familiar context by comparing them to typical values.

- State the purpose of each step in a calculation.
- Read and follow step-by-step instructions in a calculator or computer manual when learning new procedures.

3. Grades 6 through 8

By the end of the 8th grade, students should be able to:

- Find what percentage one number is of another and figure any percentage of any number.
- Use, interpret, and compare numbers in several equivalent forms such as integers, fractions, decimals, and percents.
- Calculate the circumferences and areas of rectangles, triangles, and circles, and the volumes of rectangular solids.
- Find the mean and median of a set of data.
- Estimate distances and travel times from maps and the actual size of objects from scale drawings.
- Insert instructions into computer spreadsheet cells to program arithmetic calculations.
- Determine what unit (such as seconds, square inches, or dollars per tankful) an answer should be expressed in from the units of the inputs to the calculation, and be able to convert compound units (such as yen per dollar into dollar per yen, or miles per hour into feet per second).
- Decide what degree of precision is adequate and round off the result of calculator operations to enough significant figures to reasonably reflect those of the inputs.
- Express numbers like 100, 1,000, and 1,000,000 as powers of 10.
- Estimate probabilities of outcomes in familiar situations, on the basis of history or the number of possible outcomes.

4. Grades 9 through 12

By the end of the 12th grade, students should be able to:

- Use ratios and proportions, including constant rates, in appropriate problems.
- Find answers to problems by substituting numerical values in simple algebraic formulas and judge whether the answer is reasonable by reviewing the process and checking against typical values.
- Make up and write out simple algorithms for solving problems that take several steps.
- Use computer spreadsheet, graphing, and database programs to assist in quantitative analysis.

- Compare data for two groups by representing their averages and spreads graphically.
- Express and compare very small and very large numbers using powers-of-ten notation.
- Trace the source of any large disparity between an estimate and the calculated answer.
- Recall immediately the relations among 10, 100, 1000, 1 million, and 1 billion (knowing, for example, that 1 million is a thousand thousands).
- Consider the possible effects of measurement errors on calculations.

C. Manipulation and Observation

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should be able to:

- Use hammers, screwdrivers, clamps, rulers, scissors, and hand lenses, and operate ordinary audio equipment.
- Assemble, describe, take apart and reassemble constructions using interlocking blocks, erector sets, and the like.
- Make something out of paper, cardboard, wood, plastic, metal, or existing objects that can actually be used to perform a task.
- Measure the length in whole units of objects having straight edges.

2. Grades 3 through 5

By the end of the 5th grade, students should be able to:

- Choose appropriate common materials for making simple mechanical constructions and repairing things.
- Measure and mix dry and liquid materials (in the kitchen, garage, or laboratory) in prescribed amounts, exercising reasonable safety.
- Keep a notebook that describes observations made, carefully distinguishes actual observations from ideas and speculations about what was observed, and is understandable weeks or months later.
- Use calculators to determine area and volume from linear dimensions, aggregate amounts of area, volume, weight, time, and cost, and find the difference between two quantities of anything.
- Make safe electrical connections with various plugs, sockets, and terminals.

3. Grades 6 through 8

By the end of the 8th grade, students should be able to:

- Use calculators to compare amounts proportionally.
- Use computers to store and retrieve information in topical, alphabetical, numerical, and key-word files, and create simple files of their own devising.
- Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, and temperature, and choose appropriate units for reporting various magnitudes.
- Use cameras and tape recorders for capturing information.
- Inspect, disassemble, and reassemble simple mechanical devices and describe what the various parts are for; estimate what the effect that making a change in one part of a system is likely to have on the system as a whole.

4. Grades 9 through 12

By the end of the 12th grade, students should be able to:

- Learn quickly the proper use of new instruments by following instructions in manuals or by taking instructions from an experienced user.
- Use computers for producing tables and graphs and for making spreadsheet calculations.
- Troubleshoot common mechanical and electrical systems, checking for possible causes of malfunction, and decide on that basis whether to make a change or get advice from an expert before proceeding.
- Use power tools safely to shape, smooth, and join wood, plastic, and soft metal.

D. Communication Skills

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should be able to:

- Describe and compare things in terms of number, shape, texture, size, weight, color, and motion.
- Draw pictures that correctly portray at least some features of the thing being described.

2. Grades 3 through 5

By the end of the 5th grade, students should be able to:

- Write instructions that others can follow in carrying out a procedure.
- Make sketches to aid in explaining procedures or ideas.
- Use numerical data in describing and comparing objects and events.

3. Grades 6 through 8

By the end of the 8th grade, students should be able to:

- Organize information in simple tables and graphs and identify relationships they reveal.
- Read simple tables and graphs produced by others and describe in words what they show.
- Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer databases.
- Understand writing that incorporates circle charts, bar and line graphs, two-way data tables, diagrams, and symbols.
- Find and describe locations on maps with rectangular and polar coordinates.

4. Grades 9 through 12

By the end of the 12th grade, students should be able to:

- Make and interpret scale drawings.
- Write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure.
- Choose appropriate summary statistics to describe group differences, always indicating the spread of the data as well as the data's central tendencies.
- Describe spatial relationships in geometric terms such as perpendicular, parallel, tangent, similar, congruent, and symmetrical.
- Use and correctly interpret relational terms such as *if . . . then . . . , and, or, sufficient, necessary, some, every, not, correlates with, and causes*.
- Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

E. Critical-Response Skills

1. Kindergarten through Grade 2

By the end of the 2nd grade, students should:

- Ask "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question.

2. Grades 3 through 5

By the end of the 5th grade, students should:

- Buttress their statements with facts found in books, articles, and databases, and identify the sources used and expect others to do the same.
- Recognize when comparisons might not be fair because some conditions are not kept the same.
- Seek better reasons for believing something than "Everybody knows that . . ." or "I just know" and discount such reasons when given by others.

3. Grades 6 through 8

By the end of the 8th grade, students should:

- Question claims based on vague attributions (such as "Leading doctors say...") or on statements made by celebrities or others outside the area of their particular expertise.
- Compare consumer products and consider reasonable personal trade-offs among them on the basis of features, performance, durability, and cost.
- Be skeptical of arguments based on very small samples of data, biased samples, or samples for which there was no control sample.
- Be aware that there may be more than one good way to interpret a given set of findings.
- Notice and criticize the reasoning in arguments in which (1) fact and opinion are intermingled or the conclusions do not follow logically from the evidence given, (2) an analogy is not apt, (3) no mention is made of whether the control groups are very much like the experimental group, or (4) all members of a group (such as teenagers or chemists) are implied to have nearly identical characteristics that differ from those of other groups.

4. Grades 9 through 12

By the end of the 12th grade, students should:

- Notice and criticize arguments based on the faulty, incomplete, or misleading use of numbers, such as in instances when (1) average results are reported, but not the amount of variation around the average, (2) a percentage or fraction is given, but not the total sample size (as in "9 out of 10 dentists recommend..."), (3)

absolute and proportional quantities are mixed (as in "3,400 more robberies in our city last year, whereas other cities had an increase of less than 1%), or (4) results are reported with overstated precision (as in representing 13 out of 19 students as 68.42%).

- Check graphs to see that they do not misrepresent results by using inappropriate scales or by failing to specify the axes clearly.
- Wonder how likely it is that some event of interest might have occurred just by chance.
- Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken-whether one's own or that of others-can be judged.
- Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it.
- Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. Similarly, suggest alternative trade-offs in decisions and designs and criticize those in which major trade-offs are not acknowledged.

Performance and Content Standards by Grade and Course

Kindergarten

The student will exhibit understanding of the following **content** benchmarks:

Life Science

- Use their five senses to directly observe animals. LS4-8
- Locate pictures of animals and describe how the animals are alike and different.LS4-8
- Identify likenesses and differences between animals and people (e.g., size, color, stance, number of limbs).LS4-8
- Identify likenesses and differences among themselves and others (e.g., size, shape, hair color, eye color).LS4-9
- Observe how living things change as they grow and need food, water, and air to survive.LS1-2
- Use their senses to find out about their surroundings and themselves.LS4-8
- Identify how temperatures in their environment affect them. ESS1-3
- Observe and classify animals based on simple characteristics using the five senses and simple instruments (magnifying glass) to enhance the investigations.LS4-8
- Explain that animals need to take in water and food. LS1-2
- Understand that some animals are alike in the way they look and in the things they do, and others are very different from one another.LS4-8
- Identify the features that help animals live in different environments. LS4-8
- Recognize similarities in the appearance and actions of animals and the differences among them. LS1-1
- Identify that living things are found in every part of the world.
- Describe the life needs (e.g., air, food, water, shelter) of animals, including people. LS1-2

- Classify specific physical characteristics that help animals, including humans, live in different kinds of environments. LS1-4
- Explain that things in nature and things people make have very different sizes, weights, ages, and speeds. LS4-8
- Predict how temperature, light, and precipitation bring about changes in animals (e.g., behaviors, hibernations, migrations, body covering, habitat). LS2-5

Earth/Space and Physical Science

- Make weather observations. ESS1-3, ESS1-5
- Analyze how some events in nature have a repeating pattern. The weather changes from day to day, but things such as rain (or snow) tend to be high, low, or medium in the same months every year.ESS1-4
- Identify, compare and sort objects by similar or different physical properties PS1-1
- Record observations about physical properties PS1-1
- Use simple tools to explore the property of weight PS1-3
- Observe, predict, and describe how things move, when acted upon by an outside force, in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow. PS3-7
- Describe how vibrating objects make sound PS2-4
- Assemble, describe, take apart, and reassemble constructions using interlocking blocks, erector sets, and the like.
- Describe position and speed using the terms over, under, in, out, above, below, left, right, fast, and slow.

Grade 1

Life Science

- Recognize that most food comes from farms either directly as crops or as the animals that eat the crops. LS 2-6
- Explain that plants need warmth, light, and water to grow well. LS1-2
- Identify that weeds and pests can harm crops and that there are things that can be done to protect them.LS2-6
- Recognize that part of a crop may be lost to pests or spoilage and that a crop that is fine when harvested may spoil before it gets to consumers.LS1-3
- Identify the machines that improve what people get from crops by helping in planting and harvesting, in keeping food fresh by packaging and cooling, and in moving it long distances from where it is grown to where people live.
- Observe and classify plants based on simple characteristics using the five senses and simple instruments (magnifying glass) to enhance the investigations. LS1-1
- Sort plants by shape, color, and size, identifying basic attributes and/or properties.LS1-1
- Locate pictures of plants and describe how they are alike and different.LS1-1
- Explain that plants need to take in water and light. LS1-2
- Describe the effects of light using a variety of light sources.LS1-2
- Identify the specific features or functions that help plants live in different environments.LS1-4
- Recognize similarities in the appearance and actions of plants, and the differences among them.LS1-1
- Identify that living things are found in every part of the world.
- Describe the life needs (e.g., air, food, water, shelter) of plants.LS1-2
- Locate pictures of plants; describe how they are alike and different in various environments.LS2-6
- Predict how temperature, light, and precipitation bring about changes in the life cycle of plants (e.g., growth, budding, falling leaves, wilting).LS1-3

- Explain that living things are part of a system and are dependent on their living and nonliving surroundings. LS1-2
- Learn the needs of living things and how to provide for them in the classroom.LS1-2, LS2-5
- Identify which materials are best for different uses(e.g. soils for growing plants, sand for sandbox) ESS1-6

Earth/Space and Physical Science

- *Describe, compare and sort rocks and soils by similar or different physical properties ESS1-1*
- Recognize that rocks have observable properties including size, weight, shape, color, and texture. ESS1-1
- Use simple tools such as balance scales and see-saws to explore the property of weight PS1-3
- Identify differences in physical properties using the senses and simple instruments (e.g., magnifying glass) to enhance observations.ESS1-1
- Conduct tests on how different soils retain water ESS1-2
- Describe objects in terms of materials they are made of (e.g., clay, rocks, and soil) and their physical properties (e.g., size, shape, weight, texture, color, smell, and flexibility).ESS1-1
- Describe verbally, and through pictures, a specific investigation using the following key vocabulary: shapes e.g., (circle, triangle, square, rectangle); flexibility (e.g., stiff, straight, curved); textures e.g., (rough, smooth, hard, soft); size and weight (e.g., big, little, large, small, heavy, light, wide, thin, long, short).ESS1-1
- Know that things move or can be made to move along a straight, curved, circular, back and forth, and jagged path.PS3-7
- Show how pushing and pulling moves or does not move and object PS3-7
- Explain that things move differently. Some things are slow and their journey takes a long time; others move too fast to be seen.
- Show that different objects fall to the earth unless something is holding them up PS3-7
- Learn that natural resources are limited.

Grade 2

The student will exhibit understanding of the following **content** benchmarks:

- Collect, measure, and analyze data determining orderly changes in: life cycles of plants and animals, (i.e., flowering plants developing fruit and the life cycles of insects) and weather affecting behaviors (e.g., hibernation, migration, body covering) and habitat in animals and people.LS1-3
- Describe ways in which animals and plants cause changes in their surroundings. LS1-4, LS2-6
- Classify insects by their different physical characteristics, behaviors, and needs. LS1-1. LS1-2
- For any particular environment, describe why some kinds of plants and animals survive well, some don't survive as well, and some cannot survive at all.LS1-4
- Construct simple diagrams in words or pictures that show simple food webs of plants and animals LS2-6
- Use information about simple food webs to determine how basic needs of plants and animals are met by he habit or environment LS2-6
- Explain ways in which organisms interact with one another besides providing food. LS2-6
- Predict if changes in an organism's habitat will be beneficial or harmful to it.LS2-6
- Describe the relationships between plants and animals in terms of carrying pollen to other plants or dispersing their seeds.LS2-6
- Describe how the behavior in insects and many other species is determined almost entirely by biological inheritance and how this is different from humans.LS4-9
- Identify that all animals have offspring, usually with two parents involved. LS1-2
- Discuss how offspring are very much, but not exactly, like their parents and like one another.LS4-9
- Investigate and determine how living organisms are interdependent with their living and nonliving surroundings. LS2-6
- Describe how habitats change over time due to many influences.LS2-6
- Investigate and determine the needs for plants and animals to survive (e.g., air, food, water, light).LS1-2

- Explain how animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting. LS2-6

Earth/Space and Physical Science

- Explain how water can be a liquid or a solid and can change from one form to the other. PS1-2
- Demonstrate that things can be done to materials to change some of their properties, but not all materials respond the same way. PS1-2
- Observe processes involved in evaporation. PS1-2
- Identify and describe the basic properties of solids, liquids, and gases. PS1-2
- Describe processes involved with changes in matter from one state to another. PS1-2
- Sort objects that are and are not attracted to magnets PS3-8
- Learn that natural resources are limited.
- Identify natural resources such as plants and animals, water, air, land, minerals, forests, and soil.
- Investigate recycling, reusing, and reducing consumption of natural resources.
- Recognize that familiar everyday materials and objects can be used over and over again.
- Describe how to conserve water and natural resources at home and in school.
- Demonstrate when a shadow will be created using sunny versus cloudy days. PS2-5
- Observe and record seasonal and weather changes throughout the school year. ESS1-4
- Observe, record and summarize local weather data. ESS1-5
- Observe how clouds are related to different forms of precipitation. ESS1-5
- Learn that the sun can only be seen in the day and that the moon can be seen during both the day and night. ESS2-7
- Observe that the sun and moon appear to move slowly across the sky. ESS2-7
- Learn that the moon looks different from one day to the next. ESS2-7
- Make observations about the location of stars in the sky and that they are not scattered evenly and vary in degree of brightness. ESS3-9

- Identify that the sun is a source of heat energy. PS2-4
- Identify that the sun warms the land and water. PS2-6
- Describe that objects change temperature with an increase or decrease in heat. PS2-6

Grades Kindergarten - 2

The student will exhibit understanding of the following **process** benchmarks:

These should be introduced in Kindergarten, practiced in grade 1, and mastered by the end of grade 2.

