# Table of Contents: Science

## INTRODUCTION ................................................................. 1
- The Need for Reform
- The Value of a Framework
- The Standards Movement
- Standards Initiatives in Science
- How Was This Framework Developed?

## CHAPTER 1: VISIONING ...................................................... 9
- The Importance of a Local Vision
- Creating a Vision: The Local Process
- Underlying Assumptions of a Vision for Science Learning
- Science Vision Statement

## CHAPTER 2: GOAL 3 STANDARDS ......................................... 13
- The Impact of Goal 3 Standards
- Using the Goal 3 Standards
- Suggestions for Science Educators

## CHAPTER 3: SCIENCE SUNSHINE STATE STANDARDS .............. 25
- Why is Content Important?
- The Hierarchic Structure of Strands, Standards, and Benchmarks
- Introduction to the Science Strands
- Science Sunshine State Standards

## CHAPTER 4: TEACHING AND LEARNING ................................. 145
- New Approaches to Teaching and Learning
- Instructional Strategies for the 21st Century
- Snapshot of an Effective Science Classroom
Infusing a Multicultural Perspective
Snapshot of an Effective Science Classroom
Teaching Diverse Students
  Diverse Needs
  Developmental Differences
  Learning Preferences
  Students With Disabilities
  Students Who Are Limited English Proficient
  At-Risk Students
Putting These Ideas to Work

CHAPTER 5: CURRICULAR CONNECTIONS THROUGH INSTRUCTION ...................... 183
Curricular Connections and the Transfer of Learning
Models for Curricular Connections in Instruction
  Infusion
  Parallel Instruction
  Multidisciplinary Instruction
  Transdisciplinary Instruction
Planning an Interdisciplinary Unit

CHAPTER 6: ASSESSMENT ......................... 195
The Assessment Process
Different Types of Classroom Assessment
  Traditional Assessment
  Assessment Alternatives
The Use of Assessment Rubrics
The Florida Writes Rubrics

CHAPTER 7: THE LEARNING ENVIRONMENT .................... 219
Design of Facilities
Safety
Scheduling
Learning Resources
Selection of Materials
Using Technology
Snapshot of an Effective Science Classroom
CHAPTER 8: PROFESSIONAL DEVELOPMENT .................. 231
The Importance of Professional Development
Rethinking Professional Development
Preservice Education
Effective Professional Development
The Commitment to Lifelong Learning
Attributes of the Professional Educator

CHAPTER 9: SCIENCE PROGRAM IMPROVEMENT .............. 243
The Nature of School Improvement
The Evaluation Process
Planning Changes for Improvement
The Implementation Process
Taking the Next Step

RESOURCES ................................................................. 251
Introduction

CHAPTER HIGHLIGHTS

- The Need for Reform
- The Value of a Framework
- The Standards Movement
- Standards Initiatives in Science
- How Was This Framework Developed?

The Need for Reform

All over this country, educators, citizens, and political and business leaders are working toward education reform. An increasingly service-oriented, information-based society that is virtually exploding with expanding knowledge demands that everyone have the opportunity to acquire the necessary skills to succeed in the information age. Reform is needed to keep pace with opportunities presented by technological advances, new knowledge about how students learn, and new ideas about how people can improve the productivity and quality of their organizations. The need for schools to change is reinforced by the recognition that teaching and learning are most effective when the diverse needs of students are met. Worldwide economic changes and an array of political and social issues also call for new ways of operating schools.

These new conditions require citizens who are prepared to make well-reasoned, thoughtful, and healthy lifelong decisions in an ever-changing world. Students must learn how to locate, comprehend, interpret, evaluate, manage, and apply information from a variety of sources and media. They must learn how to communicate effectively in a variety of settings and for a variety of purposes through many different media. They must develop mathematical skills to analyze information, solve problems, and create products to meet new needs. They must become creative and critical thinkers, skilled in systematic problem solving. They must learn to wisely allocate resources used to solve problems. They must learn to understand systems and to use...
technology. They must develop the integrity to work cooperatively and effectively with people from many diverse backgrounds.

Florida has created a school improvement and accountability initiative to reform education in its public schools. The goal of this initiative is to raise student achievement to world-class levels. To this end, new, high-level academic standards, called the Sunshine State Standards, have been created delineating expected achievement by all students. The science standards within the Sunshine State Standards are presented in this document in chapter 3.

Florida's reform effort is based on a commitment to continuous quality improvement in every school across the state. As such, it calls for improvement teams in schools to articulate a fundamentally new direction for instruction and to reexamine the ways in which the day-to-day business of schools is conducted.

A number of assumptions provide a foundation for Florida's school improvement and accountability initiative. These include the following:

- All children can learn at high levels, given proper instruction in a supportive environment.
- All schools can be successful.
- The state focuses on accountability for student achievement; schools focus on schooling and instructional processes necessary to raise student achievement.
- Children's health, safety, social, and educational needs must be met collaboratively by schools, parents, agencies, and the community.
- The education stakeholders closest to the learners are best able to determine the appropriate strategies to identify and solve school problems and to improve instruction.
- The individual school is the unit of educational accountability for improving student performance, and school-level public reporting of effectiveness is a critical component of accountability.
- Continuous quality improvement is “the way of work”: It results in a focus on education stakeholders, collegiality, teamwork, collaboration, responsiveness, flexibility, innovations, risk taking, and effectiveness.
- The focus of Florida's reform initiative is on what students need to know and be able to do for the 21st century.
The ultimate goal of education reform is to move from schooling that was designed in, and quite appropriate for, an industrial age to one that reflects and meets the needs of the new information age. Florida’s initiative invites schools to develop learning activities for students that deal with substantial, meaningful knowledge as it relates to performance in real life. Instead of teaching only content knowledge and skills, teachers must practice the difficult art of finding ways for each student to learn and to demonstrate that learning.

This current Florida education initiative differs from earlier approaches to school reform, which were often characterized by detailed legislative mandates and minimum standards. This initiative represents a decentralized approach to reform. The state will hold schools accountable for high levels of student achievement. Local districts and schools are free to design learning environments and experiences that best help their unique students meet the Sunshine State Standards.

Education reform, then, is about developing the capacity at the local level to identify and solve problems related to raising student achievement. Raising student achievement requires both (1) raising expectations through high academic standards grounded in a foundation of reading, writing, and mathematics, applied in real-world contexts, and (2) improving the environment for effective teaching and learning based on current research about how people learn.

**The Value of a Framework**

This curriculum framework is a resource and a guide for local education communities as they restructure their schools and improve their science programs. Local planners who recognize the diversity of their students’ unique learning styles, backgrounds, attitudes, interests, aptitudes, and needs know best what specific programs will help their students reach the Sunshine State Standards.
Grounded in national and state reform initiatives, this framework does not prescribe the specifics of classroom instruction. It presents broad, overarching concepts and ideas for the development of curriculum and instruction. Curriculum guides will need to be developed at the local level to provide specific content and specific teaching, learning, and classroom assessment activities. They will need to be far more detailed than this framework and reflect the qualities and flavor of the community as well as the unique needs of the students in the community. This framework also provides overviews of instructional strategies and assessment that can help local educators create supportive, effective educational environments in which all students can achieve Florida's high academic standards and benchmarks.

A statewide external assessment program will monitor student learning in reading, writing, mathematics, and thinking skills. This system will be based on the language arts and mathematics standards articulated in those curriculum frameworks. However, in all subject areas, instruction must support the development of these essential skills.

To help local science educators meet these challenges, this framework

- delineates for stakeholders what knowledge and skills the state will hold schools accountable for students learning at four developmental levels (grades preK-2, 3-5, 6-8, and 9-12);
- gives sample performance descriptions of how students might demonstrate these skills and knowledge, often in authentic, real-world contexts;
- correlates the sample performance descriptions to Florida's Education Goal 3 Standards;
- encourages districts and schools to develop curricula guided by a locally developed vision designed to improve instruction through sound strategies and community support;
- promotes the selection and use of sound, well-developed, flexible, and innovative instructional strategies;
- provides overviews of models of good teaching, learning, and assessment that local education planners are encouraged to investigate and consider;
- presents ideas for developing connections within science and with other disciplines;
FLORIDA CURRICULUM FRAMEWORK

• discusses the practical aspects of designing a quality learning environment;
• provides suggestions for the professional development of teachers; and
• includes suggestions and criteria for continuous district and school science program improvement.

Florida's school improvement and accountability initiative envisions more effective education for students in Florida's public schools. This system describes a vision of learning and schooling that is innovative, yet sound; ambitious, yet feasible; rigorous for students and demanding of teachers, yet achievable. The ultimate goal is success for every student.

The Standards Movement

The current effort to develop national standards in various subject areas can be traced back to September 1989, when the nation's governors recommended that America establish national education goals. Leading education reformers established goals through America 2000, later renamed Goals 2000, along with a plan to meet these goals. The National Council on Education Standards and Testing recommended the development of voluntary national standards. The National Council of Teachers of Mathematics led the way in the development of national standards; subsequently, standards have been developed in many other academic areas including science.

The Secretary's Commission on Achieving Necessary Skills (SCANS) Report, developed by the U.S. Department of Labor, verified the need for a plan for education reform. The Commission was charged with examining the demands of the workplace and determining whether the young people of the United States are prepared to meet those demands. Specifically, the Commission was directed to define the skills and competencies needed for employment, propose acceptable levels of proficiency, suggest effective ways to assess proficiency, and develop a strategy for assuring that the identified skills and competencies become a part of the learning opportunity for every American student.

The SCANS Report, What Work Requires of Schools, published in June 1991, defined the workplace competencies and foundational skills required for effective job performance in today's marketplace as well as for the future. This report has had a continuing impact on schools as they work to equip students with marketable skills.
Florida's Schoolyear 2000 Initiative conducted research that verified the importance of these skills for Florida's job market. The SCANS competencies provide the basis for Florida's Education Goal 3 Standards.

**Standards Initiatives in Science**

Several initiatives greatly influenced the development of the Florida Curriculum Framework for Science. In 1989, the Florida Department of Education and the Florida Chamber of Commerce brought together business leaders and educators to produce a Comprehensive Plan for Improving Mathematics, Science and Computer Education. The Plan was used to guide policies and practices in the mathematics and science programs in Florida. It presented the ingredients for the development of a coherent, articulated, K-12 science program that allows for local innovations.

Nationally, Project 2061 of the American Association for the Advancement of Science prepared the groundwork for change in science education and subsequently released *Benchmarks for Science Literacy*. In 1992, the Florida Department of Education received a grant from the Dwight D. Eisenhower National Program in Mathematics & Science Education (Title II) to develop and implement a pre-K-12 Florida science curriculum framework. With Dr. Martha Green as the project director, *Science for All Students: The Pre K-12 Science Curriculum Framework*, *Science for all Educators*, a professional development guide, and an electronic Curriculum Planning Tool were developed. Simultaneously, the National Science Education Standards were developed under the direction of the National Research Council. Many of the over 400 people involved in the review of the state framework participated in field reviews of the national document as well. Consensus on the knowledge and skills was overwhelming.

In 1991, the Statewide Systemic Initiative in Science (SSI) was funded for five years by the National Science Foundation. SSI was charged with the systemic improvement of K-8 science in Florida. To ensure that the SSI project and the prototype framework were consistent, members of SSI were closely involved in designing the first science framework in Florida. They served on writing and advisory committees that aligned the framework with the SSI's vision and the project's regional delivery system. *Science for All Students: The Pre K-12 Science Curriculum Framework* was used in curriculum development at the SSI pilot elementary and middle schools and in many schools in districts throughout Florida.
How Was This Framework Developed?

In response to the education reform initiative reflected in Florida’s System of School Improvement and Accountability, the Florida Department of Education began the development of a new design for state curriculum frameworks in the fall of 1993. This new design is based on approaches being used in other states and was specifically based on the prototype document for science.

In January 1994, a statewide advisory committee was formed, in cooperation with the Florida Organization of Instructional Leaders, to guide the framework activities. The Principles Guiding the Development of Florida’s New Curriculum Frameworks was produced by this committee. The writing of draft frameworks in the areas of language arts, mathematics, social studies, the arts, foreign languages, and health education/physical education, along with the revision of the science framework, was coordinated by the Department of Education through representative statewide writing teams for each subject area, under the leadership of curriculum specialists from the Department of Education. The writing teams conducted extensive research on content standards and instructional practices, received input from their professional organizations, deliberated issues, reached consensus, and crafted strong initial drafts.

In 1995, systematic analysis of the drafts of the curriculum frameworks in science and other subject areas was conducted to determine the extent to which each draft addressed the Principles, Florida’s System of School Improvement and Accountability, other major state initiatives, and national curriculum standards. The analysis also examined consistency in content, style, and format across the documents. The Center for Educational Technology (CET) at Florida State University and the Mid-continent Regional Educational Laboratory (McREL) Institute in Aurora, Colorado, conducted this analysis and developed a plan for revising and preparing the final versions of the documents. The McREL Institute was selected for this work because of its expertise in the analysis of standards for curriculum and because of its knowledge of national standards. With continued input from the original curriculum framework writing teams and experts, and the assistance of CET and the McREL Institute, the revisions for each framework were prepared and reviewed.

Statewide reviews of the drafts were conducted through meetings of the original writing teams, focus groups of education stakeholders including business leaders and
members of the Florida PTA, conference presentations, and mailings to each school district. The revisions were completed early in 1996. The new curriculum frameworks will provide assistance to all education stakeholders in their collaborative efforts to raise student achievement of Florida academic and work-related standards to world-class levels.