Observing, Asking Questions, Making Predictions

- Observe and manipulate things to determine cause and effect.
- Describe things as accurately as possible so that they may be communicated to others.
- Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.
- Describe and compare things in terms of number, shape, texture, size, weight, color, and motion.
- Identify that change is something that happens to many things.
- Understand that some of the things people do, like playing soccer, reading, and writing, must be deliberately learned and improves with practice. How well one learns sometimes depends on how one does it an how often and how hard one tries to learn.
- Develop a question and/or prediction from one or more observations.
- Recognize new, unusual, or unexpected results in an investigation or experiment.
- Identify patterns in home and school routines.
- Learn from each other by telling and listening, showing and watching, and imitating what others do.
- Create pictographs of ten or fewer units.
- Sort and sequence the physical properties of objects through direct observation.

Planning a Fair Test

- Use the Big 6™ ("Little 3") to solve information problems. Numbers can be used to count things, place them in order, or name them.
- Use the senses to find out about surroundings and themselves. Different senses give different information. Sometimes a person can get different information about the same thing by moving closer to it or further away from it.
- Identify that sometimes changing one thing causes changes in something else. In some situations, changing the same thing in the same way usually has the same results.
- Repeat a science investigation the way it was done first, and identify that you get a similar result.
- Identify that scientific investigations generally work the same way in different places.
- Identify that people can give different descriptions of the same thing. If that happens a good idea is to make some fresh observations instead of just arguing about who is right.

Collecting and Recording Data

- Store things in different ways so they can be easily found later.
- Use letters and numbers to put things in a useful order.
- Draw pictures that correctly portray at least some features of the thing being described.
- Use numbers to count any collection of things.

Interpreting Results and Drawing Conclusions

- Study a few things and try to make guesses about other things like them.
- Justify observations and ideas with reasons and facts.

Communicating Results

- Share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean.

- Learn something from each other by telling and listening, showing and watching, and imitating what others do.
- Use shapes such as circles, squares, and triangles to describe things that you see.
- Send and receive information in many different ways. Some will require answering back and some do not.

Designing and Engineering Solutions to Problems

- Invent things and ideas about science.
- Find things in nature and things that people build that exemplify circles, squares, triangles, and other shapes.
- Make patterns by putting different shapes together or taking them apart.
- Identify that similar patterns may show up in many places in nature and in the things people make.
- Make something out of paper, cardboard, wood, plastic, metal, or existing objects that can actually be used to perform a task.
- Use and follow directions to build something or to get something to work better.
- Identify that people may not be able to actually make or do everything that they can design.
- Know that when a group of people wants to build something or try something new, they should try to figure out how it might affect other people.

Grade 3

The student will exhibit understanding of the following **content** benchmarks:

Life Science

- Observe and classify plants based on simple characteristics using the five senses and simple instruments (e.g., magnifying glass) to enhance the investigations. LS1-1
- Sort seeds and plants by shape, color, and size, identifying basic attributes and/or properties. LS1-1

- Locate pictures of plants and describe how they are alike and different. LS1-1
- Explain that plants need sources of energy (food, water, light) for survival LS2-5
- Some plants are alike in the way they look and in the things they do, and others are very different from one another. LS1-2
- Explain what plants would do if their environment changes LS3-7
- Explain how the balance of the ecosystem can be disturbed LS3-7
- Identify the specific features or functions that help plants live in different environments. LS1-2, LS1-4
- Recognize similarities in the appearance and actions of plants, and the differences among them. LS1-1
- Identify the many materials that can be recycled and used again, sometimes in different forms.
- Describe how almost all kinds of animals' food can be traced back to plants. LS1-3, LS2-6
- Know that some plant varieties and animal breeds have more desirable characteristics than others, but some may be more difficult or costly to grow. The kinds of crops that can grow in an area depend on the climate and soil. Irrigation and fertilizers can help crops grow in places where there is too little water or the soil is poor.
- Recognize that the kinds of crops that can grow in an area depend on the climate and soil.
- Recognize that damage to crops caused by rodents, weeds, and insects can be reduced by using poisons, but their use may harm other plants or animals as well, and pests tend to develop resistance to poisons.
- Recognize that there are places too cold or too dry to grow certain crops and that those places can obtain food from places with more suitable climates.
- Recognize that much of the food eaten by Americans comes from other parts of the country and other places in the world.
- Compare features and characteristics of humans and other animals LS4-8
- Show connections between external and internal human body structures and how they help humans to survive LS4-8
- Identify similarities of human physical characteristics that are inherited from biological parents LS4-9
- Identify that some human behaviors are learned and some are instinctive LS4-9

Earth/Space Science

- Investigate and communicate in words the basic types and seasonal patterns of weather by measuring and recording weather data (e.g., temperature, wind speed, condensation, precipitation, drought, flood, storms). ESS1-3
- Explain the scientific tools and be used to gather data about weather and select the appropriate tools ESS1-3

Physical Science

- Investigate and communicate in words how sound vibrations travel as waves and spread out in all directions from its source.PS2-4
- Identify and explain how there are differences between high and low pitches. PS2-4
- Identify that there are differences between high and low volume.PS2-4
- Investigate the observable effects of light using a variety of light sources PS2-5
- Predict, describe and investigate how light rays are reflected, refracted and absorbed PS2-5

Grade 4

The student will exhibit understanding of the following **content** benchmarks:

Life Science

- Identify inherited versus learned traits. (e.g., eye color and fruit color vs. table manners and carpentry skills) LS4-9
- Explain that in order for offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next.LS4-9

- Investigate and explain how plants produce products LS2-6
- Investigate and explain how plants provide homes and food for many animals and prevent soil from washing LS2-6

Earth/Space Science

- Explain that waves, wind, water, and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers.ESS1-2,ESS1-4,PS1-1
- Identify sudden and gradual changes that affect the Earth. ESS1-4
- Recognize that rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock, partly from plant remains, and also contains many living organisms. ESS1-1
- Explain how the characteristics of Earth materials land themselves to specific uses. ESS1-6
- Identify the four basic materials of the Earth (soil, water, rocks, air) ESS1-1
- Build models to simulate the effects of how wind and water shape and restore the land.ESS1-4
- Compare rocks, soils and minerals by similar or different physical properties. ESS1-1, PS1-1
- Analyze data about the physical properties of rocks, solids and minerals and explain why they are or are not classified together. ESS1-1, PS1-1
- Recognize that the sun is the center of our solar system. ESS2-8
- Know that the Earth is one of several planets that orbit the sun. ESS2-8
- Learn that the moon orbits the Earth ESS2-8
- Recognize that it takes about 365 days for the Earth to orbit the sun. ESS2-8
- Observe that the sun, moon and stars appear to move slowly across the sky ESS2-7
- Learn about the moon cycles ESS2-7
- Identify patterns of stars.ESS3-9
- Communicate the basic relationship between the sun and Earth.ESS2-8
- Recognize that the rotation of the Earth on its axis every 24 hours produces the day and night cycle.ESS2-7

- Observe, record, compare and analyze weather data to describe weather changes and patterns ESS1-5

Physical Science

- Recognize that some materials conduct heat much better than others. Poor conductors can reduce heat loss. PS2-4
- Show that when warmer things are put with cooler ones, the warm ones lose heat and the cool ones gain it until they are all at the same temperature. A warmer object can warm a cooler one by contact or at a distance. PS2-6
- Show that heat moves from one object to another causing temperature change. PS2-6
- Identify the sun as a source of heat and light that warms the land, air, and water. PS2-6
- Describe ways to conserve energy.
- Identify ways that conservation of energy prevents pollution.
- Describe change in position relative to other objects or background. PS3-7
- Construct a mechanism to use air and water to do work.
- Use magnets to make things more without touching them, while exploring the relative strength of the magnetic force (e.g., repelling and attracting). PS3-8
- Use a magnet to pull on things made of iron and either push or pull other magnets without touching them. PS3-8
- Describe what happens when like and opposite poles are placed near each other. PS3-8
- Conduct experiments to show an object will fall unless something is holding it up. PS3-7
- Demonstrate that the way to change how something is moving is to give it a push or a pull. PS3-7
- Experiment with materials that have been electrically charged without touching the material, to show it pulls on all other materials. PS2-4
- Explain how electricity can move from one place to another. PS2-4
- Investigate electrically charged materials to show how it may push or pull other charged materials. PS2-4
- Observe, predict, and describe how things move (when acted upon by an outside force) in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.PS3-7

- Show how electric currents and magnets can exert a force on each other. PS3-7
- Draw, build or diagram an electrical circuit. PS2-4
- Explain how electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. PS2-4
- Describe position and speed using the terms over, under, in, out, above, below, left, right, fast, and slow.
- Describe the properties of solids, liquids and gases. PS1-2
- Identify and compare solids, liquids and gases. PS1-2
- Make predictions about changes in the state of matter when adding or taking away heat. PS1-2
- Demonstrate that when liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water. PS1-2, ESS1-5
- Describe how things that give off light often also give off heat. PS2-5
- Demonstrate an understanding that heat is produced by mechanical and electrical machines, and any time one object rubs against another. PS2-4
- Use measures of weight and objects to prove that all matter has weight and that the total weight is equal to the sum of its parts. PS1-3
- Show that the weight of an object remains the same despite a change in its shape. PS1-3
- Measure the weight of objects and prove that all matter has weight. PS1-3

Grade 5

The student will exhibit understanding of the following **content** benchmarks:

Life Science

- Recognize that some living things consist of a single cell. LS1-4

- Investigate familiar organisms to show they need food, water, and air; a way to dispose of waste; and an environment they can live in. LS1-1; LS1-
- Use microscopes to see that living things are made mostly of cells.
- Show how some organisms are made of a collection of similar cells that benefit from cooperating and some organisms' cells vary greatly in appearance and perform very different roles in the organism. LS1-4
- Explain how most microorganisms may or may not cause disease, and many are beneficial.
- Describe how almost all kinds of animals' food can be traced back to plants. LS3-9
- Recognize that some source of "energy" is needed for all organisms to stay alive and grow, including the sun. LS2-6
- Explain how over the whole earth, organisms are growing, dying, and decaying, and new organisms are being produced by the old ones.LS1-3
- Identify the ecosystem and the relationship of a host/parasite within it. LS2-5
- Identify cells as the building blocks of organisms. LS1-4
- Observe and describe (e.g. drawing, labeling) individual cells as seen through a microscope targeting cell membrane, cell wall, nucleus, and chloroplasts.
- Write a narrative procedure using the scientific method W–5–6.3,6.4,6.5

Earth and Space Science

- Identify how the patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons. ESS2-6
- Research how telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.
- Explain how planets change their positions against the background of stars. ESS2-6
- Recognize that the earth is one of several planets that orbit the sun, and the moon orbits around the earth.

ESS2-8

- Recognize that the stars are like the sun, some being smaller and some larger, but so far away that they look like points of light.
- Show that like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day. ESS2-8
- Identify and Compare the size, location, distances, and movement (e.g. orbit of planets, path of meteors) of the objects in our solar system. ESS2-6
- Compare the composition, atmosphere, and surface features of objects in our solar system. ESS2-6
- Identify major discoveries from different scientists and cultures and describing how these discoveries have contributed to our understanding of the solar system (e.g. timeline, research project, picture book).
- Use models to describe the relative motion/position of the Earth, sun and moon. ESS2-8
- Explain night/day, seasons, year, and tides as a result of the regular and predictable motion of the Earth, sun, and moon. ESS2-8
- Use a model of the Earth, sun and moon to recreate the phases of the moon. ESS2-8
- Define the Earth's gravity as a force that pulls any object on or near the Earth toward its center without touching it. ESS2-8
- Use or create a model of the Earth, sun, and moon system to show rotation and revolution. ESS2-8
- Explain that the sun's gravitational pull hold the Earth and other planets in their orbits, just as the planet's gravitational pull keeps their moons in orbit. ESS2-8
- Describe the apparent motion/position of the objects in the sky. (E.g. constellations, planets). ESS3-9
- Identify the sun as a medium-sized star located near the edge of a disk-shaped galaxy of stars. ESS3-9

Physical Science

- Recognize that different substances have properties which allow us to identify them regardless of the size of the sample.

- Compare the masses of objects of equal volume made of different substances. PS1-1
- Recognize that different substances have properties which allow them to be identified regardless of the size of the sample. PS1-2
- Explain that regardless of how parts of an object are arranged; the mass of the whole is always the same as the sum of the masses of its parts. PS1-3
- Investigate how vibrations in materials (e.g. pebble in a pond, jump rope, slinky) set up wavelike disturbances that spread away from the source. PS3-LA
- Experiment how light from the sun is made up of a mixture of many different colors of light (e.g. using prisms, spectrometers, crystals). PS3-LA
- Use units of measures in the customary and metric systems M(G&M)5-6,5-7
- Organize data using tables and graphs M(DSP) 5-3
- Analyze data M(DSP) 5-3

Grades 3 - 5

The student will demonstrate the following **process** benchmarks:

These should be introduced in grade 3, practiced in grade 4, and mastered by the end of grade 5.

Observing, Asking Questions, Making Predictions

- Use past experiences to make judgments about new situations, and demonstrate different skills, talents, motivations, or interests.
- Recognize that some predictions can be based on what is known about the past, assuming that conditions are pretty much the same now.
- Make predictions and summarize your findings.
- Describe events in terms of being more or less likely, impossible, or certain.

Planning a Fair Test

- Use the Big6™ to solve information problems.
- Use the Scientific Method to investigate, make observations, or to solve problems.
- Recognize when comparisons might not be fair because some conditions are not kept the same.

Collecting and Recording Data M(DSP) 5-3

- Organize data in graphs or tables.
- Make observations while collecting data for experiments and then record the results.
- Use and label appropriate units of measure (e.g., Fahrenheit, centimeters, miles, MPH) when measuring or counting.
- Calculate and analyze data. Then record data on a number line.
- Understand that the way data is chosen can affect results.
- Acknowledge that there exists bias in reporting only certain data.
- Keep records of investigations and observations.
- Measure and mix dry and liquid materials (i.e., in the kitchen, garage, or laboratory) in prescribed amounts, exercising reasonable safety.
- Keep a notebook that describes observations made, carefully distinguishes actual observations from ideas and speculations about what was observed, and is understandable weeks or months later.
- Record information using a variety of methods (e.g., computers, reports, video tapes).
- Show how measuring instruments can be used to gather accurate information, for making scientific comparisons of objects and events, and for designing and constructing things that will work properly.

Interpreting Results and Drawing Conclusions

- Show how something works and back it up with evidence that can be confirmed with a logical argument.
- Recognize that results should always be judged by whether they make sense and are useful.
- Identify patterns that help explain how things work or how to solve practical problems.

- Demonstrate how reasoning can be distorted by strong feelings.
- Provide valid reasons to prove a statement is true.
- Use numerical data to compare objects or events.
- Offer reasons for findings and consider reasons suggested by others.

Communicating Results

- Use technology for communication, to recognize changes, or to gain knowledge and express ideas.
- Follow specific directions and provide evidence from data to prove a theory.
- Use tables and graphs to show how values of one quantity are related to values of another.
- Spot patterns using a graphical display of numbers (i.e., comparative size and trends).
- Use visual aids to express ideas or evidence in a clear, precise written or oral presentation.

Designing and Engineering Solutions to Problems

- Design various products that show a variety of features such as safety, ease of use, appearance, or cost-effectiveness.
- Identify where the solution to one problem may create other problems.
- Show that something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched, or misconnected.
- Explore earlier forms of inventions and tools and compare to those used today.
- Explain how technology enables scientists and others to observe things that are too small or too far away and to study the motion of objects.
- Demonstrate how technology greatly influences people's lives.
- Discover how any invention is likely to lead to other inventions. Once an invention exists, people are likely to think up ways of using it that were never imagined at first.
- Show how the benefits of transportation, communications, nutrition, sanitation, health care, entertainment, and other technologies give large numbers of people today the goods and services that once were luxuries enjoyed only by the wealthy.

- Demonstrate how technologies often have drawbacks as well as benefits.
- Identify technology that helps some people or organisms but may harm others, either deliberately (e.g., weapons) or inadvertently (e.g., pesticides).
- Show how people have an enormous effect on the lives of other living things because of their ability to invent tools and processes.

Grade 6

The student will exhibit understanding of the following **content** benchmarks:

Life Science

- Know that food provides molecules that serve as fuel and building material for all organisms. LS1-2
- Explain how plants use the energy in light to make sugars out of carbon dioxide and water. LS1-2
- Describe how organisms that eat plants break down the plant structures to produce the materials and energy they need to survive. –LS1-2
- Describe how energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. LS1-2
- Define the basic characteristics which all living things share. LS1-2
- Identify the basic needs of all living things. LS1-2
- Explain the theories of Redi and Pasteur on spontaneous generation and the germ theory. LS1-2
- Observe that all living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. LS1-4
- Explain that in some kinds of organisms, all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent. –LS1-4

- Describe where the genetic information comes from in sexual reproduction and identify the genetic composition of the daughter cell. LS1-4
- Identify that genetic material (chromosomes and genes) are located in the cells nucleus. LS1-4
- Recognize the difference between inherited traits that result from one or more genes from the parents (e.g. connected earlobes, eye color, tongue rolling) and acquired traits resulting from interactions with the environment.LS4-11
- Identify some of the reasons that humans selectively breed plants and animals (i.e., characteristics and growing conditions). LS4-11
- Define selective breeding and how it relates to new varieties of cultivated plants and domestic animals. LS4-11
- Explain that small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors. LS4-11
- Trace genetic characteristics through a given pedigree to demonstrate the passage of traits. LS4-11
- Explain why individual organisms with certain traits are more likely than others to survive and have offspring and how environmental conditions can influence those traits. LS3-9
- Describe how the theory of biological evolution and natural selection accounts for species diversity, LS4adaptation, extinction, and change in species over time. LS3-9
- Identify that different body tissues and organs are made up of different kinds of cells. LS1-4
- Describe how the cells in similar tissues and organs in animals are similar to those in human beings but differ somewhat from cells found in plants. LS1-4
- Identify that fossil evidence is consistent with the idea that human beings evolved from earlier species.
- Identify biotic and abiotic factors that have an effect on human body systems. (microbes, parasites pollution, drugs) LS4-10
- Research, report, and predict the effect of biotic and abiotic factors on human health. LS4-10

Earth/Space Science

- Explain how heat energy carried by ocean currents influences climates around the world.
- Describe the evidence that shows that climates have changed abruptly in Earth's past, possibly due to volcanic eruptions or huge rocks from space hitting the Earth.
- Explain how more gradual changes in climate may occur with changes to Earth's atmosphere or oceans due to the effect of events such as El Nino, increased greenhouse gases, and deforestation.
- Explain the phases of the water cycle. LS2-7, ES1-3
- Explain the role of the water cycle in determining climatic patterns. LS2-7, ES1-3
- Explain how condensation of water vapor forms clouds which effect weather and climate.ES1-2, ES1-4
- Explain how humidity, temperature and altitude affect air pressure and how this affects local weather. ES1-2
- Identify composition and layers of Earth's atmosphere. ES1-2
- Explain how differential heating and convection affect Earth's weather patterns. ES1-2
- Describe how differential heating of the oceans affects ocean currents which in turn influence weather and climate. ES1-3, ES1-4
- Explain the cause and effect relationships between global climate and energy transfer. ES1-2, ES1-4
- Explain the relationship between differential heating/convection and the production of winds. ES1-2, ES1-4
- Explain effects of global patterns of atmospheric movements on weather. ES1-2, ES1-4
- Describe how temperature and precipitation changes with the passing of various fronts. ES1-2
- Describe how heat flow and the movement of material inside the Earth cause volcanoes and earthquakes that abruptly change the Earth's surface. ES1-1
- Know that volcanoes can build mountains and emit gas and dust into the atmosphere which can affect climate. ES1-3, ES1-4
- Explain the relationship between Earthquakes and waves. ES1-1
- Know that waves move at different speeds in different materials ES1-1.
- Describe the effects of tectonic activity, gravity, wind, and water (e.g., uplifting, weathering, and erosion) on the Earth's surface. ES1-1
- Explain how sediments of sand, silt, clay, and sometimes the remains of organisms are gradually buried and cemented together by dissolved minerals to form solid rock. This rock may be buried deep enough to be

reformed by pressure and heat and re-crystallize into different types of rock. This rock may be forced to the surface to form a new land surface or even a mountain.ES1-5
- Know that thousands of layers of sedimentary rock confirm the long history of the changing surface of the earth and the changing life forms whose remains are found in successive layers. ES1-5
- Explain why the youngest layers are not always found on top of the sediment (e.g., folding, breaking, uplift of layers). ES1-5
- Explain why the more recently deposited rock layers are more likely to contain fossils resembling existing species. ES1-5

Grade 7

The student will exhibit understanding of the following **content** benchmarks:

Life Science

- Describe where the genetic information comes from in sexual reproduction and identify the genetic composition of the daughter cell. LS3-9
- Identify that various organs and tissues function to serve the needs of cells for food, air, and waste removal.
- Describe the basic processes and recognize the names and chemical formulas of the substances involved in photosynthesis and respiration.
- Identify the role of water in cells.
- Describe how competition happens in all environments (e.g., forest, fresh water, marine).
- Identify that competition is highest among those organisms with common needs.
- Explain how the growth and survival of organisms depends on the physical conditions of their environment.LS1-2

- Describe and give an example of the variety of symbiotic relationships that organisms may have (e.g., producer/consumer, predator/prey, or parasite/host, scavengers, decomposition, competition, or mutualism). LS2-5
- Describe the ways in which two types of organisms may interact with one another (e.g., producer/consumer, predator/prey, parasite/host, decomposer, scavenger, competition, and mutualism).LS2-5
- Identify some of the variety that exists in the internal structures that contribute to animals and plants being able to make or find food and reproduce.LS3-9
- Describe why fresh water is essential for life.LS2-7
- Explain how conservation can minimize the harmful effects on life.LS2-5
- Explain why scientists classify organisms into groups.LS3-8,
- Classify organisms, based on details of internal and external anatomical features. LS3-8,LS3-9
- Define the characteristics which place organisms into the six kingdoms. LS3-8
- Define the biological species concept. LS3-8,LS3-9
- Explain how organisms interact with their environment and with other organisms to acquire energy, cycle matter, influence behavior, and establish competitive or mutually beneficial relationships. LS2-5
- Know that all organisms, including the human species, are part of and depend on two main interconnected global food webs: one including microscopic aquatic plants, the animals that feed on them, and finally the animals that feed on those animals. These cycles continue indefinitely because organisms decompose after death to return food material to the environment.LS1-2
- Understand that individual organisms and ecosystems use matter and energy for life processes, and the mechanisms accomplishing these processes are complex, integrated, and regulated. LS2-7
- Understand that all living things reproduce and pass on genetic information and that an organism's characteristics are determined by both genetic and environmental influences. LS3-9,LS1-3,LS4-11

Earth/Space Science

- Explain why the Earth seems to be the only body that can sustain life.
- Know the phases of the water cycle. ESS1-2

- Explain the role of the water cycle in determining climatic patterns. ESS1-2
- Explain the effects of fresh water depletion and pollution on industry and life processes. ESS1-2
- Identify sources of freshwater (e.g., lakes, groundwater, and rivers). ESS1-2
- Know the earth is mostly rock with three-fourths of its surface covered by a thin layer of water (some of it frozen), and is completely surrounded by a thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from the earth. ESS1-2
- Identify the effects of global environmental change on the environment and its ability to support some life forms. ESS1-3
- Explain how the water cycle is dynamic across the Earth. ESS1-2
- Explain how heat energy carried by ocean currents influences climates around the world. ESS1-3
- Explain how fresh water, limited in supply, is essential for life and also for most industrial processes. Rivers, lakes, and groundwater can be depleted or polluted, becoming unavailable or unsuitable for life. ESS1-2
- Explain the benefits of the earth's resources (e.g., fresh water, air, soil, trees) are reduced by using them wastefully or by deliberately or inadvertently destroying them.
- Explain that the moon orbits the Earth about every 28 days. Its position affects Earth's tides. ESS2-7

Physical Science

- Explain how matter is transferred from one organism to another and between organisms and their physical environment.
- Describe how energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight.PS1-2
- Identify the human activities that have increased the amount and variety of chemicals released into the atmosphere, and explain how it has changed the earth's land, oceans, and atmosphere. PS1-2
- Demonstrate that equal volumes of different substances usually have different masses.PS1-1

- Measure mass and volume of both regular and irregular objects and use those values as well as the relationship D=m/v to calculate density.PS1-1
- Observe and demonstrate how temperature and acidity of a solution influence reaction rates.PS1-2
- Identify some substances that dissolve in water and explain how their solubility facilitates reactions. PS1-2
- Identify that matter is made up of atoms, which are too small to be seen with a conventional microscope. Atoms of an element are alike but are different from those of other elements. .PS1-5
- Know that 2000 years ago, Greek philosophers believed that everything was made up of four basic substances or elements (e.g., air, earth, fire, and water), and that a different proportion of these elements combined to form all substances. ESS2-7.
- Know that all elements are represented on the periodic table and that elements combine to make all matter.
- Identify elements that are plentiful and rare and discuss that they are usually found combined with others, and that few are found in their pure form. .PS1-5
- Define molecule and understand its relationship to elements. .PS1-5
- Identify how elements are grouped on the periodic table (e.g., mass, properties, metals, non-metals, metalloids). .PS1-5
- Describe how some groups (or families) of elements are highly reactive and some are non-reactive. Reactive elements combine easily with other elements. Important reactions happen with the element oxygen such as rusting and burning. .PS1-5
- Show that when new material is made by combining two or more materials, it has properties that are different from the original materials. For that reason, a lot of different materials can be made from a small number of basic kinds of materials. PS1-2
- Observe and demonstrate how temperature and acidity of a solution influence reaction rates. PS1-2
- Identify some substances that dissolve in water, and explain how their solubility facilitates reactions. Investigate temperature changes of atoms and molecules. PS1-2
- Identify the different effects of temperature on solids, liquids, and gases. PS1-2
- Demonstrate how heating and cooling cause changes in the properties of materials. Show how many kinds of changes occur faster under hotter conditions. PS1-2

- Define the Law of the Conservation of Matter. PS1-3
- Describe that equal volumes of different substances usually have different weights.PS1-1
- Explain why Carbon and Hydrogen are important elements to all living matter.PS1-5

Grade 8

The student will exhibit understanding of the following **content** benchmarks:

Earth/Space Science

- Identify how the patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons.ESS2-8
- Research how telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye. ESS2-7
- Explain how planets change their positions against the background of stars.
- Recognize that the stars are like the sun, some being smaller and some larger, but so far away that they look like points of light.ESS2-9
- Know that the earth rotates on its axis every 24 hours, producing the night-and-day cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day. ESS2-8
- Know that the sun is a medium sized star located near the edge of a disk shaped galaxy called the Milky Way. ESS3-9
- Observe and describe that the universe contains billions of galaxies, each containing billions of stars. ESS239
- Describe the location of the sun as it relates to the earth. ESS2-8

- Explain how the light from some distant galaxies may take billions of years to get to Earth because they are so far away. ESS3-9
- Define a light year as the distance light will travel in one year (at 300,000km/sec). ESS3-9
- Explain how telescopes reveal many more stars in the night sky than are evident to the unaided eye. ESS2-7
- Know that all bodies in the universe have gravity. Every object exerts gravitational force on every other object. ESS2-8
- Explain how the force of gravity depends on how much mass the objects have and on how far apart they are.
- Know the law of universal gravitation. ESS2-8
- Describe how the sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them. ESS2-8

Physical Science

- Define the speed of an object, constant speed, average speed, velocity, reference point, and acceleration. PS3-8
- Demonstrate that speed and acceleration may be calculated and expressed in a graph. PS3-8
- Measure distance and time for a moving object and using those values as well as the relationship s=d/t to calculate speed and graphically represent the data. Solve for any unknown in the expression s=d/t given values for the other two variables. PS3-8
- Identify a force as a push or pull. Forces may be balanced in which an object will not change its motion or unbalanced which will change an object's motion.PS3-8
- Define and demonstrate Newton's First Law of Motion: the tendency of an object to resist change in its motion unless acted upon by an outside force. PS3-8
- Demonstrate that the net force on an object is equal to the product of its acceleration and mass. This is Newton's second law of motion. Describe or graphically represent that the acceleration of an object is proportional to the force on the object and inversely proportional to the object's mass. PS3-8