**Key Chapter Points**

- Education reform is needed to keep pace with a changing world.
- Florida has created an education reform initiative to raise student achievement to high levels.
- This initiative empowers schools to identify and solve problems at the local level.
- The Florida Curriculum Framework for Science articulates state-mandated academic standards that raise expectations for student achievement. It also includes overviews of best practices in instruction for local educators to further investigate.
- Standards initiatives at national and state levels influenced the development of this document.
Chapter 1: Visioning

CHAPTER HIGHLIGHTS

• The Importance of a Local Vision
• Creating a Vision: The Local Process
• Underlying Assumptions of a Vision for Science Learning
• Science Vision Statement

The Importance of a Local Vision

A vision is a vivid picture of the desired future: a detailed description of what should be, could be, and might become. Effective leaders and organizations need a clear vision of their goals if they wish to make real improvement. Similarly, Florida's education improvement initiative can best be realized if local community members come together to articulate a shared vision for educational excellence in their community.

Visioning is not about simply talking or writing about missions or goals; visioning uses words to create a dynamic picture of a new condition that will be intellectually and emotionally satisfying when achieved. Unless the stakeholders—educators, support staff, students, parents, and community members—understand the reasons for change and envision the desired changes in place, education reform cannot happen. Once the picture of a new way of doing things in schools and classrooms is clearly in the minds of education stakeholders, they are often not content with the old ways.

Education leaders need to work with the community to create and communicate visions of improved schools, science classrooms, and student achievement that education stakeholders can accept and work toward. In fact, if the vision is powerful, education stakeholders will think up new strategies along the way, find unexpected
resources, work beyond expectations, and make extraordinary things happen in order to fulfill their vision.

Creating a Vision: The Local Process

Real reform of education cannot take place unless local stakeholders share a vision of the future. Schools often develop a vision for their improvement efforts, but the visioning process does not have to stop there. Science educators in every Florida school and district are also encouraged to develop and embrace a vision that defines their discipline, provides purpose and direction for improvement efforts, unifies the school community, and articulates the goals and value of a science education.

All those interested in school improvement should contribute to the development of a school's vision. Parents and guardians, business and community leaders, and other interested stakeholders are invited to join with students, educators, and other professionals in formulating a vision for substantial change. The intellectual and cultural diversity of the vision crafters will help ensure a strong, unique community vision for science education. Involvement of all stakeholders in education builds ownership of both the process and the outcomes.

Vision crafters should focus their primary attention on how best to help their students reach Florida's high academic standards. National, state, and local trends as well as best practices in curriculum, instruction, and assessment need to be considered. The vision described in this framework may also be helpful in the development of a vision for science education in each local Florida school.

Underlying Assumptions of a Vision for Science Learning

Certain underlying assumptions support the vision for science education articulated in this framework. These include

- Every person is a learner; education professionals, employers, students, and family form a community of learners.
- Effective teaching and learning connect concepts and processes to everyday events.
- A learning environment conducive to quality teaching and learning is the responsibility of the school community.
• Learning takes place both in schools and in communities.
• Cultural diversity enriches the learning environment.
• Instructional programs and teaching strategies should accommodate diverse learning styles and needs.
• Excellence in science teaching and learning grows from a commitment shared by teachers, students, parents, administrators, and the community at large.
• Learning is a lifelong process. Successful learners are lifelong learners.

**Science Vision Statement**

This vision for science education, developed by the statewide curriculum framework writing team, is presented as a starting point to encourage local communities to develop science education visions for their students, their classrooms, their schools, and their district.

Students who learn science as envisioned by this framework become citizens who are actively and joyfully engaged in the world around them, make well-reasoned data-based decisions, continue to ask thoughtful questions and explore possible responses, and clearly communicate those questions, responses, and findings to those around them.

Learning science is a lifelong adventure that positively affects people in their daily lives and careers. As students do science, they see the relationship between science and other areas of human understanding; therefore, science instruction is relevant and recognizes the different ways and settings in which people learn. A major consequence of science education is the awakening of a feeling of excitement and adventure. Students are engaged in multiple science experiences that nurture curiosity about their own world and foster joy in their increasing understanding of the phenomena they observe and investigate. They increase their ability to offer reasonable explanations, make predictions, and engage in more fruitful observations.

Through a basic knowledge of science, students learn about the world, its technology, and its environment and the decisions that must be made to preserve the planet. Science strengthens their ability to think objectively and creatively.
When members of a community work together to form a vision, they assess their programs and goals, discuss their options, and chart a course for action. A local vision of teaching and learning in science reflects the highest ideals of a school community, serving to unify the community and to clarify its commitment to program improvement. Developing a local vision for improving science education is an ongoing process, one that reflects the best of teaching, learning, and community values.

**Key Chapter Points**

- A vision is a picture created to describe the desired future.
- Visions unify a group by sensitizing everyone to the nature of commitment.
- Because they are products of communication, visions are neither static nor restrictive.
- The vision statement serves to inspire participants to believe that learning in the science can be different and better.
- Local educators are challenged to become actively involved in assuring the quality of science education for all students.
- A vision statement helps generate a sense of deliberate and conscious effort in all that is done, serving to focus a community's imagination and energy.
- The vision for science developed by the statewide curriculum framework writing team can serve as a starting point for local communities to develop their own vision.
Chapter 2: Goal 3 Standards

Chapter Highlights
- The Impact of Goal 3 Standards
- Using the Goal 3 Standards
- Suggestions for Science Educators

There are a number of general processes and abilities that are used in all subject areas. For example, locating information, organizing that information, and then using it to solve a problem or produce a product are useful abilities in virtually any area of study. Similarly, identifying the resources necessary for accomplishing a goal, setting milestones, and then managing those resources are abilities that are common to many subject areas. They are also important to success in everyday life at home, in the community, and in the workplace.

These practical but highly important cross-disciplinary processes and abilities have been identified as standards under Goal 3 in the document Florida's System of School Improvement and Accountability. One of the seven goals that are the foundation for school reform in Florida, Goal 3 deals with student performance. It states,

Students successfully compete at the highest levels nationally and internationally and are prepared to make well-reasoned, thoughtful, and healthy lifelong decisions.

In all, eleven standards are identified within Goal 3, ten dealing specifically with student achievement. This chapter describes ways in which these ten general standards can be addressed in science.

It is important to realize that the term standard is used somewhat differently in this chapter than it is in chapter 3. A Goal 3 standard describes a general category of processes and abilities that are important to all subject areas and the world of work. The Sunshine State Standards described in chapter 3 of this framework refer to the knowledge and skills specific to science.
Both the first ten standards of Goal 3 and the science standards have been adopted by the State Board of Education and represent what the state will hold schools accountable for reaching. The Goal 3 standards can be summarized as follows:

**GOAL 3 STANDARDS**

Standard 1 Information Managers  
Standard 2 Effective Communicators  
Standard 3 Numeric Problem Solvers  
Standard 4 Creative and Critical Thinkers  
Standard 5 Responsible Workers  
Standard 6 Resource Managers  
Standard 7 Systems Managers  
Standard 8 Cooperative Workers  
Standard 9 Effective Leaders  
Standard 10 Multiculturally Sensitive Citizens  
Standard 11 Involvement of Families

In each subject area in the state of Florida, students will be expected to develop their skills and abilities as information managers, effective communicators, and so on. Indeed, Florida's public schools are accountable to their stakeholders for students learning to apply the first ten standards of Goal 3 to all subject areas. Schools are expected to conduct assessments that will, along with external assessments conducted by the state on the first four standards, show that students are making progress toward Goal 3.

**Impact of Goal 3 Standards**

Many stakeholders will be affected by the teaching and assessment of Goal 3 standards. Students have a vested interest in understanding and attaining the Goal 3 standards, because these standards will affect their ability to function effectively in their personal and professional lives. Parents or other caregivers must participate in their children's learning process and in the assessment of their children's performance on Goal 3 standards. Standard 11 of Goal 3 calls on families to "share the responsibility of accomplishing the standards set in Goal 3 throughout a student's education from preschool through 12th grade." School administrators and staff should welcome parents as full partners in helping students improve their academic
performance by making time and opportunities for mutual communication available. Parents need to communicate with school personnel regarding curriculum, assessment, and goals for individual students, provide a home environment that is supportive of improving student performance, and provide encouragement and discipline as appropriate to support school success.

Teachers must assume new and different roles in assessment. New approaches to understanding student learning and performance will place teachers in the position of assessing student progress in more authentic ways. These expanded assessments should reflect how students will need to use content knowledge, as well as the Goal 3 general processes and abilities, in real life—now and in their future.

Florida's school administrators have primary responsibility for encouraging, facilitating, and initiating changes within their schools. School administrators will be primarily responsible for identifying strategies for accessing teacher training offered by their district, the state, and other sources such as universities and colleges. Administrators' primary responsibilities within the framework of Goal 3 assessment will be to support the integration of assessment and instruction in the classroom and establish school reporting systems for the multiple data sources that will be derived from Goal 3 assessment activities.

The business community stands to benefit greatly from the emphasis on Goal 3 standards. Indeed, the Goal 3 standards directly address skills effective workers need to be successful in the 21st century. The skills identified in the U.S. Department of Labor's SCANS Report on necessary skills for the workplace are the basis of the Goal 3 standards. Consequently, Florida’s emphasis on the Goal 3 standards is an investment in the success of the business community.

**Using the Goal 3 Standards**

The Goal 3 standards do not exist in isolation; they should be an integral part of daily classroom instruction and assessment. To a great extent, the Goal 3 standards can be thought of as generic processes and abilities that help students apply specific science content knowledge to real-world situations. As students learn science content, they are using the processes and abilities involved in being an information manager, effective communicator, numeric problem solver, and so on.
Teachers should directly address the processes and abilities involved in the Goal 3 standards. In fact, the Goal 3 processes and abilities can and should become a common “language” that is used in every classroom at every grade level. In this section, examples are provided to illustrate how each of the first ten standards can be used in science education. All of the examples depict activities that the teacher designs to help students learn new knowledge and apply that knowledge to classroom and real-world activities. The designing of classroom tasks is one of the most important parts of the art of teaching. In the past, classroom activities often provided little flexibility in terms of the knowledge involved, what students do with that knowledge, and how students demonstrate their competence. The tasks designed around the Goal 3 standards should not be limiting. Each of the Goal 3 standards can play a significant role in developing tasks designed to integrate real-world problems and situations into classroom activities.

**Standard 1:** Florida students locate, comprehend, interpret, evaluate, maintain, and apply information, concepts, and ideas found in literature, the arts, symbols, recordings, video and other graphic displays, and computer files in order to perform tasks and/or for enjoyment.

Proficient **information managers** acquire, use, and manage information purposefully. Developing information managers involves creating tasks that require skills in information acquisition, use, and management. These tasks range from daily functions in school and work settings to everyday activities at home and in the community.

The infusion of technology and multimedia in various spheres of life has placed increased demands on information management skills. People frequently face challenges in locating, interpreting, applying, evaluating, and storing information. Numerous daily tasks require competence in the skills and abilities of Standard 1. Common examples include

- interpreting weather maps on television or in the newspaper;
- reading or giving directions to get to places;
• accessing information from data storage systems, such as electronic encyclopedias or atlases;
• setting up and operating a new appliance, such as a VCR;
• following instructions to complete income tax returns;
• keeping important documents and records organized;
• interacting on electronic networks, such as the Internet; and
• interpreting statistical data.

**Standard 2:** Florida students communicate in English and other languages using information, concepts, prose, symbols, reports, audio and video recordings, speeches, graphic displays, and computer-based programs.

**Effective communicators** convey thoughts, ideas, and information purposefully. Developing effective communicators involves creating tasks that require skills for transmitting and receiving communications. Communications are transmitted when a student speaks, writes, performs, or creates products. Communications are received by students through observing, reading, and listening—the skills of Standard 1. Media technology can significantly enhance communications.

To be competitive in the 21st-century global economy, students should be able to communicate effectively, not only in English, but also in one or more foreign languages. It is also important for students to be able to use languages pertinent to specialized areas, for example, mathematical notation and vocabulary, scientific language, Latin terminology, music notation, and computer languages.

Communication is an essential form of human engagement. Success in the skills and abilities that are part of Standard 2 is vital to success in school, at home, and the workplace. Common examples of activities that involve communication skills include

• making a multimedia presentation to introduce a new marketing strategy;
• writing letters of application for jobs or educational programs;
• making formal or informal announcements;
• writing a technical report or a business plan;
• initiating and making conversation;
• writing or reciting a poem;
• viewing and listening to an opera or play; and
• discussing, as a member of a team or committee, ways to solve a problem.

**Standard 3:** Florida students use numeric operations and concepts to describe, analyze, disaggregate, communicate, and synthesize numeric data, and to identify and solve problems.

**Numeric problem solvers** analyze and solve mathematical or quantitative problems in applied situations in school, life, and the workplace. Developing numeric problem solvers involves creating tasks that require students to gather, read, manipulate, interpret, organize, and analyze quantitative data. Numeric problem solvers also verify, explain, and justify solutions to quantitative or mathematical problems. Students must be able to take advantage of technology such as calculators and computers that support mathematical problem solving. Common examples of activities that require competence in the skills and abilities of Standard 3 include

• understanding bus, train, and plane schedules;
• determining the best value of things to buy;
• keeping accounts and budgets for different purposes;
• measuring ingredients for recipes and distances for travel; and
• gathering, summarizing, and analyzing data to determine needs in particular situations.

**Standard 4:** Florida students use creative thinking skills to generate new ideas, make the best decision, recognize and solve problems through reasoning, interpret symbolic data, and develop efficient techniques for lifelong learning.

**Creative and critical thinkers** gather new information to answer questions and make conclusions, connections, and inferences from existing information. Creative thinking involves divergent thinking, originality, and the ability to find novel or unique relationships and solutions. Creative thinkers have a high tolerance for ambiguity; they seek out opposing viewpoints.

Developing creative and critical thinkers involves creating tasks that require students to become proficient in using critical and creative thinking processes to solve problems. As they progress through their school years, students are expected to
apply various problem-solving processes to the scientific method, logical analysis, trial-and-error techniques, and the creation of functional objects, works of arts, and performances. Students also must be able to creatively deal with limitations imposed upon the creative process, such as space limitations or lack of availability of materials. Teachers should nurture attitudes of persistence and perseverance during problem-solving activities.

**Standard 5**: Florida students display responsibility, self-esteem, sociability, self-management, integrity, and honesty.

In order to develop responsible workers, educators should emphasize the personal and social attributes that form positive social skills, such as self-management behaviors, self-esteem, and honesty. These attributes are used in day-to-day interactions with people in school, at home, in the community, and in the workplace.

Unlike Standards 1 to 4, which focus on cognitive and academic development, Standard 5 emphasizes affective and social growth as well as self-discipline. Instruction in the skills and abilities of Standard 5 occurs in formal and informal interactive settings. Teachers, parents, the school community, and the community at large should work as partners to develop students as responsible workers. The learning environment must be conducive to nurturing the personal and social attributes that define Standard 5. Positive behaviors can be reinforced through consistent role modeling by peers and adults. Mentoring, counseling, individual education plans, and contracts between teachers and students are effective ways to help students become responsible workers.

**Standard 6**: Florida students will appropriately allocate time, money, materials, and other resources.

Developing effective resource managers involves helping students learn to allocate and manage resources to complete projects and tasks. Instruction in and assessment of the skills and abilities delineated in Standard 6 occur as students prepare action plans to accomplish tasks, allocate time and necessary resources, implement plans, and evaluate whether or not the resources allocated were adequate. Students can demonstrate their effectiveness as resource managers at home, in school and school-related activities, in the community, and in the workplace.
The intent of Standard 6 is to help students become proficient in allocating time, preparing and following time lines, preparing budgets, and acquiring and distributing materials and other resources, such as facilities, technology, or environmental resources. These skills can be used when conducting research, developing products, or preparing presentations.

**Standard 7:** Florida students integrate their knowledge and understanding of how social, organizational, informational, and technological systems work with their abilities to analyze trends, design and improve systems, and use and maintain appropriate technology.

Developing proficient systems managers involves helping students understand what systems are, how they work, and how to use the systems approach to solve problems or design solutions. Instruction in and assessment of the skills and abilities of Standard 7 occur as students analyze information and solve problems that help them see the big picture and its parts.

The intent of Standard 7 is to help students use the systems approach as a way of getting a better grasp of events and phenomena in their world. Thus, helping students learn about the natural systems of science, the systems of language, and systematic mathematical thinking is a good way to introduce the concept of systems. Efficient systems managers use systems concepts to process information, solve problems, develop new models, or change existing systems to produce better results.

Various concepts can be studied using the systems approach. Students should be able to identify and understand natural, social, organizational, informational, and technological systems. Systems in their world include grading systems, the education system, the lunchroom system, computer systems, government systems, and the judicial system.

**Standard 8:** Florida students work cooperatively to successfully complete a project or activity.

In order to develop cooperative workers, educators should emphasize the attributes and interpersonal skills necessary to work effectively in teams, a process that is used extensively in the work world. The goal is to develop students and workers who can interact cooperatively and productively in groups.
Unlike Standard 5 (responsible workers), which deals with affective and social growth on a personal level, Standard 8 deals with goal- or task-oriented social behaviors that involve group work. To help develop cooperative workers, opportunities must be provided for students to perform tasks in cooperative groups. Such opportunities should help students understand group processes, assume various roles in the group, keep the group on task, motivate the group toward task completion, and evaluate the effectiveness of the group in accomplishing goals. Instruction in the skills and abilities of Standard 8 might occur in classroom, community, or workplace-like settings.

**Standard 9:** Florida students establish credibility with their colleagues through competence and integrity, and help their peers achieve their goals by communicating their feelings and ideas to justify or successfully negotiate a position that advances goal attainment.

In order to develop effective leaders, educators should emphasize the attributes and interpersonal skills necessary for students to advance group and individual goals. Students must learn to develop skills in listening, communicating, decision making, conflict resolution, and negotiation. This standard aims to develop students who can lead groups productively.

Standard 9 is closely related to Standard 5 (responsible workers), which deals with affective and social growth on a personal level, and Standard 8 (cooperative workers), which deals with goal- or task-oriented group behaviors. In order to help develop effective leaders, opportunities must be provided for students to take on leadership responsibilities in safe, nonthreatening environments. Such opportunities should help students learn to communicate directly, treat individuals fairly, and separate work- and group-related issues from personal ones.

**Standard 10:** Florida students appreciate their own culture and the cultures of others, understand the concerns and perspectives of members of other ethnic and gender groups, reject the stereotyping of themselves and others, and seek out and utilize the views of persons from diverse ethnic, social, and educational backgrounds while completing individual and group projects.

In order to develop multiculturally sensitive citizens and workers, educators should help students become knowledgeable about their own cultural backgrounds and the cultures of others. Instruction in and assessment of the skills and abilities of Standard 10 should help students understand the importance of treating others with
dignity and respect. This standard involves broadening students' knowledge and understanding of the languages, customs, beliefs, traditions, and values of different cultures.

**Standard 11:** Families will share the responsibility of accomplishing the standards set in Goal 3 throughout a student's education from preschool through 12th grade.

Educators are encouraged to invite and facilitate the involvement of families in their children's education. Parents should be encouraged to volunteer in the classroom, help at home with homework and projects, monitor progress through parent-teacher conferences, generate community support for education, and model lifelong learning.

**Suggestions for Science Educators**

Schools will be held accountable for incorporating the Goal 3 student-achievement standards into instruction and classroom assessment. The following are examples of science classroom activities that integrate the Goal 3 standards:

Students use a rain gauge to collect and measure local rainfall and create a graph showing rainfall over a specified time period. Using appropriate reference materials, they investigate the link between rainfall and vegetation types in their region and prepare written reports on their findings. In this activity, students apply computation skills to a scientific investigation and use data to make connections between natural phenomena.

This example uses Standard 1, information managers; Standard 2, effective communicators; Standard 3, numeric problem solvers; Standard 4, creative and critical thinkers; and Standard 6, resource managers.

Students track the progress of a space probe, such as the Voyager or Galileo. They use the Internet to gather information transmitted by the probe. Students use this information to classify the planets in our Solar System by atmospheres, chemical makeup, sets of rings, and natural satellites.

This example uses Standard 1, information managers; Standard 4, creative and critical thinkers; Standard 6, resource managers; and Standard 7, systems managers.
Working in groups, students design and carry out experiments on molecular spacing and motion using helium-filled balloons. They investigate the effects of pressure and volume changes on the motion of the balloons and develop conclusions based on their research. Each student keeps a journal documenting his or her participation in the project. The students graph the results of their findings and make presentations to the class.

This example uses Standard 2, effective communicators; Standard 3, numeric problem solvers; Standard 4, creative and critical thinkers; Standard 5, responsible workers; and Standard 8, cooperative workers.

Students investigate the effects of environment on the development of civilizations. They collect data on weather patterns, climate, vegetation, water supply, and terrain from desert, tropical, mountain, and coastal regions. Working in groups, the students assimilate their information and discuss the implications of their findings on the development of civilizations in each region. Each student in the group picks one topic to study, linking scientific knowledge to a cultural development. After conducting additional independent research, each student leads a group discussion on his or her topic of study. In this activity, students use leadership and cooperative learning skills to apply scientific knowledge to human social developments.

This example uses Standard 1, information managers; Standard 2, effective communicators; Standard 4, creative and critical thinkers; Standard 6, resource managers; Standard 8, cooperative workers; Standard 9, effective leaders; and Standard 10, multiculturally sensitive citizens.

**Key Chapter Points**

- The first ten standards of Florida’s Goal 3 Standards are general processes and abilities that cut across all subject areas.

- These processes and abilities are important to success in school and in everyday life at home, in the community, and in the work world.

- These Goal 3 Standards should be an integral part of daily classroom instruction and assessment in every subject area at every grade level; they will help students apply specific content knowledge in real-world situations.
Chapter 3: Science
Sunshine State Standards

Chapter Highlights
- Why is Content Important?
- The Hierarchic Structure of Strands, Standards, and Benchmarks
- Introduction to the Science Strands
- Science Sunshine State Standards

Morgan is in science class. The topic of today's lesson is energy associated with phase changes from solid to liquid. Morgan and her lab group have designed an experiment to find out how much energy it takes to melt an ice cube. They perform the experiment, collecting and analyzing their data. They communicate the results to the other groups and carefully evaluate other groups' experimental designs. The teacher leads a discussion to relate the concept of energy in phase changes to life and earth systems as well as to the physical system of melting ice. She emphasizes that their experiment demonstrated change and that change occurs in all systems. Morgan's teacher knows that she has used science concepts, processes of science, habits of mind, and unifying themes in planning this lesson.

The standards and benchmarks for science represent the heart of this curriculum framework because high standards are the center of the efforts to reform and enhance education in Florida. Before addressing the science standards, it is useful to consider why we need academic standards. In her book National Standards in American Education: A Citizen's Guide, Diane Ravitch, former Assistant Secretary of Education at the U.S. Department of Education, explains that standards are a necessary and accepted part of American life in almost every field but education:

Americans clamor for standards in nearly every part of their lives. They expect strict standards to govern construction of buildings, bridges, highways, and tunnels; shoddy work would put lives at risk. They expect explicit standards in the field of telecommunications; imagine how difficult life would be if every city, state, and nation had incompatible telephone systems. They expect
stringent standards to protect their drinking water, the food they eat, and the air they breathe.... Even the most ordinary transactions of daily life reflect the omnipresence of standards. (pp. 8-9)

Standards have the potential of affecting many aspects of schooling in Florida. The science curriculum—what teachers teach and how they teach it—should be organized around the science standards. Assessment is one of the most obvious areas that will be affected. The state will be assessing reading, writing, and mathematics based on the language arts and mathematics curriculum frameworks. However, on the local level, the state standards for science should form the basis for classroom assessments for science. Finally, the systems used to report student progress—report cards and transcripts—should have a clear relationship with these academic standards. In short, the science standards presented in this framework should be the starting point for science education within Florida’s education system. This chapter presents those standards in detail.

**Why is Content Important?**

Changes in society and technology have greatly impacted what is and is not fundamental for a scientifically literate adult. To prepare our students for the changing world, the content of traditional curriculum, its organization, and presentation must be adapted to better meet the needs of students.

The content of this chapter is built upon the use of themes, processes, and habits of mind. These organizers are not mutually exclusive; they are woven into the fabric of this chapter. The content included is not exhaustive. Indeed, the Florida Curriculum Framework for Science recommends a shift from too much content treated superficially to fewer topics with more in-depth, thematic coverage. It also identifies concepts that all students should know and examples of some activities that all students should be able to do.

The explosive growth of scientific knowledge and continual developments in technology have transformed society. Homes, schools, and workplaces are much different now then they were a decade ago. Consequently, science education should be designed for lifelong learning in a world shaped in part by science and technology. The Florida Curriculum Framework for Science acknowledges the simple truth that “no
one can know it all,” but it also recognizes the need for every student to know something about science. Science should be a basic part of every student’s education.

There are three essential parts to science content. The first includes concepts, principles, facts, laws, and theories—the body of scientific knowledge. Science also includes processes, which are methods used to investigate the natural world. These processes involve the reasoning and inquiry techniques needed to achieve scientific knowledge. Finally, science includes certain attitudes or habits of mind common to other disciplines. These habits encourage the practice of critical and creative thinking as well as ethical behavior.

Just as we use written and spoken language to communicate in science, students should understand that mathematics is an important way of communicating scientific information. Databases are important as sources of background information. In modern scientific research, computers are used to gather, synthesize, analyze, and display data. In investigating the natural world, students should use the language of mathematics, search databases, and use computers to prepare for an increasingly technological future.

The best information available from current curriculum reform initiatives went into the development of a science content core. Ideas came from the National Science Teachers Association’s (NSTA) Scope, Sequence, and Coordination of Secondary Science, the National Assessment of Educational Progress, AAAS’s Project 2061, and the National Research Council.

According to the National Science Education Standards (1996), content is important if it

- represents central scientific ideas and organizing principles;
- has rich explanatory and predictive power;
- motivates the formulation of significant questions; and
- is applicable in many situations and contexts common to everyday experiences.
The Hierarchic Structure of Strands, Standards, and Benchmarks

The standards presented in this chapter have a specific hierarchic structure. There are several levels of information, each more specific than the next.

Subject area = domain, content area, such as language arts, mathematics, science, music

Strand = label (word or short phrase) for a category of knowledge, such as reading, algebraic thinking, nature of matter, skills and techniques

Standard = general statement of expected learner achievement

Benchmark = learner expectations (what a student should know and be able to do) at the end of the developmental levels of grades PreK-2, 3-5, 6-8, 9-12

Sample Performance Descriptions = examples of things a student could do to demonstrate achievement of the benchmark

Correlations to Goal 3 Standards = identification of the specific Goal 3 standards that are incorporated into the sample performance descriptions.

The strands, standards, and benchmarks make up the Sunshine State Standards. These have been adopted by the State Board of Education as a rule, 6A-1.09401, FAC. This rule requires public schools to provide appropriate instruction to assist students in the achievement of these standards. Each district school board must incorporate the Sunshine State Standards into the district Pupil Progression Plan.

A strand is the most general type of information. A strand is a label for a category of knowledge under which standards are subsumed. There are eight strands in science:

Strand A: The Nature of Matter
Strand B: Energy
Strand C: Force and Motion
Strand D: Processes that Shape the Earth
Strand E: Earth and Space
Strand F: Processes of Life
Strand G: How Living Things Interact With Their Environment
Strand H: The Nature of Science

Each of these strands contains two or more standards. A standard is a description of general expectations regarding knowledge and skill development within a strand. For example, within science Strand A: The Nature of Matter, there are two science standards:

Standard 1: The student understands that all matter has observable, measurable properties.