- Explain that if one object exerts a force on another object, then the second object exerts a force of equal strength in the opposite direction on the first object. This is Newton's third law of motion. PS3-8
- Demonstrate that friction is the force that one surface exerts on another when the two rub against each other. It depends on the type of surface and how hard the surfaces are pushed together.
- Identify the three types of friction: sliding, rolling, and fluid.
- Define weight. Differentiating between mass and weight PS3-8
- Explain that Momentum=mass x velocity. The law of conservation of momentum states that the total momentum of any group of objects remains the same unless acted upon by an outside force. PS3-8
- Define work as when a force exerted on an object causes it to move. Work= Force x Distance. PS3-8
- Define energy as the ability to do work or cause change. Energy of motion is called kinetic energy and energy that is stored and held in readiness is potential energy. Gravitational potential energy occurs when an object is lifted. PS1-6
- Identify the major forms of energy: mechanical energy, thermal energy, chemical energy, electrical energy, electro-magnetic energy, and nuclear energy. PS1-6
- Differentiate between electromagnetic and mechanical waves. PS3-LA
- Constructing a model to explain the transformation of energy from one form to another. (e.g. an electrical circuit changing electrical energy to light energy in a light bulb). PS3-LA
- Demonstrate that electric currents and magnets can exert a force on each other. PS3-LA
- Explain the law of conservation of energy. PS1-3
- Explain how fossil fuels contain energy that came from the sun.
- Define power as the rate at which work is done.
- Define temperature as the average kinetic energy of the individual particles in an object. PS1-4
- Define thermal energy as the total of all the energy and motion of the particles. PS1-4
- Identify heat as the movement of thermal energy from a substance at a higher temperature to another at a lower temperature. PS1-3
- Demonstrate heat transferred by conduction, convection, and radiation.ESS1-4, PS2-7

- Describe the states of matter: solids, liquids, and gases. Matter may change from one state to another if thermal energy is absorbed or released.PS1-2, PS1-3

Grades 6 – 8

The student will demonstrate the following **process** benchmarks:

These should be introduced in grade 6, practiced in grade 7, and mastered by the end of grade 8.

Observing, Asking Questions, Making Predictions

- Identify meaningful, answerable scientific questions.
- Pose meaningful, answerable scientific questions.
- Formulate a working hypothesis.
- Use experimental data from various investigators to validate results.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Test a working hypothesis.
- Acknowledge references and contributions of others.
- Complete secondary research.

Collecting and Recording Data

- Use SI units to measure length, volume, mass, and temperature.
- Work individually and in teams to collect and share information and ideas.
- Determine the relationships between quantities.

- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.

Interpreting Results and Drawing Conclusions

- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, and digital images).
- Judge the reasonableness of an answer and distinguishing between fact and opinion.
- Affirm scientific ideas according to accumulated evidence.
- Recognize data that are biased.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, and conflicts of interest).
- Use ratio and proportion in appropriate situations to solve problems.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Write and orally communicate using tables, graphs, and displays to support arguments and claims.
- Communicate conclusions derived through a synthesis of ideas.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Defend conclusions based on reflection and analysis of data.

Communicating Results

- Use models and computer simulations to extend understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, spreadsheets) that will be used for communicating results.

- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Demonstrate the ability to summarize data (e.g., measurements and observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.

Designing and Engineering Solutions to Problems

- Recognize that real problems have more than one solution and a decision to accept one over another are made on the basis of many issues.
- Learn the use of new instruments and equipment by following instructions.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.

High School Courses

Animal Science

The student will exhibit understanding of the following Grade Span Expectations:

- Discuss the history of the domestication of farm animals.
- List and explain the functions of livestock.
- Describe the size of the livestock industry in the United States.
- List and describe employment opportunities that require knowledge of animal science.
- Name, locate and describe the structures and functions of the circulatory of domestic animals.
- Name, locate and describe the functions of the structures of the digestive systems of ruminants and non-ruminants.

- Classify farm animals as ruminant or non-ruminant.
- Explain the relationships of types of digestive systems to the ability of ruminants and non-ruminants to digestive and absorb different classes of feed.
- Identify the major function of the basic nutrient groups.
- Identify feeds that are sources of each of the basic nutrient groups.
- Identify the characteristics of nutrient sources for each basic nutrient group.
- Discuss the general use and purpose of feed additives and hormone implants.
- Discuss labeling and regulation of feed additives.
- Analyze the labels of livestock feeds.
- Describe the impact of hormones on livestock product.
- Argue the need for public education on the importance and effect of feed additives and hormones.
- Classify feeds as roughages or concentrates.
- Describe the six functions of a good ration.
- Explain the characteristics of a good ration.
- Balance livestock rations using commonly accepted practices.
- Explain how genetics relates to improvements in livestock production.
- Describe how cell division occurs.
- Diagram and explain how animal characteristics are inherited.
- Diagram and explain sex determination.
- Compare and contrast the male and female reproductive organs of mammals and poultry.
- Describe the reproductive failures that occur.
- Define fertilization, gestation, parturition, and estrus cycle.
- Define agricultural biotechnology.
- Discuss the use of genetic engineering in animal science.
- Discuss problems related to the use of genetic engineering in animal science.
- Discuss the use of embryo transfer and artificial insemination.
- List some current research projects in genetic engineering as it applies to the livestock industry.

- Name and describe common breeding systems used in livestock production.
- Explain the affects, advantages and disadvantages, of using common breeding systems.
- Identify the factors involved in selecting common breeding systems.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.

- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: LS1-1b, LS1-2b, LS1-2bb, LS3-7a, LS3-7aa, and LS4-10b.

Aquaponics I

The student will exhibit understanding of the following Grade Span Expectations:

- Explain the development of aquaculture as a part of agriculture.
- Define aquaculture.
- Compare and contrast traditional farming with aquaculture.
- Discuss why aquaculture evolved from fishing practices.
- Discuss how the catfish industry developed and why Mississippi leads in catfish production.
- Explain why Idaho leads in trout production.
- Discuss how aquaculture is expanding and what the future holds for aquaculture.

- Identify significant scientific events or people that contributed to the development of aquaculture.
- Discuss the role of science and technology in the development of aquaculture.
- Compare and contrast farm raised fish and wild caught fish.
- Discuss concerns surrounding the aquaculture industry.
- Explain the quality features of water for aquaculture.
- Define terms related to water quality management.
- Calculate volume for various aquatic structures.
- Calculate treatments for volumes of water.
- Define dissolved oxygen.
- List causes of dissolved oxygen loss.
- Describe the prevention of oxygen depletion and methods of correcting a deficiency.
- Explain how changes in water affect aquatic life.
- Discuss the role of temperature in oxygen management.
- Identify and describe the nitrogen cycle.
- Explain the importance of the nitrogen cycle in a closed recirculating system.
- Perform various water quality tests.
- Distinguish between different types of major aquatic structures.
- Identify the function of the major components of a closed recirculating system.
- Construct a closed recirculating system.
- Compare some of the biological concerns with cages and closed systems.
- Define marketing.
- Describe the process of marketing aquaculture.
- Describe some scientific skills required to maintain quality fish and fish products.
- Define "processing".
- Describe the importance of processing to the aquaculture industry.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).

- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: LS2-3a, LS2-3b, and LS2-4b.

Aquaponics II

The student will exhibit understanding of the following Grade Span Expectations:

- Name the major aquatic species in the United States.
- Name five aquatic animals that hold potential for aquaculture in the United States.
- Explain why aquatic crops may be more productive than terrestrial crops.
- Describe the general water and feeding characteristics of five aquatic animals.
- List aquatic plants that could potentially be cultured in the United States.
- List other uses for aquatic plants besides food.
- Define polyculture.
- Identify and describe aquatic animals and plants that could be used in polyculture.
- Recognize the scientific names for some common aquatic species.
- Describe important biological characteristics in selecting a species for aquaculture.
- Explain how aquatic species save energy when compared to terrestrial species.

- List and describe the major characteristics of aquatic plants and animals.
- Identify the morphology, anatomy and physiology of common aquatic animals.
- Name and describe the nine body systems of aquatic animals.
- Compare and contrast the anatomy and physiology of finfish, crustaceans and shell fish.
- Describe the purpose and functions of a fish hatchery.
- Describe harvesting methods.
- List general management guidelines for different aquatic species.
- Compare and contrast the management of different finfish.
- Describe the commercial culture of tilapia, catfish, trout, and hybrid striped bass.
- Discuss methods of controlling reproduction in fish.
- List salmonids that could be or are commonly cultured.
- Identify the process and purpose of breeding systems.
- Describe the culture of crawfish, shrimp, oysters and clams.
- Describe the life cycle of each of the economically important aquatic species.
- Discuss the potential for aquatic plant culture.
- Define plant aquaculture.
- Describe economic and production consideration of plant aquaculture.
- Explain nutrient uptake and photosynthesis in aquatic plants.
- List four reproductive methods used by aquatic plants.
- Identify methods for preparing feed and feeding fish.
- Name potential ingredients for fish diets.
- Discuss the different feeding practices for different species of fish.
- Calculate the amount of feed needed for different species/ life stages of fish.
- Calculate the feed conversion ratio.
- Calculate feed cost.
- Describe the protein and energy levels of typical feeds.
- Discuss the effect of water temperature on feeding requirements and weight gain.

- Explain the relationship of body weight to the amount of feed.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.

- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: LS2-3a, LS2-3b, LS2-4aa, LS2-4b, and LS4-10a.

Astronomy

The student will exhibit understanding of the following **content** benchmarks:

- Demonstrate the interrelationship of the atmosphere, hydrosphere, cryosphere, geosphere, biosphere, and astrosphere using an earth/space systems approach.
- Describe the purpose and advantage of current tools used to study the universe.
- Describe the purpose and advantage of current delivery systems used to study the universe.
- Describe the purpose and advantage of current techniques used to study the universe.
- Describe the purpose and advantage of current tools used to study the atmosphere, land, and water on earth.
- Describe the purpose and advantage of current delivery systems used to study the atmosphere, land, and water on earth (satellite based).
- Describe the purpose and advantage of current techniques used to study the atmosphere, land, and water on

earth (imaging and spectroscopy).
- Explain the role of Newton's universal law of gravitation in the formation and operation of the universe.
- Explain the role of the Big Bang Theory in the formation, structure, and evolution of the universe.
- Explain the role of forces in stellar structure and evolution.
- Explain the role of forces in the formation and evolution of our solar system.
- Explain the role of Kepler's Laws in the operation of our solar system.
- Explain the role of forces in the sun/earth connection (thermonuclear process, sunspot cycle, coronal mass ejection, flare, solar wind, and auroras).
- Explain the role and interaction of revolution, rotation, and gravity on the sun/moon/earth system (seasons, change in direct solar ray, length of day and night, and direction of sunlight).
- Explain the role and interaction of revolution, rotation, and gravity on eclipses in the sun/moon/earth system.
- Explain the role and interaction of revolution, rotation, and gravity on the relationship between the lunar phases and tides.
- Describe space exploration in terms of physical laws.
- Describe the objectives and activities of the space program.
- Describe the characteristics of members of the solar system which distinguish them from other celestial bodies.
- Use the law of universal gravitation to determine the acceleration due to gravity for a planet.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.

- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).
- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.

- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Select appropriate instruments and materials to conduct an investigation.
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: ESS3-5a, ESS3-5aa, ESS3-6a, PS3-9a, PS3-9b.

Biology

The student will exhibit understanding of the following **content** benchmarks:

- Describe the importance of lipids in the lipid bilayer of cell membranes.
- Describe proteins and explain their role as a structural component of cells and their function as enzymes.
- Explain the concept of osmosis.
- Identify the effects of changes in the solute concentration of a cell.
- Identify the role of ATP in the transfer and use of energy in photosynthetic and non-photosynthetic organisms.

- Compare the structure of an animal cell and a plant cell.
- Distinguish between prokaryotic and eukaryotic cells.
- Identify the role of the cell membrane in the transport of materials into and out of cells.
- Compare active and passive transport.
- Describe the process of waste disposal at both the cellular and organism levels.
- Identify the role of the 4 plant tissue types.
- Differentiate between unicellular and multicellular organisms (cell specialization).
- Identify the role of the body systems in maintaining homeostasis.
- Identify movements of cells.
- Describe the relationship between feedback mechanisms (negative and positive) and homeostasis.
- Identify the role of feedback in maintaining cellular and organism homeostasis.
- Identify the structure and function of organelles, organs, and organ systems
- Identify various cells in diagrams, photographs, or slides.
- Identify common unicellular organisms in diagrams, photographs, or slides.
- Compare the processes of mitosis and meiosis.
- Distinguish between the role of mitochondria and chloroplasts in energy production.
- Investigate how information is passed from parents to offspring in encoded molecules (DNA fingerprinting and gel electrophoresis)
- Identify the role of the ribosome in protein synthesis.
- Investigate the role of radiation in cancer and mutations.
- Describe the effects of toxins (natural or synthetic) on cells and organisms.
- Analyze the effects of crossing over on variation in offspring.
- Define fertilization as the combination of haploid gametes to produce a diploid zygote.
- Identify phenotypes as the expression of inherited characteristics.
- Distinguish between dominate and recessive alleles.
- Distinguish among modes of inheritance of traits.
- Demonstrate how sex-linked traits are inherited.

- Given the parents, use a Punnett Square to predict the genotype and phenotype of offspring.
- Predict the genotype and phenotype of an individual by performing a testcross.
- Use a pedigree to interpret patterns of inheritance within a family.
- Describe the structure of DNA.
- Show how the sequence of bases directs protein formation.
- Distinguish among the roles of DNA, mRNA, tRNA, and rRNA in protein synthesis.
- Describe beneficial and harmful effects of mutations on individuals, society, and/or environment.
- Define mutations in terms of DNA structure.
- Identify the beneficial or harmful effects of genetic engineering on the individual, society, and/or the environment.
- Using data, explain how our understanding of genetic variation has developed over time.
- Compare and contrast the various theories of evolution.
- Define natural selection.
- Describe the effects of environmental pressure on natural selection.
- Distinguish between microevolution and macroevolution.
- Identify examples of adaptations.
- Use molecular and fossil evidence to explain natural selection and evolution.
- Identify the effects of adaptations on the survival of organisms.
- State the effects of variation on survival.
- Use relationships between organisms as a basis for classification.
- Describe the significance of anatomical similarities among organisms as evidence for evolutionary relationships.
- Use common classification schemes as a basis for evolutionary trends.
- Investigate and defend a biological issue (e.g., animal rights, drug and alcohol abuse, viral diseases, genetic engineering, bioethics, biodiversity, population growth, global sustainability, origin of life).
- Analyze the water cycle and its relationship to living systems
- Analyze the cyclic relationship between photosynthesis and respiration during the carbon cycle
- Discuss human impact on the ecosystem

- Explain why the nitrogen cycle is important to living things
- Discuss how equilibrium is achieved in an ecosystem
- Describe how energy is transferred from the sun to organic molecules through the process of photosynthesis (i.e., energy conversion, light, chemical, basic molecules involved)
- Explain how the amount of energy decreases as it is transferred through an ecosystem
- Describe the effect of diversity on the ecosystem
- Analyze food pyramids and biomass
- Describe the effects of natural disasters, disease, population increase, and depletion of food on populations
- Identify ways to minimize human impact on the environment
- Illustrate how global food webs may be positively or negatively influenced by human activity and technology

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).

- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend his or her understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.

- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: LS1-1a, LS1-1b, LS1-1bb, LS1-1c, LS1-2a, LS1-2b, LS1-2c, LS1-2cc, LS2-3a, LS2-3b, LS2-3c, LS2-4a, LS2-4aa, LS2-4b, LS2-5a, LS2-5b, LS3-6a, LS3-7a, LS3-7aa, LS3-7b, LS3-7bb, LS3-7c, LS3-8a, LS3-8b, LS3-8c, LS3-8d, LS4-9a, LS4-9b, LS4-10a, LS4-10b.

Biotechnology I

This course is focused on Biotechnology as it applies to the agricultural industry. The production of food and fiber is tremendously impacted by the field of Biotechnology. With this in mind, the work done in this class will focus on the impact of biotechnology on agricultural production in present society to meet the world's needs for nutritious, safe, and plentiful food sources. Other careers in biotechnology will be identified, but the processes and skills will be taught using plant materials.

The student will exhibit understanding of the following **content** benchmarks:

- Describe proteins and explain their role as a structural component of cells and their function as enzymes.
- Describe nucleic acids (DNA).
- Compare the structure of an animal cell and a plant cell.
- Distinguish between prokaryotic and eukaryotic cells.
- Identify and describe the role of the cell membrane in the transport of materials into and out of cells.
- Compare and contrast sexual and asexual reproduction in various organisms.
- Compare and contrast the processes of mitosis and meiosis.

- Define the organelles of eukaryotic cells and describe their functions.
- Describe the effects of toxins (natural or synthetic) on cells and organisms.
- Analyze the effects of crossing over on variation in offspring.
- Identify phenotypes as the expression of inherited characteristics.
- Distinguish between dominant and recessive alleles.
- Distinguish among modes of inheritance of traits.
- Use heterozygous and homozygous pairs of alleles to represent genotypes.
- Define a gene.
- Analyze the parts of a nucleotide on a molecular basis and identify the significance of base sequencing.
- Distinguish among the roles of DNA, mRNA, tRNA, rRNA, and ribosomes in protein synthesis.
- Describe beneficial and harmful effects of mutations.
- Define mutations in terms of DNA structure.
- Identify the effects of abnormal chromosome number and form in organisms.
- Explain monoploidy and triploidy.
- Identify the beneficial or harmful effects of genetic engineering on the individual, society, and/or the environment.
- State the effects of variations and adaptations on survival.
- Compare and contrast the advantages of various species as hosts for rDNA (recombinant DNA) technology.
- Define recombinant DNA and explain its use in biotechnology.
- Discuss the role of enzymes in rDNA technology.
- Explain what contamination could do to the rDNA process.
- Differentiate between the ways of harvesting rDNA product.
- Explain the role of genes in the transfer of characteristics.
- Discuss the concept of gene interaction.
- Define a GMO (genetically modified organism).
- Discuss the steps involved in placing foreign DNA into an organism.
- Describe how a segment of DNA is selected and removed from a DNA strand.

- Explain how vectors are used to insert DNA into an organism.
- Compare and contrast the process of splicing DNA into plants and animals.
- Explain how transgenetic animals are used in genetic research.
- Describe how bacteria are used to create insect resistance, herbicide resistance, disease resistance, and tolerance to climatic changes.
- Explain how Bt (Bacillus thuringiensis) kills insects and remains harmless to humans.
- Describe how plants are genetically engineered to prevent viral infections.
- List ways that biotechnology, such as genetic engineering, is currently being used in producing plants.
- Explain how biotechnology is used in animal breeding.
- Explain the process of artificial insemination and discuss its advantages and disadvantages.
- Explain the embryo transfer process and discuss its advantages and disadvantages.
- Discuss the advantages and disadvantages of producing only male or only female offspring.
- Explain the importance of proper nutrition in the human diet (e.g. Vitamin A).
- Discuss how genetic engineering is used to produce golden rice.
- Trace some important developments in preserving foods.
- Explain the importance of genetic engineering on the quality, quantity, and availability of food supply.
- Describe the major consumer concerns about cloning through the use of biotechnology.
- Explain how the issues that are resolved about cloning will have a direct impact on, and huge implications for, the biotechnology industry.
- Describe the various methods of cloning plants.
- Explain the foundational concepts of biotechnology.
- Explain how biotechnology is rooted in and related to many science disciplines.
- Explain how biotechnology affects our lives and the world in which we live.
- Explain historical events and discoveries that have had a profound impact on the evolution of the biotechnology industry.
- Describe the hazardous materials within a classroom environment and explain handling and storage requirements.
- Describe the risks and hazards associated with each form of hazardous energy.

- List common causes of accidents.
- List specific safety precautions to take when working with pressurized equipment.
- Explain the reasons for the strict sanitation and sterilization in a biotechnology environment.
- Describe the sources of contamination and the technique used to minimize contamination.
- Explain when and how each piece of equipment should be used.
- List the emergency equipment available in a biotechnology laboratory.
- Identify the proper precautions and evacuation procedures as well as the procedures to be followed in the event of a hazardous materials spill.
- Explain the use of warning labels and signs.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify and pose meaningful, answerable, scientific questions (e.g., cause and effect).
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).
- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.

- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Practice proper techniques for dealing with and disposing of biohazardous materials.
- Recognize and demonstrate appropriate aseptic technique.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate and test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.

- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.
- Successfully demonstrate plant cloning procedures by conventional asexual propagation and tissue culture techniques.
- Successfully demonstrate aseptic technique in biotechnological processes.

The GSE's that correlate to the above mentioned course are: LS1-1a, LS1-1aa, LS1-1b, LS1-1c, LS1-1cc, LS1-2a, LS1-2b, LS1-2bb, LS1-2c, LS1-2cc, LS3-6aa, LS3-7a, LS3-7aa, LS3-7b, LS3-8a, LS4-9a, LS4-9b.

Chemistry

The student will exhibit understanding of the following **content** benchmarks:

- Gather and interpret data related to chemical and physical properties of matter such as density and percent composition.
- Classify matter as solids, liquids, and gases, in reference to the relative position, motion, and energy of particles.
- Differentiate among elements, compounds, mixtures, and solutions.
- Compare homogeneous and heterogeneous mixtures.
- Classify elements as metals, non-metals, and metalloids.
- Distinguish between physical and chemical changes.
- Illustrate the structure of the atom using the Bohr model, including the charge, relative mass, and location of the subatomic particles.
- Use atomic mass, atomic number, and charge to identify neutral atoms, ions, and isotopes.
- Calculate and explain the significance of an element's atomic mass.
- Demonstrate that the arrangement and number of subatomic particles determine the position of the elements on the periodic table.
- Use families, periods, and common family names in discussions of periodic trends.

- Predict chemical and physical properties based on an element's location on the periodic table.
- Predict oxidation numbers (applies to Honors level classes only).
- Use the periodic table to describe the relative atomic radii, ionic radii, electronegativity, ionization energy, electron affinity, and reactivity of elements.
- Infer from the family and period in which the element is located, the valence electrons and overall electron configuration.
- Construct electron configuration for elements and justify exceptions.
- Explain how atoms will interact with other atoms through the transfer of or sharing of electrons in the formation of ionic, covalent, and metallic bonds.
- Compare the characteristics of the neutral atom to its ion.
- Construct electron dot structure of atoms and ions to demonstrate the formation of ionic and covalent compounds.
- Determine the molecular geometry through tetrahedral compounds based on Lewis dot diagrams and octet rule.
- Distinguish among metallic, ionic, and covalent solids in terms of solubility, melting point, boiling point, and conductivity.
- Compare intermolecular and intramolecular forces and relate them to properties of substances.
- Explain that the properties of a molecule are determined by the number and types of atoms it contains and how they are arranged.
- Determine the types and numbers of atoms represented by a given formula.
- Analyze molecular geometry in order to classify molecules as polar or non-polar.
- Apply the concept of polar and non-polar molecules to predict the solubility of substances.
- Illustrate that heat energy in a material consists of the ordered and disordered motions of its colliding particles.
- Predict a boiling point elevation and /or a freezing point depression conceptually.
- Explain why the interactions between particles involve a change in the energy system in terms of endothermic and exothermic change and specific heat.
- Explain that the total amount of energy in any closed system remains constant.

- Explain that all systems tend toward disorder and lower energy.
- Investigate the specific heat of a substance to justify the Law of the Conservation of Energy.
- Describe the observed changes in pressure, volume, or temperature of a sample of gas in terms of the behavior of particles.
- Apply the combined and ideal gas laws in calculations.
- Describe kinetic theory of ideal gases at STP (Standard Temperature Pressure).
- Apply Graham's Law and Dalton's Law in calculations.
- Manipulate the ideal gas law in ideal gas stoichiometry problems.
- Use Hess's Law to calculate the energy of a reaction.
- Write symbols for and name elements.
- Write formulas for compounds including binary compounds, polyatomic ions, and common acids and bases.
- Write the name of compounds when given the formula.
- Calculate the molecular weight of a compound given the periodic table.
- Identify traditional nomenclature.
- Demonstrate that chemical reactions can be represented by symbolic or word equations.
- Transpose word equations into symbolic chemical equations and visa versa.
- Apply the law of conservation of mass and energy by explaining the use of coefficients to balance a chemical equation.
- Identify and classify chemical reactions into general types, including synthesis, decomposition, single replacement, double replacement, and combustion.
- Demonstrate that adjusting quantities of reactants will affect the amount of products formed.
- Use the coefficients of a balanced equation to predict amounts of reactants and products.
- Predict products of chemical reactions based on the reactivity series.
- Write net ionic equations (applies to Honors level classes only).
- Describe a neutralization reaction.
- Contrast the properties of acids and bases.
- Define an acid or base using the Arrhenius definition.

- Distinguish between strong and weak acids and bases.
- Describe concentrated and diluted as they apply to acids and bases.
- Describe the characteristics of salts.
- Describe the pH scale.
- Predict whether a substance is an acid or a base based on its pH value (applies to Honors level classes only).
- Explain the relationship between the Hydronium ion concentration and the pH (applies to Honors level classes only).
- Calculate pH given the Hydronium or Hydroxide ion concentration (applies to Honors level classes only).
- Use calculations to determine the relationship between pH, pOH, and Kw (applies to Honors level classes only).
- Calculate Ka and Kb (applies to Honors level classes only).
- Identify and define Avogadro's number and the mole concept operationally and conceptually.
- Utilize dimensional analysis to perform mole to mole, mass to mass, particle to mole, and mole to particle calculations.
- Utilize dimensional analysis to perform particle to mass and mass to particle calculations.
- Use formula mass to calculate percent composition of a compound.
- Use lab data to calculate the empirical and molecular formula of a compound.
- Solve problems involving quantitative relationships in equations including stoichiometric concepts.
- Manipulate the limiting reagent concept qualitatively.
- Determine limiting and excess reagents quantitatively to predict percent yield.
- Calculate the quantities needed to prepare molar solutions.
- Calculate the concentration of the solution by percent mass.
- Analyze factors that determine the properties of solutions such as electrolytes, polar vs. non-polar, and solubility factors.
- Distinguish among the types of solutions by degree of concentration.
- Describe systems at equilibrium (applies to Honors level classes only).
- Predict the effect of a change on a system at equilibrium (applies to Honors level classes only).
- Investigate an issue (e.g., hazardous waste disposal, the role of food additives, the substitution of synthetic

products for natural products).
- Apply chemistry to concepts in other fields of science.
- Recognize mathematics as an integral part of chemistry, comprehend the nature of chemical thinking, and become familiar with key mathematical ideas and skills.
- Investigate the role of chemistry in areas of human endeavor and achievement.

The student will demonstrate the following **process** benchmarks:

- Select appropriate instruments to directly or indirectly measure length, mass, volume, and temperature.
- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).
- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend his or her understanding of scientific concepts.

- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements/observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.

- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: PS1-1a, PS1-1aa, PS1-1b, PS1-1bb, PS1-2a, PS1-3a, PS1-3b, PS1-4a, PS1-4aa, PS1-4b, PS1-4bb, PS1-4c, PS2-5a, PS2-5aa, PS2-5b, PS2-6a, PS2-6aa, PS2-6bbb.

Earth and Physical Science

The student will exhibit understanding of the following **content** benchmarks:

- Gather and interpret data related to chemical and physical properties of matter such as density and percent composition.
- Classify elements as metals and nonmetals.
- Illustrate the structure of the atom and describe the characteristics of the subatomic particles.
- Demonstrate that the arrangement and number of electrons determine the properties of elements and their position on the periodic table.
- Explain how the understanding of the atomic structure has changed over time.
- Compare the characteristics of a neutral atom to its ion.
- Explain how atoms interact with other atoms through the transfer and sharing of electrons in the formation of ionic and covalent bonds.
- Determine the types and numbers of atoms represented by a given formula.
- Illustrate that heat energy and phase change in a material consists of the ordered and disordered motions of its colliding particles.
- Explain why interactions among particles involve a change in the energy of a system.
- Conclude that the conservation of mass and energy holds true for all systems and that the total amount of energy in any closed system remains constant.
- Describe the observed changes in pressure, volume, or temperature of a sample of gas in terms of the behavior of particles.

- Identify the names and symbols for elements.
- Write formulas for compounds given the name of the compounds.
- Show that chemical reactions can be represented by symbolic or word equations that specify all reactants and products involved.
- Apply the law of conservation of mass and energy by balancing simple equations.
- Describe the changes in energy that occur in exothermic and endothermic reactions.
- Identify whether a given chemical reaction will release or consume energy.
- Explain how the nuclear make-up of atoms determines the types of emissions created in the atom's nucleus (radioactive decay)
- Explain the concept of half-life and predict the approximate age of a material.
- Compare and contrast fission and fusion in nuclear reactions.
- Manipulate equations appropriate to the study of physics.
- Use algebraic concepts to describe an object's motion.
- Explain how distance and velocity change over time for a free falling object.
- Explain the gravitational force between objects (Universal Gravitational Law).
- Apply Newton's Laws of Motion and the Conservation of Momentum to the motion of objects.
- Demonstrate the principle that like charges repel and unlike charges attract.
- Describe the types of electric charges and the forces that exist between them.
- Describe the sources and effects of electric and magnetic fields (static charge, moving charges, simple circuits, and permanent magnets).
- Describe how different kinds of materials respond to electric and magnetic fields (conductors, insulators, and magnetic materials).
- Explain the principle of electromagnetic induction and its applications (motors and generators).
- Describe and demonstrate how waves can be used to transmit energy.
- Describe the regions of the electromagnetic spectrum.
- Compare the propagation of mechanical waves (longitudinal and transverse).
- Describe and mathematically calculate wave characteristics.