Standard 2: The student understands the basic principles of atomic theory.

These science standards provide more specific guidance concerning what students should know and be able to do in relationship to the Nature of Matter strand.

The most specific level of information is the benchmark. A benchmark is a statement of expectations about student knowledge and skill at the end of one of four developmental levels: grades PreK-2, 3-5, 6-8, and 9-12. Benchmarks translate science standards into expectations at different levels of student development. Within a science standard, one would expect high school students to be performing differently from primary students. The benchmarks describe these differing levels of expectations. Although the identified developmental levels span several grades in order to accommodate continuous progress approaches, the benchmarks describe expected achievement as students exit the developmental level, that is, at the end of second grade, at the end of fifth grade, at the end of eighth grade, and at the end of twelfth grade. It is expected that several benchmarks might often be combined in a single teaching or assessment activity. The listing of separate benchmarks should not be construed to mean that students must demonstrate achievement of them one at a time, to be checked off by the teacher.

Expectations of student knowledge and skills are described in the benchmarks, but the benchmarks are also written with some assumptions regarding student learning. Although knowledge and skills stated at an earlier level of schooling might not be reiterated within benchmarks at later levels, they remain important and should be
reinforced and even retaught, if necessary. For example, in the early years, if students are expected to master the concept that sound is caused by vibrations, learning and assessments in later grades should also incorporate this knowledge, even though the expectation is not explicitly restated within benchmarks for the later years. It is also assumed that in meeting the expectations described in these benchmarks, students are working with material that is developmentally appropriate with regard to their age, developmental level, and grade level.

Accompanying the benchmarks are sample performance descriptions. These sample performance descriptions suggest how teachers might ask students to apply the knowledge and skill described in the benchmark. For example, consider the following benchmark at the 6-8 level within science Strand A, Standard 1:

The student knows that equal volumes of different substances may have different masses.

The sample performance description that accompanies this benchmark is

[Achievement of the benchmarks may be demonstrated when the student] determines the mass of a solution, a solute, and a solvent before and after mixing and mathematically compares the mass of the whole with the mass of the parts.

To perform this activity, students must apply the knowledge and skill described in the benchmark.

Each sample performance description is keyed to specific Goal 3 standards; for example, in the above sample performance description, students are using the processes and abilities associated with Goal 3 Standards 1, 2, 3, 4, and 6. In addition, these sample performance descriptions incorporate Goal 3 performance at the appropriate developmental levels. In chapter 2, Goal 3 standards were described as an integral part of Florida education. The first ten standards within Goal 3 are to be integrated into each content area.

The sample performance descriptions and their Goal 3 correlations are meant to suggest to local curriculum and assessment developers and teachers the kinds of classroom assessment activities that can be used with the benchmarks. They are not one-to-one assessment items for the benchmarks; neither are they state-mandated
assessment activities. They serve only to suggest to local curriculum and assessment designers and teachers how they might begin to think about ways to determine if students are achieving or are making adequate progress toward achieving the benchmarks. They also provide examples of ways in which to integrate knowledge and skills from other content areas. As districts implement these frameworks, it is anticipated that more sample performance descriptions will be developed that are grade specific and will cover the scope of the benchmarks. Designers and teachers should choose the content, topic, or processes for the activities appropriate to the local curriculum and develop completely new performance descriptions.

For ease of reference, the table of standards and benchmarks uses an identification system that mirrors the hierarchic structure just described. Each strand, standard, benchmark, and sample performance description has been assigned a unique identification code. The codes associated with the benchmarks and sample performance descriptions reflect the structure of this coding system. For example, note the following benchmark:

SC.G.2.2.3
The student understands that changes in the habitat of an organism may be beneficial or harmful.

This code indicates that the benchmark is in the content area of science (SC) under Strand G, How Living Things Interact With Their Environment. The next two numbers identify the standard (2) under which the benchmark is categorized, and the developmental level (2) designated for this benchmark, that is, grades 3-5. The last number, 3, signifies that this is the third benchmark found under the standard at this developmental level. Sample performance descriptions share a similar identification code but differ in having a lowercase letter appended. This can be seen in the code for a sample performance description associated with the benchmark above:

SC.G.2.2.3.a
Achievement of the benchmarks may be demonstrated when the student writes a story about an organism whose habitat has changed, describing the consequences of this change to the organism.
The letter “a” indicates that this is the first sample performance description provided for this benchmark.

In addition to the coding system, the layout of the table that follows reflects the hierarchic structure: Each new strand, standard, and benchmark level begins a new page. This offers an easy way for teachers to re-sort and organize the material by developmental level.

The standards and benchmarks in the curriculum frameworks identify the essential knowledge and skills that students should learn, for which the state will hold schools accountable. Nevertheless, how the standards and benchmarks are organized, what specific curriculum, instructional strategies, materials, and activities are designed to teach them, how much time is spent teaching them, and when they are taught within the developmental levels are local decisions.

**Introduction to the Science Strands**

Knowledge strands consist of standards and benchmarks that provide the foundation for the understanding and application of scientific knowledge. With the accompanying sample performance descriptions, these strands emphasize the use of knowledge by providing problems, projects, and current science-related issues that allow students to use critical thinking and decision-making techniques.

The ideas within the standards and benchmarks are reinforced and extended in a spiral manner at a successively higher progression of understanding. The ideas in the higher grades are framed in a larger, more global context allowing students to relate science, not only to themselves, but to the rest of the world.

Common to all scientific disciplines, the **processes of science** are used to construct science knowledge. These processes not only help students find meaning in science and other disciplines, but help them develop important life management skills:

- formulating questions;
- making predictions;
- planning experiments;
- making observations;
To use the processes of science successfully, it is necessary to develop certain attitudes or habits of mind. These include

- honesty,
- skepticism,
- creativity,
- curiosity,
- tolerance,
- open-mindedness,
- sharing, and
- objectivity.

The Florida Curriculum Framework for Science recommends that students have opportunities to practice and develop to the fullest their habits of mind. Students become scientists as they think about paradoxes, conflicting philosophies, and the implications of their own beliefs and actions. As students question, wonder, argue, dream, plan, fail, succeed, rethink, innovate, and imagine, they learn that education is a lifelong journey.

**Strand A: The Nature of Matter**

An amazing variety of materials and objects make up the physical world. Central to an understanding of matter is that it has observable, measurable properties. All matter occupies space, has mass, and may exist in three common states: solid, liquid, and gas. Each of these states has different characteristics. Things can be done to materials (e.g., cutting, heating, and freezing) to change their appearance and some of their properties. Matter undergoes many changes that can be classified as physical and chemical changes. Materials made by chemically combining two or more substances may have properties that differ from the original materials. Many different materials can be made by combining basic substances; many different objects can be made by combining different materials.
Atomic theory is also a key concept connected to an understanding of matter. Scientists have demonstrated that despite differences in shape, color, texture, and density, all matter is really composed of building blocks called atoms. Consisting of a massive nucleus of protons and neutrons, surrounded by a "cloud" of electrons, atoms are capable of undergoing fission and nuclear fusion reactions, which produce large amounts of energy. Substances that are made of the same kinds of atoms are called elements. Different kinds of atoms can combine to form simple molecules of substances, such as water, as well as the most complex molecules in the universe, such as proteins.

Through observation, comparison, and classification, students can learn the basic properties and characteristics of matter, and begin to see the role of matter in the everyday world. Other methods further develop students' understanding of matter and how it behaves under a variety of circumstances.

**Strand B: Energy**

Energy is an abstract but fundamental concept in science. Learning about energy is essential to understanding changes observed in natural and human-made systems. Energy manifests itself in a variety of forms, including mechanical, chemical, electrical, magnetic, nuclear, and radiant energy. These forms of energy often convert into one another, which involves work and/or heat. Everything that goes on in the universe, from the collapsing of stars to the production of food, involves the transformation of one form of energy to another.

Energy concepts are an integral part of all scientific disciplines. Energy functions in a variety of ways. Objects and substances store energy both chemically and physically. Plants use energy in the process of photosynthesis. Electrical energy is used to run machines and appliances, and produce light. Physical and chemical reactions require or release energy. In living organisms, all biological processes involve chemical reactions and energy. Building, erosion, and rebuilding of the earth requires energy.

Students should understand the role of energy use in society. Each type of energy source has its advantages and disadvantages. Consequently, society must make tradeoffs in choosing energy sources for personal and industrial use. Political and economic pressures influence the use of different types of energy sources as well.
Strand C: Force and Motion

Force and motion are essential components of the physical and biological world. Everything from atoms and molecules to the earth and everything on its surface moves. In fact, the universe is never at rest. Position in space, distance traveled, displacement, speed, velocity, and acceleration are all properties of motion. Forces explain phenomena such as starting, stopping, changing direction, floating, falling, and many other motion-related phenomena. Although a large number of forces have been discovered, they can all be classified into four fundamental types: gravitational, electromagnetic, strong nuclear, and weak nuclear. When forces act upon objects, the speed and direction of the motion changes. Both force and motion can be described, measured, and predicted.

The relationship between force and motion of an object is central to understanding different types of movement that occur everyday. Isaac Newton's Three Laws of Motion explain this relationship: The first and second laws generalize the relationship between forces and changes in motion; the third law describes fundamental properties of all forces.

Strand D: Processes that Shape the Earth

The physical laws that have governed the entire universe in the past are the same ones that govern material interactions today. Understanding and applying these laws to geological processes provides insight into how Earth formed, how it has evolved, and how it continues to change. The Earth is a unique planet with four major interacting systems: lithosphere (solid), atmosphere (gas), hydrosphere (liquid), and biosphere (life). Processes in these four systems interact to shape the Earth.

The Earth’s surface is in a continuous state of change. Waves, wind, ice and other factors change Earth’s surface to produce the features of the land such as cliffs, deserts, and shorelines. Wind and water move soil downstream and deposit it. Rain and evaporation influence the shape of the land. Other changes include movements inside the Earth that create mountains and ocean basins, and cause earthquakes and volcanic eruptions.

Through a variety of methods, the need for protection of the natural systems of the Earth is expected. An understanding of human involvement in Earth’s systems is of
utmost importance. Humans can affect the Earth in a variety of ways. Water, air, and soil are limited natural resources. The processes and products of the Earth need to be examined in light of how humans can make informed decisions about the use of its resources. Conversely, land formation, climate, and resources of Earth’s surface affect where and how people live and how human history unfolds.

**Strand E: Earth and Space**

We are part of the Earth and the universe. Although our planet is quite insignificant when viewed as part of the entire universe, we know its relevance in time and space. In our quest for meaning, scientists attempt to verify the constancy of natural laws, detect the possible presence of other intelligent beings, and predict the future evolutionary paths of our galaxy.

The interaction and organization of matter and energy in our solar system and the universe is central to an understanding of Earth and space. The organization of the solar system, the galaxy, and the universe is fundamental. The universe is the sum total of the existing matter and energy that surrounds us in all directions. No discussion of the solar system, galaxy, and the universe is complete without an analysis of the current theories surrounding the formation of the known universe.

Students expand their understanding of Earth and space by studying the role of the Earth in the solar system and the universe. The size of the solar system, the relationship of the planets to one another, the Earth-Moon relationship, the features of other planets, and the development of stars contribute to a stronger understanding of the relationship between Earth and the vast universe. The development of technology associated with space travel has helped students gain a sense of astronomical distance, explore the basic chemistry of intergalactic space, and learn the arrangement of bodies found within and outside galaxies. X-ray telescopes, computer simulations of gravitational systems, nuclear reactions, space-probes, and supercollider simulations generate data about our universe. Using these data allows scientists to examine small slices of time and space, accounting for most of our expanding knowledge of the universe.
Strand F: Processes of Life

A fundamental goal of the biological sciences is to understand the essential processes of life on Earth. Central to an understanding of these processes are the patterns of structure and function in living things. Organisms are linked to one another and to their physical settings via an exchange of matter and energy that allows for the growth, maintenance, and change of living things. Through a variety of methods, students should learn elements of anatomy, stages of life, the ways in which microbes infect the body, and the social impact of some diseases, such as Acquired Immune Deficiency Syndrome (AIDS).

Students should also learn the fundamental characteristics of living things, the functions of cells, the mechanisms of evolution, and the process and importance of genetic diversity. Organisms maintain a set of systems, each designed to perform a different function necessary to grow, survive, and reproduce a new generation. During reproduction, genetic material provides for both the inheritance of traits from one generation to the next and the variation that can, in time, lead to differences within a species and to different species. The result of this process is a rich variety of interdependent life forms on our planet.

Strand G: How Living Things Interact With Their Environment

Living things depend on one another and their environment. This strand attempts to expand that knowledge. It describes specific relationships that exist among organisms, the kinds of physical conditions that organisms must endure, and the kinds of environments created by the interaction of organisms with one another and with their physical surroundings. The complexity of living, interdependent systems as well as the competitive, cyclic nature of living things in the environment is described. Interactions between plants, animals, and microorganisms, the relationship between food webs and ecosystems, the process of natural selection, and changes in the environment that have produced qualitative changes in the plant and animal species inhabiting earth are examples of the types of interactions students...
should understand. Many different examples of ecosystems, starting with those near at hand, should be provided.

In keeping with the concept of interdependence, the consequences associated with the use of limited natural resources are provided. The Earth has limited resources, and living things must compete for them. Organisms that are best adapted to compete for the available resources in the environment have the greatest chance of survival. Successful organisms survive to pass their adaptations to their offspring. Despite their dependence on the environment for survival, humans today are placing their environmental support systems at risk. Rapid human population growth is pushing Earth's resources to its limits. Because of the impact of human economic systems, environmental degradation and resource depletion is threatening the carrying capacity and the biological diversity of the biosphere. Understanding these critical problems is essential to extending biological awareness into the study of social science, history, and literature.

**Strand H: The Nature of Science**

The nature of science and the nature of inquiry are synonymous. Using the process of inquiry, scientists ask carefully posed questions about the natural world. Such scientific investigation becomes the main pathway to knowledge for scientists and students alike. Inquiry can result either from the students' direct observation of the natural world or the discovery that present knowledge has evolved from previous investigations by others. Either way, inquiry is a critical component of the science curriculum. As students grow and mature, so does their ability to use the various inquiry-related process skills.

Students should become familiar with the scientific processes of scrutiny, skepticism, curiosity, and verification associated with problem solving. Scientists use a variety of methods to implement these processes: collecting things, designing and conducting simple experiments, making predictions, asking questions about observations, classifying things and observations, and making generalizations. Measuring tools and other instruments are also used by scientists to obtain information from their surroundings. Through the study of historical and current discoveries, scientists provide information about the inquiry process and its effects. Scientists not only explore the natural world but also communicate the results of their explorations to others. This communication is essential to all human activity. Scientists
communicate with oral and written words, diagrams, maps, graphs, and mathematical equations.

Central to an understanding of the nature of science is the idea that most natural events occur in comprehensible, consistent patterns. Using their intellect and aided by instruments that extend the senses, scientists can discover patterns in nature. Scientific tools such as microscopes, balances, and other instruments facilitate inquiry and problem solving. Because science historically relies on evidence, great value is placed on the development of better instruments and techniques of observations. The findings of any one investigator or group usually are verified by others.

Students should recognize that science, technology, and society are interwoven and interdependent. Because science is related to real-world issues, it requires a thoughtful critique of all aspects of investigations as well as extensive opportunities for setting up, executing, and designing investigations. Science is a complex social activity that provides information, insight, and analytical skills needed in matters of public concern. Scientific information helps us understand the likely causes of natural or technological events and estimate the possible effects of projected policies.

**A Closing Word**

Learning emerges from context and connectedness. This chapter provides benchmarks of what all students should know and be able to do in science. These examples encourage students to apply knowledge, collect, analyze, and interpret data, and develop values. It is important that students experience and interact with the natural world before they learn terms, symbols, and equations that scientists use to explain the natural world. Students should actively seek information by making connections, rather than just absorbing facts.

Finally, this chapter provides the flexibility science curriculum planners need to design programs based on local needs. The strands, themes, processes, and habits of mind accommodate both an integrated and a connected approach to science education.
Summary of Strands and Standards for Science

A. The Nature of Matter
   1. The student understands that all matter has observable, measurable properties.
   2. The student understands the basic principles of atomic theory.

B. Energy
   1. The student recognizes that energy may be changed in form with varying efficiency.
   2. The student understands the interaction of matter and energy.

C. Force and Motion
   1. The student understands that types of motion may be described, measured, and predicted.
   2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

D. Processes That Shape the Earth
   1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.
   2. The student understands the need for protection of the natural systems on Earth.

E. Earth and Space
   1. The student understands the interaction and organization in the Solar System and the Universe and how this affects life on Earth.
   2. The student recognizes the vastness of the Universe and the Earth’s place in it.

F. Processes of Life
   1. The student describes patterns of structure and function in living things.
   2. The student understands the process and importance of genetic diversity.
G. How Living Things Interact With Their Environment
   1. The student understands the competitive, interdependent, cyclic nature of living things in the environment.
   2. The student understands the consequences of using limited natural resources.

H. The Nature of Science
   1. The student uses the scientific processes and habits of mind to solve problems.
   2. The student understands that most natural events occur in comprehensible, consistent patterns.
   3. The student understands that science, technology, and society are interwoven and interdependent.
## A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Grade</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PreK-2</td>
<td>SC.A.1.1.1</td>
<td>SC.A.1.1.1a observes, groups, and describes the volumes, shapes, colors, and weights of common objects.</td>
<td>1, 3, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SC.A.1.1.1.b groups common articles based on one or two attributes (e.g., things that are round and rough, things that are square and smooth) and explains the system used to group objects.</td>
<td>1, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC.A.1.1.2</td>
<td>SC.A.1.1.2.a observes, compares, and contrasts the observable properties of common solids, liquids, and gases.</td>
<td>3, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC.A.1.1.3</td>
<td>SC.A.1.1.3.a uses senses to compare and contrast the observable properties of material (e.g., texture, color, reaction to temperature changes, and magnetic characteristics).</td>
<td>2, 4</td>
</tr>
</tbody>
</table>
## A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades</td>
<td>SC.A.1.2.1</td>
<td>SC.A.1.2.1.a uses scientific equipment to classify or order a set of objects using length, weight, or volume and explains the classification scheme used. SC.A.1.2.1.b compares properties of oil and water and discusses the implications for oil spills.</td>
<td>2, 3, 6, 9</td>
</tr>
<tr>
<td>3-5</td>
<td>determines that the properties of materials (e.g., density and volume) can be compared and measured (e.g., using rulers, balances, and thermometers).</td>
<td></td>
<td>1, 5, 7</td>
</tr>
<tr>
<td></td>
<td>SC.A.1.2.2</td>
<td>SC.A.1.2.2.a observes, describes, and compares changes of state for several common substances.</td>
<td>4, 7</td>
</tr>
<tr>
<td></td>
<td>knows that common materials (e.g., water) can be changed from one state to another by heating and cooling.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| Grades 3-5 | SC.A.1.2.3  
knows that the weight of an object always equals the sum of its parts. | SC.A.1.2.3.a  
compares the weight of a box of crayons or an orange when whole and when taken apart. | 1, 3, 4 |
| | SC.A.1.2.4  
knows that different materials are made by physically combining substances and that different objects can be made by combining different materials. | SC.A.1.2.4.a  
constructs different things using the same small parts (e.g., blocks, Legos, Tinker Toys, or geometric shapes), takes the structures apart, and rearranges them to form other constructs. | 1, 3, 4, 7 |
| | SC.A.1.2.5  
knows that materials made by chemically combining two or more substances may have properties that differ from the original materials. | SC.A.1.2.5.a  
observes and describes the properties of vinegar-and-oil and starch-and-water mixtures respectively and compares the properties of the mixtures to those of each ingredient. | 1, 3, 4 |
### A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.A.1.3.1</td>
<td>identifies various ways in which substances differ (e.g., mass, volume, shape, density, texture, and reaction to temperature and light).</td>
<td>1, 4, 6</td>
</tr>
<tr>
<td></td>
<td>SC.A.1.3.2</td>
<td>understands the difference between weight and mass.</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>SC.A.1.3.3</td>
<td>knows that temperature measures the average energy of motion of the particles that make up the substance.</td>
<td>1, 3, 4, 5</td>
</tr>
</tbody>
</table>
## A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| Grades 6-8 | S.C.A.1.3.4  
knows that atoms in solids are close together and do not move around easily; in liquids, atoms tend to move farther apart; in gas, atoms are quite far apart and move around freely. | S.C.A.1.3.4.a  
measures the pressure, temperature, and volume of a gas sample and identifies how these factors influence one another.  
S.C.A.1.3.4.b  
describes the reason for the rise of a hot-air balloon in terms of molecular spacing and motion.  
S.C.A.1.3.4.c  
describes characteristics (e.g., shape, size, weight, and volume) that change and those that do not change when a solid, such as ice, first melts and then evaporates. | 1, 2, 3, 4 |
|       | S.C.A.1.3.5  
knows the difference between a physical change in a substance (i.e., altering the shape, form, volume, or density) and a chemical change (i.e., producing new substances with different characteristics). | S.C.A.1.3.5.a  
chemically combines a variety of substances and determines if the resulting materials are different from the original materials.  
S.C.A.1.3.5.b  
explains how chemical and physical changes relate to events such as the water cycle, the carbon cycle, and plant growth. | 1, 2, 3, 4, 7 |
|       |           |                               | 1, 2, 4, 6, 9   |

Sunshine State Standards: Science, 1996
## A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.A.1.3.6 knows that equal volumes of different substances may have different masses.</td>
<td>SC.A.1.3.6.a determines the mass of a solution, a solute, and a solvent before and after mixing and mathematically compares the mass of the whole with the mass of the parts.</td>
<td>1, 2, 3, 4, 6</td>
</tr>
</tbody>
</table>
### A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.A.1.4.1 knows that the electron configuration in atoms determines how a substance reacts and how much energy is involved in its reactions.</td>
<td>SC.A.1.4.1.a interprets data from experiments to predict the mass ratio by which elements combine to form compounds.</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>SC.A.1.4.2 knows that the vast diversity of the properties of materials is primarily due to variations in the forces that hold molecules together.</td>
<td>SC.A.1.4.2.a determines the density of common solids, liquids, and gases, compares their values, and reports findings.</td>
<td>1, 2, 3, 4, 6</td>
</tr>
<tr>
<td></td>
<td>SC.A.1.4.3 knows that a change from one phase of matter to another involves a gain or loss of energy.</td>
<td>SC.A.1.4.3.a designs an experiment and collects data to determine if the average thermal energy of the particles in a solid is less than the average thermal energy of the particles in liquid or gaseous form and reports findings.</td>
<td>1, 3, 4</td>
</tr>
</tbody>
</table>
A. The Nature of Matter

1. The student understands that all matter has observable, measurable properties.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.A.1.4.4 experiments and determines that the rates of reaction among atoms and molecules depend on the concentration, pressure, and temperature of the reactants and the presence or absence of catalysts.</td>
<td>SC.A.1.4.4.a works with a team to demonstrate a mathematical relationship between solubility and temperature for a simple solid.</td>
<td>1, 2, 3, 4, 6, 8</td>
</tr>
<tr>
<td></td>
<td>SC.A.1.4.5 knows that connections (bonds) form between substances when outer-shell electrons are either transferred or shared between their atoms, changing the properties of substances.</td>
<td>SC.A.1.4.5.a grows crystals, observes them under a microscope, and works with others to create models of the crystalline structure.</td>
<td>1, 2, 6, 7, 8</td>
</tr>
</tbody>
</table>
A. The Nature of Matter

2. The student understands the basic principles of atomic theory.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.A.2.1.1 recognizes that many things are made of smaller pieces, different amounts, and various shapes.</td>
<td>SC.A.2.1.1.a with other students in a small group, examines common objects (e.g., rocks, styrofoam, and fruitcake) where they are commonly found and identifies smaller units, numbers, and shapes within the objects.</td>
<td>1, 2, 4, 8, 9</td>
</tr>
</tbody>
</table>
## A. The Nature of Matter

2. The student understands the basic principles of atomic theory.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.A.2.2.1 knows that materials may be made of parts too small to be seen without magnification.</td>
<td>SC.A.2.2.1.a uses a hand lens to observe things smaller than the eye can normally see. The student then describes these things and records his or her observations.</td>
<td>1, 2</td>
</tr>
</tbody>
</table>
## A. The Nature of Matter

2. The student understands the basic principles of atomic theory.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.A.2.3.1 describes and compares the properties of particles and waves.</td>
<td>SC.A.2.3.1.a uses technology and mathematical equations to describe light when it behaves like a particle and when it behaves like a wave.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.A.2.3.2 knows the general properties of the atom (a massive nucleus of neutral neutrons and positive protons surrounded by a cloud of negative electrons) and accepts that single atoms are not visible.</td>
<td>SC.A.2.3.2.a with other students in a small group, constructs models of several kinds of atoms and describes their properties. SC.A.2.3.2.b analyzes various substances to determine that the atoms of any element are alike but are different from atoms of other elements.</td>
<td>1, 2, 3, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.A.2.3.3 knows that radiation, light, and heat are forms of energy used to cook food, treat diseases, and provide energy.</td>
<td>SC.A.2.3.3.a discusses constructive uses of common forms of energy.</td>
<td>1, 2, 6, 7</td>
</tr>
</tbody>
</table>
# A. The Nature of Matter

2. The student understands the basic principles of atomic theory.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.A.2.4.1 knows that the number and configuration of electrons will equal the number of protons in an electrically neutral atom and when an atom gains or loses electrons, the charge is unbalanced.</td>
<td>SC.A.2.4.1.a with other students in a small group, develops hypotheses, designs simple experiments to explain variations in the acidity or alkalinity (pH) of local water samples, and reports on findings and the processes used.</td>
<td>1, 2, 3, 4, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.A.2.4.2 knows the difference between an element, a molecule, and a compound.</td>
<td>SC.A.2.4.2.a with other students in a small group, designs and carries out an experiment to oxidize glucose to form elemental carbon and reports on findings in a balanced equation and on processes used.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.A.2.4.3 knows that a number of elements have heavier, unstable nuclei that decay, spontaneously giving off smaller particles and waves that result in a small loss of mass and release a large amount of energy.</td>
<td>SC.A.2.4.3.a discusses the positive and negative effects of the use of radioactive isotopes.</td>
<td>1, 2, 4, 9</td>
</tr>
</tbody>
</table>
### A. The Nature of Matter

2. The student understands the basic principles of atomic theory.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>S.C.A.2.4.4</td>
<td>knows that nuclear energy is released when small, light atoms are fused into heavier ones.</td>
<td>SC.A.2.4.4.a explains how life on Earth ultimately depends on the fusion reactions taking place in the Sun.</td>
</tr>
<tr>
<td></td>
<td>S.C.A.2.4.5</td>
<td>knows that elements are arranged into groups and families based on similarities in electron structure and that their physical and chemical properties can be predicted.</td>
<td>S.C.A.2.4.5.a predicts the chemical and physical properties of hydrogen, oxygen, nitrogen, and carbon atoms and compounds, using the periodic table to make generalizations about properties of certain elements.</td>
</tr>
<tr>
<td></td>
<td>S.C.A.2.4.6</td>
<td>understands that matter may act as a wave, a particle, or something else entirely different with its own characteristic behavior.</td>
<td>S.C.A.2.4.6.a gives examples of when matter acts as a wave, a particle, or something entirely different.</td>
</tr>
</tbody>
</table>
## B. Energy