- Describe and demonstrate reflection of waves.
- Describe and demonstrate refraction of waves.
- Describe and demonstrate refraction of the Doppler Effect.
- Describe how the Doppler Effect applies to the movement of stars.
- Apply the properties of particles and explain the composition and location of stars.
- Explain how scientific knowledge regarding plate tectonics has changed over time.
- Plot the location of mountain ranges, earthquakes, and volcanoes to identify patterns.
- Explain how heat affects the rock cycle.
- Explain how convection currents affect plate movement and seismic activity.
- Explain conservation of matter applies to the rock cycle.
- Explain how Earth processes alter the crust.
- Analyze a sample of rock to determine the relative age of the rock structure.
- Explain the Big Bang Theory and how the theory has developed over time.
- Explain how advanced technologies (e.g., space probes, x-ray telescopes) have improved scientific knowledge in regards to the structure of the universe.
- Apply the properties of particles to explain the composition and location of stars.
- Describe how the interaction of gravity, fusion, and energy release contribute to the development of a star.
- Identify and describe the characteristics common to most stars in the universe.
- Describe the life cycle of a star.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.

- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).
- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.

- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: PS1-1a, PS1-1aa, PS1-1b, PS1-2a, PS1-3a, PS1-3b, PS1-4a, PS1-4b, PS1-4c, PS2-5a, PS2-5b, PS2-6a, PS2-6b, PS2-6c, PS2-6d, PS2-6e, PS2-7a, PS2-7b, PS2-7c, PS3-8a, PS3-8b, PS3-9a, PS3-9b, PS3-10a, PS3-10b, PS3-10c, ESS1-1a, ESS1-2a, ESS1-3a, ESS1-3b, ESS1-3c, ESS1-3d, ESS1-4a, ESS3-5a, ESS3-6a, ESS3-7a, ESS3-8a, ESS3-8b.

Floral Design

The student will exhibit understanding of the following Grade Span Expectations:

- Describe the basic historical styles of floral design (Roman Period, Middle Ages, Renaissance, Baroque and Dutch-Flemmish Styles, French Period, English-Georgian Period, Victoria Era).
- Describe how the basic historical styles of floral design have influenced and contributed to modern floral design.

- Explain how the appearance, quality, and longevity of flowers depend on the conditions during cultivation, harvest, and postharvest.
- Compare and contrast the how longevity varies among species of flowers.
- Explain what factors contribute to reasons why flowers wilt and die.
- Describe and exhibit proper care and handling procedures for cute flowers and foliage.
- Identify and describe the proper tools necessary to construct floral arrangements.
- Identify and describe the various shapes, styles, and types of containers used to achieve harmony and unity in floral designs.
- Describe how proportion, scale, shape, mechanics, balance, and focal area impact wearable floral designs.
- Describe and implement the wiring and construction techniques of various styles of wearable floral designs (boutonnieres, corsages, chaplet, etc).
- Describe the factors that influence floral arrangement shape.
- Identify and describe the basic shapes of floral arrangement (triangular and circular and those related variations.)
- Describe the design process and the concepts of harmony and unity in floral designs.
- Understand and describe the properties and psychological effects of color.
- Describe and implement successful floral designs using various color schemes.
- Describe and implement proper balance in floral designs (physical and visual balance).
- Describe and implement proper proportion in floral designs.
- Describe and implement proper scale in floral designs.
- Describe the concept of focal point.
- Describe the concept of rhythm.
- Explain why establishing a point of emphasis/focal point is the best way to establish interest in a floral arrangement.
- Explain how focal point and incorporated rhythm in floral designs creates visual satisfaction.
- Implement floral arrangements that demonstration appropriate focal point and rhythm.
- Describe the importance of line as a tool for the floral artist.

- Describe the importance of form as a tool for the floral artist.
- Describe the importance of space as a tool for the floral artist.
- Describe the importance of depth as a tool for the floral artist.
- Implement floral arrangements that demonstrate appropriate line, form, space and depth.
- Explain how texture appeals to both the visual and tactile senses.
- Explain how fragrance of flowers can enhance a floral arrangement.
- Describe and demonstrate the successful blending of line, form, space, and depth in a floral arrangement.
- Describe why much of the business of the floral industry is seasonal.
- List and describe major floral holidays in the United States.
- Design and create traditional floral arrangements for Thanksgiving.
- Design and create various traditional floral arrangements for Christmas.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.

- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: none.

Forestry

The student will exhibit understanding of the following Grade Span Expectations:

- Identify important forest products that contribute to the comfort and health of people and to economies of nations.
- Describe the kinds of plants that compose the vegetative strata that are found in a forest.
- List the major life forms that contribute to the biological value of a forest.
- Suggest some natural functions of a forest that affect its biological value.
- Describe how a watershed functions, and explain why a forested watershed is superior to a watershed that lacks forest plants cover.
- Identify ways that forest environments contribute to stable populations of wild animals.
- Distinguish between renewable resources and non-renewable resources.
- Account for the major uses of forest resources in the United States.
- List ways that forest products such as wood and other biomass materials are used as sources of energy.
- Explain the multiple-use concept of management for public lands.
- Name the regional forests of North America.
- List the most important species of trees in each region.
- Explain the principle of biological succession.***
- Describe the distinguishing features between trees classed as conifers, deciduous, and evergreen.
- Identify some characteristics of the Northern Coniferous Forest region that accounts for the relatively low production of this forest.
- Name some important forest products in addition to wood and paper.
- Explain why it is usually important to harvest trees in a timely manner once they become mature.
- Define silviculture and give some examples of silviculture practices.
- Speculate on the process by which the geological feature known as an alluvial fan was formed.
- Identify some characteristics of the Pacific Coast Forest region that account for the relatively high production of this forest.
- List and describe the most common tree groups in North America on the basis of leaf structure.
- Distinguish between the anatomy and the physiology of a tree.
- Name the basic structures of a plant cell.***

- Describe the different tissue systems of a tree.***
- Identify the external parts of a tree leaf.
- Explain the importance of xylem tissue in a tree.***
- Compare and contrast the methods of seed production between angiosperms and gymnosperms
- Describe the importance of meristem tissue as it relates to growth of trees.***
- Name, describe and illustrate the basic structure of a tree root.
- Name, describe and illustrate the basic parts of a flower.
- Explain the importance of photosynthesis in sustaining plant and animal life.
- Name the type of cell division that accounts for most of the growth in trees.***
- Describe the process of meiosis in the production of male and female gametes.***
- Distinguish between sexual and asexual propagation of plants.
- Explain the difference between a high forest and a low forest.
- Compare and contrast the different forms of vegetative reproduction.
- Explain how tissue culture technology is used to propagate plants.***
- Explain the relationship between soil erosion and pollution of surface water.
- Describe how natural cycles function to prevent pollution and to renew the environment.
- Discuss the importance of the element carbon to living organisms.
- Suggest some reasons why soil is considered to be one of our most important natural resources.
- Distinguish among the three soil orders that are of significance to forestry in North America.
- Explain the major functions and significance of watersheds.
- Illustrate the different events that occur in the water cycle.***
- Describe some effects of air pollution on forests.
- Compare and contrast food chains, food webs, and food pyramids.
- Define silviculture.
- Compare and contrast natural and artificial methods of regenerating forests.
- Describe the steps that should b e followed in transplanting a tree seedling.
- Describe the characteristic s of the different growth stages of trees such as seedling, sapling, pole, and mature

tree.

- Describe some intermediate treatments that are applied to forests.
- Describe some silviculture practices that are used to improve the growth and quality of trees. Explain types of information that are needed to develop a long-term forest management plan based on sustained yields.
- Describe the features of the two types of land surveys that are used in the United States.
- Explain the relationship of baselines and principle meridians to the initial point location from which each rectangular survey begins.
- Explain how instruments such as the stereoscope and the planimeter are used in preparing a forest type map.
- Name some tools that are used to estimate the diameter and height of a standing tree, and explain how each tool is used.
- Define the role of a timber cruiser.
- Contrast the differences between a 100% cruise and a partial cruise, and explain when each is appropriate to use.
- List some assumptions that apply to partial cruises that may influence the accuracy of the results.
- Explain the formula for measuring forest growth, and describe each of the formula components.
- Describe the most commonly used methods for scaling logs.
- Identify factors that influence decisions affecting timber harvests.
- Describe some important components of a timber harvest plan.
- Distinguish between harvest methods leading to even-aged and uneven-aged forests.
- Explain how the planned method of forest regeneration affects the selection of a harvest method.
- Relate the volume of timber harvests to forest growth as they affect the forest management concept of sustained yield.
- Speculate on the reasons the National Environmental Protection Agency Act included a requirement for an environmental impact statement to be filed as part of each timber harvest plan.
- List and explain each of the steps involved in harvesting timber.
- Explain the historical relationship between roach construction in forests and surface water quality.
- Evaluate the practice of salvage logging.
- Describe some methods that are used to minimize litigation related to timber harvests.

- Describe ways that fire is both beneficial and destructive to forests.
- Identify three key elements that must be present for a fire to occur.
- Analyze the differences that exist among surface, ground and grown fires.
- List the major causes of destructive forest fires.
- Explain the effects of wildfire on forests and forest environments.
- Discuss ways that prescribed burns may be used to improve the health of forests.
- Analyze the fire suppression policy of the United States Forest Service as it has been implemented in the past and as it exists today.
- Calculate the rate of spread for a fire at different wind speeds.
- Describe the indirect attack method of fire suppression.
- Explain how direct attack methods of fire suppression act on the key ingredients of a fire.
- Evaluate past and present efforts of government and industry to prevent destructive fires in the forests.
- Assess the effects of a short-duration fire cycle on the health of a forest.
- Appraise career opportunities in the emerging field of urban forestry.
- Define the roles of trees in urban settings.
- Identify factors that should be considered in selecting trees for urban uses.
- Explain how a zone map should be used to guide tree selection.
- Name three basic functions of soil.
- Describe the relationship between soil characteristics and root development in trees.
- Evaluate the use of a tensiometer as a water management too.
- Explain why it is important to prune trees.
- Describe a systematic approach to diagnosing problem trees.
- Explain how cables and other hardware items are used to stabilize and repair damaged trees.
- Analyze the differences between the Plant Health Care system of managing trees and traditional method of management.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.

- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are:

Geology

The student will exhibit understanding of the following **content** benchmarks:

- Demonstrate the interrelationship of the atmosphere, hydrosphere, cryosphere, geosphere, biosphere and astrosphere using and earth/space systems approach.
- Describe the purpose and advantage of current tools used to study the atmosphere, land, and water on earth (e.g., scanner, seismograph, radiosonde profiler, flow meter).
- Describe the purpose and advantage of current delivery systems used to study the atmosphere, land, and water on earth (satellite and ground based).
- Describe the purpose and advantage of current techniques used to study the atmosphere, land, and water on earth (imaging, Geographic Information Systems, and triangulation).
- Explain how variation and energy transfer affects global phenomenon (e.g., mantle convection, seismic activity, volcanism, landslides, tsunamis, meteorite impacts, mountain building).
- Compare the origin and structure of igneous, metamorphic, and sedimentary rocks using concepts of the structure of matter (e.g., atoms, molecules, isotopes).
- Compare the physical properties of common rock-forming mineral groups in igneous, metamorphic, and

sedimentary rocks.

- Compare the chemical composition of common rock-forming mineral groups in igneous, sedimentary and metamorphic rocks.
- Compare the origin, texture, and mineral composition of common rock groups.
- Explain how the transfer of energy drives destructive processes in the rock cycle (e.g., weathering, erosion, melting, subsidence).
- Explain how the transfer of energy drives constructive processes in the rock cycle (e.g., lithification, deformation, metamorphism, cooling/crystallization, and deposition).
- Explain how the transfer of energy drives land form changes (e.g., surface and ground water coasts, glacial processes, desert processes).
- Explain changes in earth's surface using continental drift.
- Explain changes in earth's surface using sea floor spreading.
- Explain changes in earth's surface using the theory of plate tectonics (e.g., crustal plate composition, mantle circulation, divergent/convergent/transform fault boundaries, subduction zones, trenches, island arcs, hot spots, island chains, seismic activity, volcanism, mountain building).
- Apply principles of relative dating to events in earth's geologic and biologic past (e.g., superposition in rock columns, core samples, unconformities, uniformitarianism, cross-cutting relationships, and correlation of rock layers).
- Apply principles of relative dating to events in the history of other objects in our solar system (e.g., superposition of craters, cracks, lava flows).
- Apply principles of absolute dating to events in earth's geologic and biologic past (radioactive dating).
- Compare events in earth's history that have been grouped according to similarities (e.g., geologic time scale and magnitude, era, period, epoch).
- Describe the basic fossil types and mechanisms of fossil formation.
- Compare the structure of fossils and present day life forms.
- Demonstrate an understanding the role of geology in determining quality of life.
- Develop an awareness of the current opportunities in the geological sciences.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).
- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological

advances allow for additional scientific accomplishments.

- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: ESS1-1a, ESS1-2a, ESS1-3a, ESS1-3aa, ESS1-4a, ESS1-4aa, ESS3-5a, PS1-1a .

Introduction to Agriculture I

The student will exhibit understanding of the following Grade Span Expectations:

- Define and discuss the concept of Natural Resources.
- List and describe the major categories of Natural Resources in America.
- Contrast exploitation, conservation and preservation as they relate to natural resource management.
- Briefly outline the history of conservation in the United States.
- Compare and contrast the differences between non-exhaustible, renewable, and exhaustible natural resources.
- Outline the process involved in soil formation.
- Describe a mature soil profile.
- Discuss the eight land capability classes.
- Define a soil series and explain how it differs from land capability classes.
- Differentiate between natural soil erosion and soil erosion caused by humans.
- List and define the major types of soil erosion.
- Discuss the role of ecology in human efforts at Natural Resource Management.
- Explain the components of the hydrologic cycle.
- Explain the categories of main water users.
- Identify the three major water pollution groups.
- Explain the four major categories of industrial pollution.
- List and explain the major agricultural pollutants.
- Explain common water pollution control measures.
- Discuss how invertebrates are used to determine water quality.
- Explain the differences between commercial and non-commercial forests.
- List and describe the major forest regions of the United States.
- Identify the parts of a tree and describe the function of each part.
- Differentiate between pure and mixed forests.

- Define forest canopy and discuss the importance of shade tolerance in the canopy.
- Define the most common ways to measure wood.
- Describe the different measures of harvesting a stand of trees and explain the advantages and disadvantages of each.
- Explain how a forest can grow faster if the trees are harvested.
- Describe the major insect pests of our forests.
- Describe the most important disease problems in the forests of the United States.
- Outline woodland management techniques for controlling insect and disease problems in United States forests.
- List and describe some of the most destructive forest fire in US history.
- Draw and explain the fire triangle.
- Explain how fire can be used as a positive tool in woodland management.
- Describe the anatomy of a typical forest fire.
- Explain the use of solar and wind energy and hydroelectric and geothermal power as alternate energy sources.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.

- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: ESS1-3c, ESS1-3d, LS1-1bb, LS2-3b, LS2-3c, and LS2-4b.

Introduction to Agriculture II

The student will exhibit understanding of the following Grade Span Expectations:

- Describe the importance of agriculture.
- Discuss how agriculture was necessary in the development of civilization.
- Identify key inventions and techniques that propagated the use of agriculture.
- Describe the functions of plant's stems, leaves, roots, and flowers.
- Explain how stems, leaves, roots and flowers are used by humans.
- Explain why producers have to deal with pests.
- Discuss how insects are controlled.
- Analyze the concept of integrated pest management.
- Explain what a weed is and how they are controlled.
- Define a plant nursery.
- Identify and describe the basic green house types.
- Distinguish between sexual and asexual propagation.
- Discuss the meaning of the term "organically raised product".
- Explain some of the concerns that people have with the United States' food supply.
- List ways organic producers fertilize their crops.
- List ways organic producers control insect pests.
- Analyze the controversial issues surrounding organically raised products.
- Discuss the extent of the U.S. beef industry.
- Discuss the different phases of the beef industry.
- Explain how pork is produced in the U.S.
- Discuss the sheep industry in the U.S.
- Describe the types of and uses for horses in this country.
- Explain the importance of the dairy industry.

- Explain how milk is produced.
- Explain how milk is processed and graded.
- Discuss the cheese making process.
- Explain the importance of poultry to humans.
- List the different segments of the poultry industry.
- Explain how eggs are hatched commercially.
- Describe how broilers are produced.
- Explain how eggs are produced.
- Discuss how over engineering has changed the turkey industry and compare it to heritage stock.
- Discuss ways in which companion animals are used to assist humans.
- Explain the benefits of hippotherapy.
- Define zoonoses and list several types.
- Identify several aspects of responsible companion animal ownership.
- Distinguish between animal rights and animal welfare.
- Discuss why people might have feelings that agricultural animals are mistreated.
- Discuss why the use of management practices is human.
- Discuss the use of animals for experimentation.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).

- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: LS1-1b, LS1-2bb, LS2-3b, LS3-7aa, LS4-9a, and LS4-9b.

Landscape Design

The student will exhibit understanding of the following Grade Span Expectations:

- Describe the basic principles that lead to good design
- Explain how these principles are applied to landscape designing.
- Describe features of plant materials, hardscape materials, and architecture that make them useful as design elements.
- Describe the origins and forms of the plants used in landscapes.
- Explain plant nomenclature
- Describe the factors relevant to proper plant selection.
- Identify and use properly the traditional tools of the landscape designer
- Measure and interpret dimensions to scale.
- Describe different methods of lettering designs.
- Create a variety of lettering styles.
- Distinguish between plan views, elevations, perspectives views, and axonometric views of landscape proposals.
- Create plan view symbols for major landscape features and label them correctly.
- Lay out a complete landscape design plan.
- Compare and contrast different levels of graphic presentations and the proper uses of each.
- Describe the characteristics and uses of graphite pencils, colored pencils, felt pens, markers, pastels, pressure graphics, foam board, and the papers and films used for both original and copied work.
- Arrange the components of a graphic presentation
- Identify indoor and outdoor use areas.
- List and define the features of the outdoor room.

- Define the word site and explain its significance in the development of a landscape.
- List the typical features that must be evaluated on most sites.
- Describe sources of site information
- Explain geographic information systems.
- Define the terms setback, zoning regulations, property lines, right of way, easement, and zero lot line.
- Describe the limitations that the terrain imposes upon human activities.
- Understand the basic concepts of land grading.
- Describe how to prepare a base map.
- Describe the uses and limitations of flowers in a landscape design.
- Explain the difference between annual, perennial, and biennial flowers.
- List the characteristics of hardy and tender bulbs.
- Explain the difference between a flower bed and a flower border.
- Design a flower planting.
- Plan a naturalized bulb planting.
- Explain what is meant by hardscape.
- Describe how hardscape materials serve in functional and/or aesthetic ways.
- Explain how hardscape materials are selected.
- Choose from among many types of enclosure and surfacing materials.
- Explain how the dimensions of outdoor steps are calculated.
- Describe the basic steps in the creation of a recirculating water feature.
- Explain the uses of 12-volt lighting systems in illumination of the landscape.
- Explain the cyclic natures of the landscape process.
- List the component steps of each phase of the cycle.
- Conduct a client interview.
- Distinguish between functional diagrams, preliminary designs, and final plans.
- Explain the difference between cost and price.
- Explain the difference between an estimate and a bid.

- Describe landscape specifications.
- Prepare a design cost estimate.
- Describe the calculations needed for landscape take-offs.
- Explain the importance of organization and standardization when doing take-offs.
- Perform typical calculations required for take-offs.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).

- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: none

Meteorology

The student will exhibit understanding of the following **content** benchmarks:

- Know the structure and composition of the Earth's atmosphere.
- Understand that the Earth's atmosphere has evolved over time.
- Explain what causes air pressure.
- Describe how energy transfer within the atmosphere influences weather (e.g., conduction, radiation, convection and heat of condensation in clouds, precipitation, wind, and storms).
- Describe and explain the factors that may influence weather such as prevailing winds and proximity to oceans.

- Explain why different latitudes on Earth receive different amounts of solar energy and describe the Coriolis Effect.
- Describe how weather is associated with fronts and high and low pressure areas.
- Explain how data is collected for weather maps and forecasts, and identify symbols used in a weather station model.
- Describe and explain the factors that act as climate controls such as proximity to water, topography, and latitude.
- Explain the interrelationship between the circulation of oceans and weather and climate.
- Describe possible causes of climatic change and explain how El Nino affects climate.
- Analyze the effects of laws and policies, technology, and economics on management of natural resources.
- Investigate and explain the occurrence and effects of storms on human populations and the environment.
- Describe and explain the factors that may influence climate and weather such as burning fossil fuels, acid precipitation, greenhouse effect, and ozone layer depletion.
- Identify cause and effect relationships within an atmospheric system.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable scientific questions (e.g., cause and effect).
- Pose meaningful, answerable scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.

- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).
- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend his or her understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).

- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: ESS1-3aa, ESS1-3bb, ESS1-3d, PS2-5aa .

Oceanography

The student will exhibit understanding of the following **content** benchmarks:

- Compare and contrast the aphotic and photic zones in the ocean.
- Describe the differences between the neritic and oceanic zones.
- Explain how organisms in various marine habitats obtain energy.
- Describe the relationships between marine and fresh water habitats.
- Describe the various topographic features of the global ocean.
- Use a topographic model to show how sonar is used to determine topographic features.
- Explain how topographic features determine the numbers and kinds of organisms inhabiting those areas.
- Describe the sun's role in the surface circulation of the ocean.
- Describe the typical gyre circulation pattern found in each of the major ocean basins.
- Describe the relative speeds, temperatures, and directions of the currents comprising a typical gyre.
- Explain how upwelling leads to increased biological productivity.

- Explain how the gravitational attraction between the earth, moon, and sun forms ocean tides.
- Explain some of the different types of ocean tides the moon helps generate.
- Describe the major characteristics of shallow water waves.
- Measure and calculate wave characteristics using wave tables.
- Describe the water motions associated with shallow water ocean waves.
- Describe the major characteristics of deep water waves.
- Describe the water motions associated with deep water ocean waves.
- Describe how the downward transfer of heat from warm ocean surface creates the layered structure of the oceans.
- Explain how small variations in temperature and salinity create the thermohaline (deep ocean) circulation.
- Demonstrate the causes of coastal upwelling and downwelling.
- Explain how coastal upwelling and downwelling can lead to changes in biological productivity.
- Describe the use of a radar altimeter to measure sea surface height.
- Describe the relationship between seafloor topography and the height of the overlying sea surface.
- Explain how the pH of seawater affects the quality of life for marine organisms.
- Explain the importance of understanding the percentage of dissolved gasses in seawater.
- Explain how latitude variations affect salinity and aid in ocean circulation.
- Explain how sea level measurements are being applied to help to better understand global events such as global warming and El Nino.
- Explain that the location of a coast depends primarily on global tectonic activity and the ocean's water volume.
- Explain that the shape of a coast is a product of many processes including uplift and subsidence, erosion, sediment transport, and deposition.
- Describe the difference between erosion coasts and deposition coasts.
- Explain beach shape and volume as a function of wave energy and the balance of sediment input and removal.
- Compare and contrast various habitats within the oceanic zone and ocean bottom with those of the intertidal/neritic zones.
- Describe the common characteristics of major marine phyla and explain how current human actions are

impacting marine life groups and their habitats.
- Hypothesize what can be done to lessen and/or eliminate the negative impacts of human actions and interactions.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).
- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.

- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: LS2-3a, LS2-3b, LS2-3bb, LS2-4a, ESS1-2a, ESS1-3a, ESS1-3aa, ESS1-3bb, ESS1-3c, ESS1-3d, PS3-9a, PS3-10a, PS3-10c.

Physics

The student will exhibit understanding of the following **content** benchmarks:

- Distinguish between scalar and vector quantities.
- Symbolically represent vector quantities.
- Graphically add vectors that are collinear and at right angles.
- Resolve vectors into their components graphically and mathematically.
- Mathematically add vectors using their components and appropriate units.
- Determine direction of an object by measurement and by using kinematic equations.
- Determine magnitude by measurement and by using kinematic equations.
- Compute position, velocity, and time for motion with constant velocity.
- Compute position, velocity, acceleration, and time for motion with constant acceleration.
- Solve linear frames of reference problems.
- Solve problems using "G" as the constant acceleration of an object in free fall on earth.
- Compute average velocity and total distance traveled using position time graphs.
- Determine displacement and acceleration using velocity time graphs for constant acceleration.
- Analyze an object moving in two directions in terms of constant accelerated motion.
- Use kinematics equations in two dimensions to describe projectile motion.
- Compute the position velocity and centripetal acceleration of an object experiencing uniform circular motion.
- Compute the period, frequency, amplitude, position, velocity, equilibrium velocity, and acceleration of an object experiencing simple harmonic motion.
- Determine the effect of balanced and unbalanced forces.
- Draw a free body diagram, identifying forces acting on an object.

- Predict an object's motion using inertia.
- Recognize the relationship among the net force on an object, its mass, and its acceleration.
- Identify the difference between weight and mass.
- Solve problems using the concept action/reaction.
- Recognize that gravitational fields exist around any object with mass.
- Use torque to analyze objects in equilibrium and compute angular acceleration.
- Solve qualitative and quantitative problems involving the force friction.
- Recognize the inverse square relationship of gravitational and electromagnetic forces.
- Describe qualitatively and quantitatively the relationship among force, work, power, and energy.
- Identify qualitatively and quantitatively whether work is positive or negative.
- Describe qualitatively and quantitatively an object's potential and kinetic energy.
- Qualitatively and quantitatively relate work to changes in potential or kinetic energy by applying the principle of conservation of energy.
- Describe qualitatively and quantitatively an object's momentum.
- Analyze systems involving conservation of momentum in one dimension, including elastic and inelastic interactions.
- Apply the principles of the conservation of momentum in two dimensions.
- Analyze systems involving conservation of angular momentum.
- Explain the inverse square relationship of electrical forces.
- Understand that electric charges can be positive or negative in sign.
- Describe how a charge's sign determines whether it is attracted or repulsed by another charge.
- Apply Coulombe's Law to two or more charges.
- Describe the electric field for static point charge, line of charge, and parallel plates.
- Describe the magnetic field created by a moving charge.
- Develop the concept of electrical potential difference by relating it to the work done on a charge in an electric field.
- Identify the general properties of magnets.

- Explain how conductors, insulators, and magnetic materials respond to electric and magnetic fields.
- Explain the effect electric and magnetic fields have on a moving charge, a static charge, simple circuits, and a permanent magnet.
- Describe how electromagnetic induction is applied to a motor and a generator.
- Analyze situations using Lenz's Laws.
- Diagram DC circuits.
- Use meters to measure quantities in series and parallel circuits.
- Compare and contrast the design and properties of ammeters and volt meters.
- Calculate the equivalent resistance, current, and voltage drop for circuits.
- Identify the relationship between electric potential, current, and resistance.
- Solve problems involving electric power.
- Understand the role of capacitors and inductors in an electric circuit.
- Identify practical applications regarding electric currents.
- Describe the physical vs. electromagnetic transfer of energy by a wave.
- Describe how longitudinal and transverse waves vibrate relative to their direction of transmission.
- Describe qualitatively and quantitatively the wavelength of a wave.
- Describe qualitatively and quantitatively the relationship between frequency, period, and energy of a wave.
- Solve problems involving the velocity of a wave.
- Describe the amplitude of a wave and its relationship to energy.
- Identify incident, reflected, and transmitted waves with the use of ray models and the law of reflection.
- Explain total internal reflection.
- Describe changes in wave behavior when it encounters a boundary between two media.
- Calculate the index of refraction and the speed of light in a medium.
- Use Snell's Law to solve refraction problems.
- Apply the concept of diffraction.
- Describe polarization of light.
- Apply the principle of interference.

- Describe the properties of sound waves.
- Differentiate between pitch and loudness.
- Describe how sound is produced and detected.
- Solve problems involving closed pipe and open pipe resonators when a standing wave is produced.
- Apply the laws of reflection in plane and concave mirrors.
- Distinguish between real and virtual images.
- Describe real and virtual images formed by concave mirrors.
- Describe virtual images formed by convex mirrors.
- Determine the position of virtual images formed by concave lenses.
- Determine the position of real and virtual images formed by convex lenses.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Recognize biased data.
- Explain factors that produce biased data (e.g., incomplete data, using data inappropriately, conflicts of interest).

- Learn the use of new instruments and equipment by following instructions.
- Determine the relationships between quantities and develop the mathematical model that describes these relationships.
- Use models and computer simulations to extend understanding of scientific concepts.
- Use computers and/or graphing calculators to produce the visual materials (e.g., tables, graphs, spreadsheets) that will be used for communicating results.
- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
- Critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.

- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: PS2-5b, PS2-7a, PS2-7b, PS2-7c, PS3-8a, PS3-8b, PS3-8bb, PS3-9a, PS3-9b, PS3-10a, PS3-10b, PS3-10c.

Physiology

The student will exhibit understanding of the following **content** benchmarks:

- Analyze the relationships between the anatomical structures and physiological functions of all body systems (e.g., digestive, integumentary, and urinary).
- Evaluate the cause and effect of disease, trauma, and congenital defects on the structure and function of cells, tissues, organs, and systems.
- Identify characteristics of the aging process on body systems.
- Analyze and explain the chemical reactions that provide energy for the body.
- Analyze the effects of energy deficiencies in malabsorption disorders, such as diabetes, hypothyroidism, and Crohn's disease.
- Investigate and describe the integration of chemical and physical properties of variables of the body, including: temperature, pH balance, chemical reactions, passive and active transport, and feedback which contribute to homeostasis.
- Predict the consequences of the failure to maintain homeostasis.
- Analyze the physical, chemical, and biological properties of transport systems including cardiovascular, respiratory digestive, lymphatic and excretory.

- Analyze the effects of pressure, movement, tension, and elasticity on the human body.
- Research and evaluate technological advances and limitations in the treatment of system disorders.
- Explain how coordination of muscles, bones, and joints allows movement of the body.
- Identify the means by which energy is processed and stored within the body, including the structure and function of the digestive system.
- Illustrate the conduction systems such as nerve transmission or muscle stimulation.
- Identify and describe the factors that alter the normal functions of transport systems.
- Compare the interactions among the transport systems.
- Identify the monomers of lipids, proteins, carbohydrates, and nucleic acids.
- Describe the characteristics of carbohydrates (e.g., organic molecule: monosaccharides as building blocks, supplier of energy, and dietary fiber; structural component of cells; cell wall and cellulose).
- Describe lipids (e.g., organic molecule, component of cell membranes, stored energy supply).
- Describe the importance of lipids as a component of the lipid bilayer in cellular membranes.
- Describe proteins (e.g., organic molecule, amino acids as building blocks, structural and functional role, including enzymes).
- Explain the role of proteins as a structural component of cells and their functions as catalysts in biochemical reactions.
- Identify the general role of minerals in living systems (inorganic substances essential for cellular processes).
- Describe the role of vitamins in maintaining good health in the human body (e.g., organic molecule; role in human body: C – wound healing, K – blood clotting, D – bone growth)
- Identify the role of vascular tissues in the transport of materials.
- Identify the role of the cardiovascular system in the transport of materials in the human body.
- Describe the process of waste disposal at both the cellular and organism levels (e.g., roles of cell membrane, excretory, circulatory systems).
- Identify movements of cells (e.g., flagella, cilia, and pseudopodia).
- Identify the interactions between skeletal and muscular systems in producing movement.
- Describe the relationship between feedback mechanisms and homeostasis (e.g., water balance, pH, temperature,

role of endocrine system).
- Identify the roles of feedback and the endocrine system in maintaining organism homeostasis.
- Describe the roles of sensory organs and the nervous system in the control of structures in human systems.
- Compare the processes of mitosis and meiosis.
- Identify analogies of structure and function using organelles, organs, or organ systems.
- Describe the role of the mitochondria in energy capture and release.
- Identify the role of the ribosome in protein synthesis.
- Investigate the role of radiation in cancer and mutations.
- Describe the effects of toxins (natural and synthetic) on cells and organisms.
- Distinguish between human autosomal diseases and human sex-linked diseases.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
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- Use ratio and proportion in appropriate situations to solve problems.
- Use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
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- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Read a technical selection and interpret it appropriately.
- Communicate conclusions derived through a synthesis of ideas.
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- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.

- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.
- Complete secondary research.

The GSE's that correlate to the above mentioned course are: LS1-1a, LS1-1b, LS2-2cc, LS3-7aa, LS4-9a, Ls4-10a, LS4-10b, LS4-10bb.

Plant Science

The student will exhibit understanding of the following Grade Span Expectations:

- Discuss the importance of taxonomic systems in naming plants.
- Describe how agriculture uses various formal and informal scientific and non-scientific classification systems to classify crop plants.
- Give an example of crops used for the following purposes: food, beverages, fiber, industry, and oil.
- Describe the binomial system for naming plants.
- Name the two classes for the Spermataphyta classification of plants.
- List the differences between monocots and dicots and give examples of each.
- Describe Gymnosperms and Angiosperms and give examples of each type.
- Use the terms that explain the vegetative parts of the plant.
- Identify and use terms that describe the reproductive parts of plants.
- Name three types of roots and give their functions.
- Describe a stem, give three parts of stems, and describe their functions.
- List all of the parts of a typical leaf.
- Describe types of venation in leaves.

- Compare and contrast an incomplete and complete flower.
- Identify all of the parts on a complete flower and describe their functions.
- Describe the functions of the essential reproductive parts of a flower.
- Name the two large categories of fruits.
- Identify all of the parts of a typical seed.
- Compare and contrast plant and animal cell structures.
- List the two generalized tissues in plants: meristematic and permanent.
- Describe the function of xylem and phloem.
- Identify plant tissues and describe how they are organized.
- Describe the anatomy of the primary roots, stems, and leaves.
- Discuss what soil is and where it comes from.
- Describe soil layers and how they differ.
- Discuss how plants depend on soil for growth.
- Describe the relationship between soil properties and plant growth.
- Describe the unique characteristics of water.
- List the role of water in plants.
- Describe how water moves through plants.
- Identify and explain wilt in plants; tugor pressure.
- Name four types of irrigation to fulfill the water needs of plants.
- Discuss the effects of too much or too little water.
- Explain translocation and transpiration.
- Name the essential plant nutrients and explain each nutrients role in plant health.
- Describe soil testing for determining plant nutrient need and fertilizer sources.
- Describe the effect of organic matter on soil fertility.
- Discuss how soil pH influences the availability of nutrients.
- Describe the deficiency signs of the big three nutrients.
- Explain how many pounds of nitrogen, phosphate and potash are in a bag of fertilizer.

- List five types and sources of fertilizer.
- Identify the reasons why plants require sunlight and how they use that light in the process of photosynthesis.
- Describe the growth of vegetative organs: stems, leaves, and roots.
- Discuss the coordination of vegetative growth and how environmental factors or agricultural management practices affect growth rates.
- Compare and contrast annuals, biennials, and perennials.
- List factors that lead to natural plant death.
- Describe the process of germination.
- Explain seed dormancy.
- Discuss the differences between sexual and asexual propagation.
- Describe the formation of gametes and the processes of fertilization and pollination.
- Differentiate between self-fertilization and cross-fertilization.
- Explain how plants produce seed.
- List five ways that plants may be propagated without seed.
- Discuss how and why people may improve plants; biotechnology.
- Describe three types of vegetable production.
- Identify three basic principles of vegetable production.
- Develop a plan for building a vegetable garden including the following: plant placement, irrigation, soil quality and preparation, fertilizer, types of plants, days of germination, length until harvest, and pest control.
- Define genetic engineering, biotechnology, and related terms.
- Describe future impacts of biotechnology and genetic engineering.
- List goals of genetic engineering in plants.
- Describe a transgenic plant.
- Discuss environmental, ethical, control, and conflict of interest concerns brought about by biotechnology.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on

the basis of many issues.

- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
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- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.

- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: ESS1-3d, LS1-1a, LS1-3d, LS2-3b, LS2-4aa, LS2-4b, LS3-7aa, LS3-7b, and LS3-8d.

Turf Grass Management

The student will exhibit understanding of the following Grade Span Expectations:

- Explain the role of turf grasses.
- Understand the diversity and importance of the turf grass industry.
- Describe the history of the turf grass industry.
- Describe opportunities in the turf grass industry.
- Discuss the classification of grasses.
- Explain the life cycle of grass plants.
- Describe the functions of grass plant structures.
- Explain how grass plants reproduce both sexually and asexually.
- Explain why certain turf is adapted to the warm season zone in the United States.
- Describe the important characteristics of the warm season turf grasses.
- Analyze the proper conditions for the use of each type of warm season grass.
- Discuss how a turf manager selects the best species and cultivar for a particular site.
- Explain why certain turf is adapted to the cool season zone in the United States.

- Describe the important characteristics of the cool season turf grasses.
- Analyze the proper conditions for the use of each type of cool season grass.
- Describe the components of soil.
- Explain important soil characteristics such as texture and structure.
- Discuss how texture and structure of soil affect plant growth.
- Illustrate and describe a soil profile.
- Explain how undesirable soil conditions can be improved by modifying the soil.
- Describe the most effective methods of soil modification.
- Identify organic matter sources which can be used to improve soil structure.
- Discuss the basic principles of soil fertility.
- Explain the soil pH on plant growth.
- Describe the materials used to raise or lower soil pH and their specific affect.
- State why soil testing is important.
- Collect a representative soil sample.
- Demonstrate how soil test kits are used.
- Discuss how a site must be prepared before planting.
- Analyze a seed label and identify what information is present.
- Discuss the four methods of turf grass establishment: (1) seeding, (2) sodding, (3) sprigging, and (4) plugging.
- Identify the nutrients required by turf grass plants.
- Discuss the different types of fertilizer.
- List the factors that influence the selection of an appropriate fertility program.
- Explain why nitrogen is the key element of a fertility program.
- Distinguish between fast-release and slow-release nitrogen carriers.
- Discuss the rate and frequency of fertilizer application.
- Discuss methods of fertilizer application.
- Explain why correct mowing practices are important to the quality of turf.
- Explain the effects of mowing on turf grass plants.

- Identify the factors that influence the selection of the correct cutting height.
- Describe the factors that determine how often turf grass should be cut.
- Compare and contrast the different types of mowers.
- Compare the advantages and disadvantages of collecting grass clippings.
- Distinguish between safe and unsafe mowing practices.
- Explain why a correct turf grass maintenance program results in less weed competition.
- List some of the important weed species.
- Identify the types of herbicides.
- Discuss the methods of controlling annual grasses, perennial grassy weeds, and broad leaf weeds.
- Diagnose turf grass injury caused by insects.
- Describe the ways that insect pests injure turf grass.
- Identify the insect species that are serious pests to turf grass.
- Discuss the life cycles and characteristics of major injurious pests.
- Explain how insect pests are controlled.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.

- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.
- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: ESS 1-3d, LS1-1a, LS2-3b, LS2-4b, LS3-7aa, and LS3-8a.

Wildlife Management

The student will exhibit understanding of the following Grade Span Expectations:

- Describe the development of wildlife management in America.
- List specific actions that led to wildlife management.
- Discuss the role that wildlife has played in the development of America.
- Describe the era of exploitation of America's wildlife.
- Identify common natural resources that people use.
- Compare and contrast non-renewable and renewable resources.
- Describe the importance of natural resources.
- Diagram the energy flow in an ecosystem that compares the energy at different trophic levels.
- Describe the basic habitat requirements for all wildlife.
- Describe wildlife ecosystems.
- List the elements necessary for ideal wildlife habitats.
- Explain how each element in ideal wildlife habitats is of equal importance.
- Discuss the many things that impact wildlife habitats.
- List the ways that humans have affected wildlife habitat.
- Describe human activities that destroy or harm wildlife habitat.
- Describe things that humans do to benefit wildlife.
- Explain the primary sources of funding for wildlife habitat enhancement in the United States.
- Describe the relationship between sport hunters and wildlife populations.
- List major private wildlife conservation organizations.
- Explain how funding generated by sport hunters/fishermen also benefits non-game species.
- Identify the practices used in modern wildlife management.
- Describe the factors that limit a wildlife population.
- List several species whose numbers have increased due to proper wildlife management.

- Explain why species become endangered.
- List management practices for endangered species.
- Explain how we have driven several species in the United States to extinction.
- List the requirements for species being put on an endangered list.
- Discuss the impacts of invasive and introduced species.
- Identify the common large mammals and large game in the United States.
- Describe the characteristics of common large mammals and large game in the United States.
- Identify the type of habitat where you may find large mammals or large game.
- List at least one major food source for each large mammal species.
- Describe some of the behavior traits of each large mammal species.
- Identify the common small mammals in the United States.
- Describe the characteristics of common small mammals in the United States.
- Identify the type of habitat where you may find small mammals.
- List at least one major food source for each small mammal species.
- Describe some of the behavior traits of each small mammal species
- Identify the avian predators commonly found in the United States.
- Describe some of the behavior traits of the avian predators of the United States.
- Identify the type of habitat where each avian species might be found.
- List some characteristics of each species of avian predator.
- List some of the prey species that each avian predator may utilize.
- Identify the major federal agencies directly involved in wildlife management.
- Describe the methods that these agencies use to protect wildlife resources.
- Explain the need for these federal agencies.

The student will demonstrate the following **process** benchmarks:

- Recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.

- Identify meaningful, answerable, scientific questions (e.g., cause and effect).
- Pose meaningful, answerable, scientific questions.
- Defend the need for verifiable data.
- Analyze data to make predictions, decisions, or draw conclusions.
- Describe trends revealed by data.
- Create and/or interpret graphics (e.g., scale drawings, photographs, digital images, field of view).
- Describe similarities and differences when explaining concepts and/or principles.
- Judge the reasonableness of an answer, distinguishing between fact and opinion.
- Modify or affirm scientific ideas according to accumulated evidence.
- Work individually and in teams to collect and share information and ideas.
- Use computers to produce the visual materials (e.g., tables, graphs, and spreadsheets) that will be used for communicating results.
- Use computers to perform calculations for tables, graphs, or spreadsheets.
- Recognize mathematics as an integral part of the scientific process.
- Organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes, and appropriate title).
- Use experimental data from various investigators to validate results.
- Demonstrate the ability to summarize data (e.g., measurements, observations).
- Explain scientific concepts and processes through drawing, writing, and/or oral communication.
- Use tables, graphs, and displays to support arguments and claims in both written and oral communication.
- Communicate conclusions derived through a synthesis of ideas.
- Select appropriate instruments and materials to conduct an investigation.
- Identify appropriate methods for conducting an investigation (e.g., independent and dependent variables, proper controls, repeat trials, appropriate sample size).
- Develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
- Recognize safe lab procedures.
- Demonstrate safe handling of the chemicals and materials of science.

- Determine the sources of error that limit the accuracy or precision of experimental results.
- Formulate a working hypothesis.
- Test a working hypothesis.
- Use analyzed data to confirm, modify, or reject a hypothesis.
- Acknowledge references to and contributions of others.
- Defend conclusions based on reflection and analysis of data.

The Secondary Science Grade Span Expectations that correlate to the above mentioned course are: LS2-3a, LS2-3b, and LS2-4a.

References

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