1. The student recognizes that energy may be changed in form with varying efficiency.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades</td>
<td>PreK-2</td>
<td>The student achievement of the benchmarks may be demonstrated when the student</td>
<td>1, 2, 3, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.1.1 knows that the Sun supplies heat</td>
<td>SC.B.1.1.1.a places a thermometer in the sunlight, records and graphs the change in temperature</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and light energy to Earth.</td>
<td>over time, and compares the results with other students.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC.B.1.1.2 knows that light can pass through</td>
<td>SC.B.1.1.2.a uses a light source to shine through objects and to cast shadows of other objects</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>some objects and not others.</td>
<td>and compares the results.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC.B.1.1.3 describes a model energy system</td>
<td>SC.B.1.1.3.a builds a biosphere in a plastic soda bottle and identifies visible changes over time</td>
<td>1, 2, 3, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>(e.g., an aquarium or terrarium).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC.B.1.1.4 knows that heat can be produced</td>
<td>SC.B.1.1.4.a identifies and discusses several ways in which heat can be produced.</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td></td>
<td>in many ways (e.g., by burning and rubbing).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC.B.1.1.5 knows that every human action</td>
<td>SC.B.1.1.5.a lists different kinds of things to eat that give people energy and discusses why</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>requires energy that comes from food.</td>
<td>people eat snacks.</td>
<td></td>
</tr>
</tbody>
</table>
B. Energy

1. The student recognizes that energy may be changed in form with varying efficiency.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.B.1.2.1 knows how to trace the flow of energy in a system (e.g., as in an ecosystem).</td>
<td>SC.B.1.2.1.a draws a food pyramid for a terrarium and explains the transfers of energy.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.2.2 recognizes various forms of energy (e.g., heat, light, and electricity).</td>
<td>SC.B.1.2.2.a explores the room and identifies different energy sources.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.2.3 knows that most things that emit light also emit heat.</td>
<td>SC.B.1.2.3.a designs an experiment to measure the amount of heat released from various light sources.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
</tbody>
</table>
### B. Energy

1. The student recognizes that energy may be changed in form with varying efficiency.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.B.1.2.4 &lt;br&gt;knows the many ways in which energy can be transformed from one type to another.</td>
<td>SC.B.1.2.4.a &lt;br&gt;identifies several processes that involve energy transformation.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.2.5 &lt;br&gt;knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measured in ways that make it possible to determine the amount of energy that is transformed.</td>
<td>SC.B.1.2.5.a &lt;br&gt;calculates and reports the amount of energy used by the school each day and graphs the results.</td>
<td>1, 2, 3, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.2.6 &lt;br&gt;knows ways that heat can move from one object to another.</td>
<td>SC.B.1.2.6.a &lt;br&gt;designs, conducts, and explains an experiment to show that some materials conduct heat better than others.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
</tbody>
</table>
## B. Energy

1. The student recognizes that energy may be changed in form with varying efficiency.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td>SC.B.1.3.1 identifies forms of energy and explains that they can be measured and compared.</td>
<td>SC.B.1.3.1.a uses appropriate mathematical models to represent energy released and transformed.</td>
<td>1, 2, 3, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.3.2 knows that energy cannot be created or destroyed, but only changed from one form to another.</td>
<td>SC.B.1.3.2.a constructs a simple circuit (given the necessary materials) that can do work and explains the energy transfers taking place in the system.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.3.3 knows the various forms in which energy comes to Earth from the Sun (e.g., visible light, infrared, and microwave).</td>
<td>SC.B.1.3.3.a uses diffraction gratings and prisms to investigate light from different sources, interprets the data, and develops new hypotheses. SC.B.1.3.3.b draws an electromagnetic spectrum and places all forms of radiant energy along the continuum according to wavelength.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
B. Energy

1. The student recognizes that energy may be changed in form with varying efficiency.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| Grades 6-8 | SC.B.1.3.4  
knows that energy conversions are never 100% efficient (i.e., some energy is transformed to heat and is unavailable for further useful work). | SC.B.1.3.4.a  
determines, compares, and reports fuel efficiency for vehicles of the same weight, engine size, and aerodynamics. | 1, 2, 3, 7       |
|       | SC.B.1.3.5  
knows the processes by which thermal energy tends to flow from a system of higher temperature to a system of lower temperature | SC.B.1.3.5.a  
gives examples of the types of heat transfer down a thermal gradient. | 1, 2, 4, 7       |
|       | SC.B.1.3.6  
knows the properties of waves (e.g., frequency, wavelength, and amplitude); that each wave consists of a number of crests and troughs; and the effects of different media on waves. | SC.B.1.3.6.a  
experiments with tuning forks, ripple tanks, slinkies, and other objects to observe and analyze the properties of waves. | 1, 2, 3, 4, 6, 7 |
## B. Energy

1. The student recognizes that energy may be changed in form with varying efficiency.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 9-12</strong></td>
<td>SC.B.1.4.1</td>
<td>The student understands how knowledge of energy is fundamental to all the scientific disciplines (e.g., the energy required for biological processes in living organisms and the energy required for the building, erosion, and rebuilding of the Earth).</td>
<td>1, 2, 3, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.4.2</td>
<td>SC.B.1.4.2.a designs, conducts, and reports on an experiment to determine the effect of several variables on home or school use of electricity.</td>
<td>1, 2, 3, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.4.3</td>
<td>SC.B.1.4.3.a measures and reports latent heat of fusion for an ice cube.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
## B. Energy

1. The student recognizes that energy may be changed in form with varying efficiency.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.B.1.4.4 knows that as electrical charges oscillate, they create time-varying electric and magnetic fields that propagate away from the source as an electromagnetic wave.</td>
<td>SC.B.1.4.4.a with other students in a small group, builds an electromagnetic generator, measures the energy generated when applied in a household tool, and reports on the process and results.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.4.5 knows that each source of energy presents advantages and disadvantages to its use in society (e.g., political and economic implications may determine a society’s selection of renewable or nonrenewable energy sources).</td>
<td>SC.B.1.4.5.a with other students in a small group, designs and constructs a solar collector, collects data on its effectiveness, and compares this model with other designed by classmates.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.B.1.4.6 knows that the first law of thermodynamics relates the transfer of energy to the work done and the heat transferred.</td>
<td>SC.B.1.4.6.a diagrams a heat pump at work in heating and in cooling and shows areas of high-pressure vapor, low-pressure vapor, high-pressure liquid, and low-pressure liquid.</td>
<td>1, 2, 4, 5, 6, 7</td>
</tr>
</tbody>
</table>
|             | SC.B.1.4.7 knows that the total amount of usable energy always decreases, even though the total amount of energy is conserved in any transfer. | SC.B.1.4.7.a demonstrates activities that increase the entropy in a system.  
SC.B.1.4.7.b demonstrates the conservation of energy and mass in a system. | 1, 2, 4, 7 |
# B. Energy

2. The student understands the interaction of matter and energy.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.B.2.1.1 recognize systems of matter and energy.</td>
<td>SC.B.2.1.1.a identifies the parts of a simple system (e.g., parts of a manual egg beater in use).</td>
<td>1, 2, 7</td>
</tr>
</tbody>
</table>

The student

Sample Performance Descriptions

Achievement of the benchmarks may be demonstrated when the student
# B. Energy

2. The student understands the interaction of matter and energy.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.B.2.2.1 knows that some source of energy is needed for organisms to stay alive and grow.</td>
<td>SC.B.2.2.1.a with other students in a small group, designs, conducts, and explains an experiment to identify the effects of energy on plant or animal growth.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.B.2.2.2 recognizes the costs and risks to society and the environment posed by the use of nonrenewable energy.</td>
<td>SC.B.2.2.2.a gives examples of substances, situations, and materials that store energy and explains how that energy can be released.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.B.2.2.3 knows that the limited supply of usable energy sources (e.g., fuels such as coal or oil) places great significance on the development of renewable energy sources.</td>
<td>SC.B.2.2.3.a uses common objects to design and construct an apparatus or device that will store energy.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
</tbody>
</table>
### B. Energy

#### 2. The student understands the interaction of matter and energy.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.B.2.3.1. knows that most events in the universe (e.g., weather changes, moving cars, and the transfer of a nervous impulse in the human body) involve some form of energy transfer and that these changes almost always increase the total disorder of the system and its surroundings, reducing the amount of useful energy.</td>
<td>SC.B.2.3.1.a designs, performs, and reports on an experiment to show how food energy is used by the body and identifies instances where energy is transformed from one form to another. SC.B.2.3.1.b with other students in a small group, given necessary materials, constructs a simple circuit that can do work and explains the energy transfers taking place in the system.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.B.2.3.2. knows that most of the energy used today is derived from burning stored energy collected by organisms millions of years ago (i.e., nonrenewable fossil fuels).</td>
<td>SC.B.2.3.2.a keeps a record of the kinds of energy used in the classroom and identifies the sources.</td>
<td>1, 2, 5, 6, 7</td>
</tr>
</tbody>
</table>
## B. Energy

2. The student understands the interaction of matter and energy.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.B.2.4.1 knows that the structure of the universe is the result of interactions involving fundamental particles (matter) and basic forces (energy) and that evidence suggests that the universe contains all of the matter and energy that ever existed.</td>
<td>SC.B.2.4.1.a compares the interactions of energy and matter on Earth with models of these interactions in the galaxy.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## C. Force and Motion

1. The student understands that types of motion may be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.C.1.1.1 understands that different things move at different speeds.</td>
<td>SC.C.1.1.1.a moves a toy car across the room, measures the distance it travels in a specific time, and describes how big and little pushes affect the motion of the car.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.1.1.2 knows that there is a relationship between force and motion.</td>
<td>SC.C.1.1.2.a observes a student walking at various speeds across the playground and describes his or her motion using terms such as fast, slow, speed up, and slow down. SC.C.1.1.2.b observes various moving toys and describes what causes them to move.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## C. Force and Motion

1. The student understands that types of motion may be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.C.1.2.1</td>
<td>The student understands that the motion of an object can be described and measured.</td>
<td>SC.C.1.2.1.a describes and compares the distance traveled and the speed and motion of various types and sizes of balls. SC.C.1.2.1.b describes the motion of an object traveling down an incline plane placed at various heights in terms of time, distance traveled, and direction.</td>
</tr>
<tr>
<td></td>
<td>SC.C.1.2.2</td>
<td>knows that waves travel at different speeds through different materials.</td>
<td>SC.C.1.2.2.a generates waves in different materials, then measures and compares the time required for waves to move the same distance.</td>
</tr>
</tbody>
</table>
### C. Force and Motion

1. The student understands that types of motion may be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.C.1.3.1 knows that the motion of an object can be described by its position, direction of motion, and speed.</td>
<td>SC.C.1.3.1.a calculates the average speed of a toy or an animal moving in a straight or curved path by making appropriate measurements with a ruler and timing device</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>SC.C.1.3.2 knows that vibrations in materials set up wave disturbances that spread away from the source (e.g., sound and earthquake waves).</td>
<td>SC.C.1.3.2.a determines and reports the length, direction, and speed of the waves when a solid sphere is dropped into flexible material.</td>
<td>1, 2, 3, 4</td>
</tr>
</tbody>
</table>
### C. Force and Motion

1. The student understands that types of motion may be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.C.1.4.1. knows that all motion is relative to whatever frame of reference is chosen and that there is no absolute frame of reference from which to observe all motion.</td>
<td>SC.C.1.4.1.a gives an example of an object moving in a circular path and finds and compares its speed, period, frequency, acceleration and centripetal force with other masses and reports these findings.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.1.4.2. knows that any change in velocity is an acceleration.</td>
<td>SC.C.1.4.2.a collects and graphs data and explains that acceleration is a change in velocity or direction of travel.</td>
<td>1, 2, 3</td>
</tr>
</tbody>
</table>
### C. Force and Motion

2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.C.2.1.1.1 knows that one way to change how something is moving is to give it a push or a pull.</td>
<td>SC.C.2.1.1.a with others in a small group, designs a boat to carry cargo and compares motion when the boat is pushed or pulled empty and full. SC.C.2.1.1.b fills a box with different amounts of cargo and compares the amount of pushing or pulling required to move the box across the floor.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.1.2 knows that sound is caused by vibrations (pushing and pulling) to cause waves.</td>
<td>SC.C.2.1.2.a talks forcefully into a bowl filled with water, draws the patterns of waves that result, and compares findings with others in a group.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
C. Force and Motion

2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 3-5</strong></td>
<td>SC.C.2.2.1 recognizes that forces of gravity, magnetism, and electricity operate simple machines.</td>
<td>SC.C.2.2.1.a designs a simple machine, explains how the effort force is applied and how the machine applied resistance force, and suggests uses for the machine. SC.C.2.2.1.b uses building blocks to make simple machines.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.2.2 knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.</td>
<td>SC.C.2.2.2.a concludes which of several magnets exerts the largest force by counting how many paper clips it will pick up. The student then describes the motion of the clips toward the magnet. SC.C.2.2.2.b uses a spring to launch paper airplanes by applying different amounts of pressure. The student then determines and reports the speed, distance, and direction traveled.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
## C. Force and Motion

2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| **Grades 3-5** | SC.C.2.2.3  
knows that the more massive an object is, the less effect a given force has. | SC.C.2.2.3.a  
collects data and draws conclusions about the relationship between the mass of a ball and the distance traveled when pushed. | 1, 2, 3, 4, 7 |
| | SC.C.2.2.4  
knows that the motion of an object is determined by the overall effect of all of the forces acting on the object. | SC.C.2.2.4.a  
identifies the forces that act on an object.  
SC.C.2.2.4.b  
determines, compares, and reports the distance traveled and the speed and motion of various kinds and sizes of balls as they are thrown. | 1, 2, 3, 4, 7 |
## C. Force and Motion

2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td>SC.C.2.3.1 knows that many forces (e.g., gravitational, electrical, and magnetic) act at a distance (i.e., without contact)</td>
<td>SC.C.2.3.1.a measures the distance over which different forces act and plots the data on a graph.</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.3.2 knows common contact forces.</td>
<td>SC.C.2.3.2.a measures the various net forces acting on an object and their effects, makes a model of the object and the forces acting on it, and develops an explanation for the resulting motion of the object.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.3.3 knows that if more than one force acts on an object, then the forces can reinforce or cancel each other, depending on their direction and magnitude</td>
<td>SC.C.2.3.3.a uses circular and bar magnets and iron filings to determine magnetic fields, designs a demonstration to show lines of force in two dimensions, and suggests other forces that may be acting on the fields.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.3.4 knows that simple machines can be used to change the direction or size of a force</td>
<td>SC.C.2.3.4.a determines and explains the effectiveness of a lever in moving objects with different masses.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
## C. Force and Motion

2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.C.2.3.5 understand that an object in motion will continue at a constant speed and in a straight line until acted upon by a force and that an object at rest will remain at rest until acted upon by a force.</td>
<td>SC.C.2.3.5.a collects data on the distance various objects will travel at a constant speed and in a straight line before coming to rest. The student interprets these data and explains how distance may be increased or decreased.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.3.6 explains and shows the ways in which a net force (i.e., the sum of all acting forces) can act on an object (e.g., speeding up an object traveling in the same direction as the net force, slowing down an object traveling in the direction opposite of the net force).</td>
<td>SC.C.2.3.6.a with other students in a small group, designs a parachute to demonstrates that two or more forces determine the net force acting on an object by designing a parachute. The student then describes the forces acting on the parachute during descent.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.3.7 knows that gravity is a universal force that every mass exerts on every other mass.</td>
<td>SC.C.2.3.7.a determines and reports the relationship of cotton puff balls and tennis balls to one another when they are poured from a bucket onto a smooth surface.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## C. Force and Motion

2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.C.2.4.1, knows that acceleration due to gravitational force is proportional to mass and inversely proportional to the square of the distance between the objects.</td>
<td>SC.C.2.4.1.a calculates and reports the acceleration and motion of several different objects when released from the same position.</td>
<td>1, 2, 3, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.4.2, knows that electrical forces exist between any two charged objects.</td>
<td>SC.C.2.4.2.a measures, compares, and reports the electrical forces between charged objects.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.4.3, describes how magnetic force and electrical force are two aspects of a single force.</td>
<td>SC.C.2.4.3.a observes, interprets, and explains the behavior of a compass needle near a permanent magnet.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.4.4, knows that the forces that hold the nucleus of an atom together are much stronger than electromagnetic force and that this is the reason for the great amount of energy released from the nuclear reactions in the sun and other stars.</td>
<td>SC.C.2.4.4.a formulates a model of radioactive decay, explains why hospitals keep radioactive materials for ten half-lives before disposing of these materials and calculates the fraction of the original activity left after ten half-lives.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
### C. Force and Motion

2. The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.C.2.4.5 knows that most observable forces can be traced to electric forces acting between atoms or molecules</td>
<td>SC.C.2.4.5.a describes how electric forces on neutral particles may be used to collect soot in smokestacks and paint cars uniformly.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.C.2.4.6 explains that all forces come in pairs commonly called action and reaction.</td>
<td>SC.C.2.4.6.a demonstrates that for every action there is an equal and opposite reaction by identifying the places on a roller-coaster ride where one feels heavier or lighter. SC.C.2.4.6.b with other students in a small group, designs and builds a model car or vehicle that uses energy stored in a spring or the potential energy stored in a lifted weight to provide force to propel the vehicle. The student then measures the distance traveled, the speed, and the acceleration of the vehicle, and reports on the processes used and findings.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>

Sunshine State Standards: Science, 1996
# D. Processes that Shape the Earth

1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades PreK-2</strong></td>
<td>SC.D.1.1.1</td>
<td>recognizes that the solid materials making up the Earth come in all sizes, from boulders to grains of sand. SC.D.1.1.1.a sorts samples of rocks, gravel, sand, and clay into groups of different sizes and describes the results.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.1.2</td>
<td>knows that life occurs on or near the surface of the Earth in land, air, and water. SC.D.1.1.2.a gives examples of things that live in the water, on land, and in the air.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.1.3</td>
<td>recognizes patterns in weather. SC.D.1.1.3.a records changes in temperature and rainfall daily and compares findings for the school year.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## D. Processes that Shape the Earth

1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.D.1.2.1 knows that larger rocks can be broken down into smaller rocks, which in turn can be broken down to combine with organic material to form soil.</td>
<td>SC.D.1.2.1.a with other students in a small group, investigates properties of rocks and minerals using hand lenses and microscopes. The student then develops systems to group minerals and rocks into sets that have similar properties and reports findings.</td>
<td>1, 2, 4, 5, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.2.2 knows that 75 percent of the surface of the Earth is covered by water.</td>
<td>SC.D.1.2.2.a calculates, compares, and reports the area of the surface of the Earth that is water and the area that is land.</td>
<td>1, 2, 3, 7</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.2.3 knows that the water cycle is influenced by temperature, pressure, and the topography of the land.</td>
<td>SC.D.1.2.3.a graphs daily weather changes and then describes and compares weather situations in various places on Earth.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## D. Processes that Shape the Earth

1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 3-5</strong></td>
<td>SC.D.1.2.4&lt;br&gt;knows that the surface of the Earth is in a continuous state of change as waves, weather, and shifts of the land constantly change and produce many new features.</td>
<td>SC.D.1.2.4.a&lt;br&gt;collects, analyzes, and presents data on the location, size, and distribution of earthquakes recorded during the last ten years. SC.D.1.2.4.b&lt;br&gt;predicts the outcome when a quart of water is dumped into one end of a sand-filled tank and makes observations to verify the prediction.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.2.5&lt;br&gt;knows that some changes in the Earth’s surface are due to slow processes and some changes are due to rapid processes.</td>
<td>SC.D.1.2.5.a&lt;br&gt;uses local examples to show and compare geologic processes that occur in a week (e.g., gully washes) and those that take years (e.g., river beds).</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
### D. Processes that Shape the Earth

1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td>SC.D.1.3.1 knows that mechanical and chemical activities 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.</td>
<td>SC.D.1.3.1.a uses a ripple tank to demonstrate the processes that formed the local landscape (e.g., shorelines, sand dunes, and sinkholes).</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.3.2 knows that over the whole Earth, organisms are growing, dying, and decaying as new organisms are produced by the old ones.</td>
<td>SC.D.1.3.2.a examines fossils, explains the similarities and differences between different fossils and between fossils and living organisms, and discusses why they remain.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.3.3 knows how conditions that exist in one system influence the conditions that exist in other systems.</td>
<td>SC.D.1.3.3.a researches and reports on the influence of conditions in a hydrologic system that affect a biotic system.</td>
<td>1, 2, 6, 7</td>
</tr>
</tbody>
</table>
D. Processes that Shape the Earth

1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td><strong>SC.D.1.3.4</strong> knows the ways in which plants and animals reshape the landscape (e.g., bacteria, fungi, worms, rodents, and other organisms add organic matter to the soil, increasing soil fertility, encouraging plant growth, and strengthening resistance to erosion).</td>
<td>SA.C.D.1.3.4.a with other students in a small group, constructs and explains models that show how plants and animals may change the landscape.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td><strong>SC.D.1.3.5</strong> understands concepts of time and size relating to the interaction of Earth’s processes (e.g., lightning striking in a split second as opposed to the shifting of the Earth’s plates altering the landscape, distance between atoms measured in Angstrom units as opposed to distance between stars measured in light-years).</td>
<td>SC.D.1.3.5.a constructs models in stream tables and wave tanks and then writes a report on erosion and deposition. SC.D.1.3.5.b demonstrates how ocean basins are formed and how, through weathering and erosion, they make available many of the minerals upon which our society depends.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
</tbody>
</table>
## D. Processes that Shape the Earth

1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 9-12</strong></td>
<td>SC.D.1.4.1 knows how climatic patterns on Earth result from an interplay of many factors (Earth's topography, its rotation on its axis, solar radiation, the transfer of heat energy where the atmosphere interfaces with lands and oceans, and wind and ocean currents).</td>
<td>SC.D.1.4.1.a creates climatograms and explains why major biomes exist.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.D.1.4.2 knows that the solid crust of Earth consists of slow-moving, separate plates that float on a denser, molten layer of Earth and that these plates interact with each other, changing the Earth's surface in many ways (e.g., forming mountain ranges and rift valleys, causing earthquake and volcanic activity, and forming undersea mountains that can become ocean islands).</td>
<td>SC.D.1.4.2.a describes how and why the appearance of the surface of the Earth is changing.</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC.D.1.4.2.b in small groups with other students, determines the density and porosity of common rocks found in the crust (e.g., granite, basalt, sandstone, and limestone) and explains the significance of their crustal positions.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC.D.1.4.2.c develops models that explain the theories of how continents are assembled, altered, and changed over vast amounts of time.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### D. Processes that Shape the Earth

1. The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| **Grades 9-12** | SC.D.1.4.3  
knows that changes in Earth’s climate, geological activity, and life forms may be traced and compared.  
SC.D.1.4.3.a  
compares and describes methods for determining the ages of organic materials. | 1, 2, 4, 7 |
| | SC.D.1.4.4  
knows that Earth’s systems and organisms are the result of a long, continuous change over time.  
SC.D.1.4.4.a  
designs a flow chart or other mechanism to show how one change in a system, such as the advent of an ice age or the emergence of a new mountain range, causes changes in other systems. | 1, 2, 4 |
D. Processes that Shape the Earth

2. The student understands the need for protection of the natural systems on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.D.2.1.1 understands that people influence the quality of life of those around them.</td>
<td>SC.D.2.1.1.a provides examples of how people have changed the air, water, and land.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## D. Processes that Shape the Earth

2. The student understands the need for protection of the natural systems on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.D.2.2.1 knows that reusing, recycling, and reducing the use of natural resources improve and protect the quality of life</td>
<td>SC.D.2.2.1.a in small groups with other students, develops, implements, and reports on a plan to recycle in the home and in school.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
## D. Processes that Shape the Earth

2. The student understands the need for protection of the natural systems on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| Grades 6-8 | SC.D.2.3.1 understands that quality of life is relevant to personal experience | SC.D.2.3.1.a participates in and reports on school and community efforts to conserve, and/or recycle community resources.  
SC.D.2.3.1.b develops and presents a personal action plan to use recyclable materials and products whenever possible.  |
|        | SC.D.2.3.2 knows the positive and negative consequences of human action on the Earth's systems. | SC.D.2.3.2.a describes the use of pesticides by humans and lists possible benefits and harmful effects of these actions.                                                                                                                                                       | 1, 2, 4, 6, 7    |
## D. Processes that Shape the Earth

2. The student understands the need for protection of the natural systems on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.D.2.4.1 understands the interconnectedness of the systems on Earth and the quality of life</td>
<td>SC.D.2.4.1.a in small groups with other students, develops skits, infomercials, and presentations to governing institutions, where laws and decisions are made, to describe the systems on Earth and how the decisions made about these systems affect the quality of life on Earth.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
## E. Earth and Space

1. The student understands the interaction and organization in the Solar System and the Universe and how this affects life on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.E.1.1.1 knows that the light reflected by the Moon looks a little different every day but looks the same again about every 28 days.</td>
<td>SC.E.1.1.1.a draws the shapes of the appearance of the Moon for a 28-day period.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.1.2 knows that the appearance of sunrise and sunset is due to the rotation of Earth every 24 hours.</td>
<td>SC.E.1.1.2.a uses a sundial to determine the relationship between time and the change of the Sun's position in the sky. SC.E.1.1.2.b draws a shadow of a classmate or a common object, specifying direction and length at different times of the day and different seasons.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### E. Earth and Space

1. The student understands the interaction and organization in the Solar System and the Universe and how this affects life on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.E.1.2.1 knows that the tilt of the Earth on its own axis as it rotates and revolves around the Sun causes changes in season, length of day, and energy available</td>
<td>SC.E.1.2.1.a demonstrates and relates day and night to the rotation of the Earth on its axis and the concept of seasons to the tilted axis of the Earth.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.2.2 knows that the combination of the Earth’s movement and the Moon’s own orbit around the Earth results in the appearance of cyclical phases of the Moon.</td>
<td>SC.E.1.2.2.a uses a ball, globe, and light source to demonstrate the phases of the Moon and makes a chart to record observations and communicate the pattern observed.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.2.3 knows that the Sun is a star and that its energy can be captured or concentrated to generate heat and light for work on Earth.</td>
<td>SC.E.1.2.3.a with other students in a small group, designs, builds, and uses a solar cooker to cook or warm food and reports on the experience</td>
<td>1, 2, 4, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.2.4 knows that the planets differ in size, characteristics, and composition and that they orbit the Sun in our Solar System.</td>
<td>SC.E.1.2.4.a classifies planets by atmospheres, chemical makeup, sets of rings, and natural satellites and explains the classification.</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.2.5 understands the arrangement of planets in our Solar System.</td>
<td>SC.E.1.2.5.a with other students in a small group, constructs models that demonstrate the distance between the Earth, Sun, and other planets.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
E. Earth and Space

1. The student understands the interaction and organization in the Solar System and the Universe and how this affects life on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.E.1.3.1 understand the vast size of our Solar System and the relationship of the planets and their satellites.</td>
<td>SC.E.1.3.1.a shows numerical representations of “light-years” between a satellite and Earth, calculates how long it might take a signal from the satellite to reach Earth, and explains why it would take this long.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.3.2 knows that available data from various satellite probes show the similarities and differences among planets and their moons in the Solar System.</td>
<td>SC.E.1.3.2.a compares information gathered by the various satellite probes and photographic missions to particular aspects of each of the planets. SC.E.1.3.2.b describes surface features and activities of planets, including the nature and number of satellites, magnetic fields, and orbital characteristics.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.3.3 understands that our Sun is one of many stars in our galaxy.</td>
<td>SC.E.1.3.3.a makes a map of the stars seen in the night sky or at a planetarium and compares the seasonal changes in the patterns.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## E. Earth and Space

1. The student understands the interaction and organization in the Solar System and the Universe and how this affects life on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.E.1.3.4 knows that stars appear to be made of similar chemical elements, although they differ in age, size, temperature, and distance.</td>
<td>SC.E.1.3.4.a uses a spectroscope to observe light emitted from different chemicals and suggests how a similar technique can be used to analyze the chemical makeup of stars. SC.E.1.3.4.b with other students in a small group, prepares a multimedia presentation of the events described in the Big Bang Theory of the beginning of the universe.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## E. Earth and Space

1. The student understands the interaction and organization in the Solar System and the Universe and how this affects life on Earth.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 9-12</strong></td>
<td>SC.E.1.4.1 understands the relationships between events on Earth and the movements of the Earth, its Moon, the other planets, and the Sun.</td>
<td>SC.E.1.4.1.a graphs the changes in tide height versus time to determine the relationship between phases and positions of the Moon, and the times of spring and neap tides. SC.E.1.4.1.b calculates and reports the amount of time needed to travel from one planet to another and to our Moon. SC.E.1.4.1.c constructs a scale diagram of the orbital diameters of the planets that shows the distances and diameters of the planets and their moons in relative units.</td>
<td>1, 2, 3, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.4.2 knows how the characteristics of other planets and satellites are similar to and different from those of the Earth.</td>
<td>SC.E.1.4.2.a uses a model designed by a computer program to describe and compare the characteristics of the planets and their satellites.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.1.4.3 knows the various reasons that Earth is the only planet in our Solar System that appears to be capable of supporting life as we know it.</td>
<td>SC.E.1.4.3.a identifies the properties of Earth that make it capable of supporting life and explains why it is necessary to understand systems that support life.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## E. Earth and Space

2. The student recognizes the vastness of the Universe and the Earth's place in it.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades</td>
<td>PreK-2</td>
<td>SC.E.2.1.1.a describes objects seen in the night sky that are not visible in daylight.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.2.1.1 knows that there are many objects in the sky that are only visible at night.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### E. Earth and Space

2. The student recognizes the vastness of the Universe and the Earth’s place in it.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.E.2.2.1 knows that, in addition to the Sun, there are many other stars that are far away.</td>
<td>SC.E.2.2.1.a compares the color and brightness of our Sun with other stars.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## E. Earth and Space

2. The student recognizes the vastness of the Universe and the Earth's place in it.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.E.2.3.1 knows that thousands of other galaxies appear to have the same elements, forces, and forms of energy found in our Solar System.</td>
<td>SC.E.2.3.1.a models, describes, and compares spiral, elliptical, and irregular galaxies.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.2.3.1.b diagrams the position of the Sun in our galaxy and of our galaxy in relation to other galaxies.</td>
<td></td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## Earth and Space

2. The student recognizes the vastness of the Universe and the Earth's place in it.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.E.2.4.1 knows that the stages in the development of three categories of stars are based on mass: stars that have the approximate mass of our Sun, stars that are two- to three-stellar masses and develop into neutron stars, and stars that are five- to six-stellar masses and develop into black holes.</td>
<td>SC.E.2.4.1.a explains the evolution of solar-mass-type stars from the protostar stage to the black dwarf stage</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td>9-12</td>
<td>SC.E.2.4.2 identifies the arrangement of bodies found within and outside our galaxy.</td>
<td>SC.E.2.4.2.a discusses the likelihood of extraterrestrial intelligent life and makes predictions on the probability that, given the vast distances involved, such life might communicate with beings on Earth. SC.E.2.4.2.b describes the galactic system of the universe as it is understood.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td>9-12</td>
<td>SC.E.2.4.3 knows astronomical distance and time.</td>
<td>SC.E.2.4.3.a calculates the amount of Earth time needed to travel from one planet to another in our Solar System, given pertinent data.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
### E. Earth and Space

2. The student recognizes the vastness of the Universe and the Earth's place in it.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.E.2.4.4 understands stellar equilibrium.</td>
<td>SC.E.2.4.4.a researches and reports on the balance between the explosive force of a star, its nuclear fusion, and the implosive force of its gravity.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.2.4.5 knows various scientific theories on how the universe was formed.</td>
<td>SC.E.2.4.5.a debates various theories of the formation of the universe</td>
<td>1, 2, 4, 7, 9</td>
</tr>
<tr>
<td></td>
<td>SC.E.2.4.6 knows the various ways in which scientists collect and generate data about our universe (e.g., X-ray telescopes, computer simulations of gravitational systems, nuclear reactions, space probes, and supercollider simulations).</td>
<td>SC.E.2.4.6.a compares the data-collecting abilities of the Hubble Space Telescope and Advanced X-ray Astronomy Facility and describes the data that each generate</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.E.2.4.7 knows that mathematical models and computer simulations are used in studying evidence from many sources to form a scientific account of the universe</td>
<td>SC.E.2.4.7.a uses computer simulations with mathematical models to study data about the universe that has been collected by telescopes</td>
<td>1, 2, 3, 4, 7</td>
</tr>
</tbody>
</table>
### F. Processes of Life

1. The student describes patterns of structure and function in living things.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.F.1.1.1 knows the basic needs of all living things.</td>
<td>SC.F.1.1.1.a describes and illustrates the basic needs of all living things.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.1.2 knows how to apply knowledge about life processes to distinguish between living and non-living things.</td>
<td>SC.F.1.1.2.a lists examples of those things that have or had life and those that do not.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.1.3 describes how organisms change as they grow and mature.</td>
<td>SC.F.1.1.3.a with other students in a small group, observes several kinds of insects and records the changes in their life cycle from eggs to adults.</td>
<td>1, 2, 4, 5, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.1.4 understands that structures of living things are adapted to their function in specific environments.</td>
<td>SC.F.1.1.4.a designs a fictitious animal or plant with physical characteristics that enable it to survive in a particular habitat or ecosystem.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.1.5 compares and describes the structural characteristics of plants and animals.</td>
<td>SC.F.1.1.5.a describes and compares adaptations of plants and animals that live in the ocean with those that live on land.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### F. Processes of Life

1. The student describes patterns of structure and function in living things.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.F.1.2.1, know that the human body is made of systems with structures and functions that are related.</td>
<td>SC.F.1.2.1.a, with other students in a small group, using available materials, constructs a model of the human body that shows major organ systems and makes a class presentation on how these systems work.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.2.2, know how all animals depend on plants.</td>
<td>SC.F.1.2.2.a, constructs food chains to show how animals are dependent on plants.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.2.3, know that living things are different but share similar structures.</td>
<td>SC.F.1.2.3.a, collects and compares a variety of insects attracted to a light at night and sorts them into groups based on structural characteristics.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.2.4, know that similar cells form different kinds of structures.</td>
<td>SC.F.1.2.4.a, observes a videomicrograph or microscope slide of a plant leaf and identifies the types of cells present.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## F. Processes of Life

1. The student describes patterns of structure and function in living things.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>SC.F.1.3.1</strong>&lt;br&gt;understands that living things are composed of major&lt;br&gt;systems that function in reproduction, growth, maintenance, and regulation.</td>
<td><strong>SC.F.1.3.1.a</strong>&lt;br&gt;designs models to demonstrate the major systems in living things.</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td>Grades 6-8</td>
<td><strong>SC.F.1.3.2</strong>&lt;br&gt;knows that the structural basis of most organisms is the cell and most organisms are single cells, while some, including humans, are multicellular.</td>
<td><strong>SC.F.1.3.2.a</strong>&lt;br&gt;designs and constructs a model of a cell and identifies the parts. <strong>SC.F.1.3.2.b</strong>&lt;br&gt;compares different kinds of cells within a single organism with cells from different organisms and reports the findings.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td><strong>SC.F.1.3.3</strong>&lt;br&gt;knows that in multicellular organisms cells grow and divide to make more cells in order to form and repair various organs and tissues.</td>
<td><strong>SC.F.1.3.3.a</strong>&lt;br&gt;diagrams and compares the process of cellular division for growth and for reproduction.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td><strong>SC.F.1.3.4</strong>&lt;br&gt;knows that the levels of structural organization for function in living things include cells, tissues, organs, systems, and organisms.</td>
<td><strong>SC.F.1.3.4.a</strong>&lt;br&gt;uses computer simulation to remove and identify the systems, organs, tissues, and cells from a frog.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## F. Processes of Life

1. The student describes patterns of structure and function in living things.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.F.1.3.5 explains how the life functions of organisms are related to what occurs within the cell.</td>
<td>SC.F.1.3.5.a explains the functions of cell structures.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.3.6 knows that the cells with similar functions have similar structures whereas those with different structures have different functions.</td>
<td>SC.F.1.3.6.a compares and contrasts structures that are common in muscle cells with those in white blood cells.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.3.7 knows that behavior is a response to the environment and influences growth, development, maintenance, and reproduction.</td>
<td>SC.F.1.3.7.a with other students in a small group, observes, records, analyzes, and compares the behavior of several different organisms in response to heat, light, touch, and water.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
## F. Processes of Life

1. The student describes patterns of structure and function in living things.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.F.1.4.1 [knows that the body processes involve specific biochemical reactions governed by biochemical principles.]</td>
<td>SC.F.1.4.1.a [describes biochemical reactions that are common to living things.]</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.4.2 [knows that body structures are uniquely designed and adapted for their function.]</td>
<td>SC.F.1.4.2.a [identifies the structure and function of the major body systems.]</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.4.3 [knows that membranes are sites for chemical synthesis and essential energy conversions.]</td>
<td>SC.F.1.4.3.a [diagrams the membrane sites in living systems where chemical reactions occur.]</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.4.4 [understands that biological systems obey the same laws of conservation as physical systems.]</td>
<td>SC.F.1.4.4.a [demonstrates the laws of conservation in living systems.]</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.4.5 [knows that complex interactions among the different kinds of molecules in the cell cause distinct cycles of activity governed by proteins.]</td>
<td>SC.F.1.4.5.a [with other students in a small group, designs tests to identify factors that guide the regulation of cell activity with enzymes and explains the results.]</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
### F. Processes of Life

1. The student describes patterns of structure and function in living things.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.F.1.4.6 knows that separate parts of the body communicate with each other using electrical and/or chemical signals.</td>
<td>SC.F.1.4.6.a gives examples of how distant parts of the body communicate with one another.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.4.7 knows that organisms respond to internal and external stimuli.</td>
<td>SC.F.1.4.7.a identifies responses to internal and external stimuli.</td>
<td>1, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.1.4.8 knows that cell behavior can be affected by molecules from other parts of the organism or even from other organisms.</td>
<td>SC.F.1.4.8.a uses single-celled organisms to demonstrate the effect of molecules on their behavior; for example, by placing salt in a solution containing the organism.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### F. Processes of Life

2. The student understands the process and importance of genetic diversity.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.F.2.1.1 knows that living things have offspring that resemble their parents.</td>
<td>SC.F.2.1.1.a identifies the parents of offspring from their photos.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.2.1.2 knows that there are many different kinds of living things that live in a variety of environments.</td>
<td>SC.F.2.1.2.a with other students in a small group, explores water, soils, and land for different kinds of living things, compares the variety found in different locations, and reports on findings.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
### F. Processes of Life

2. The student understands the process and importance of genetic diversity.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td><strong>SC.F.2.2.1</strong>&lt;br&gt;knows that many characteristics of an organism are inherited from the parents of the organism, but that other characteristics are learned from an individual’s interactions with the environment.</td>
<td><strong>SC.F.2.2.1.a</strong>&lt;br&gt;prepares a list of characteristics that are inherited from parents and those that are learned from experiences in life.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### F. Processes of Life

2. The student understands the process and importance of genetic diversity.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.F.2.3.1 knows the patterns and advantages of sexual and asexual reproduction in plants and animals.</td>
<td>SC.F.2.3.1.a compares the production of new cells when new genetic information is acquired with the production of cells that are copying themselves to make new individuals.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.2.3.2 knows that the variation in each species is due to the exchange and interaction of genetic information as it is passed from parent to offspring.</td>
<td>SC.F.2.3.2.a given appropriate information, cites the variety of all probable gene combinations for one trait in the offspring of any two parents.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.2.3.3 knows that generally organisms in a population live long enough to reproduce because they have survival characteristics.</td>
<td>SC.F.2.3.3.a compares and explains the survival of a population of light-colored creatures in a birch forest with a population of light-colored creatures in a dense, pine forest.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.F.2.3.4 knows that the fossil record provides evidence that changes in the kinds of plants and animals in the environment have been occurring over time.</td>
<td>SC.F.2.3.4.a compares fossils of similar species and describes subtle changes in structure.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## F. Processes of Life

### 2. The student understands the process and importance of genetic diversity.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| Grades 9-12 | SC.F.2.4.1  
understands the mechanisms of asexual and sexual reproduction and knows the different genetic advantages and disadvantages of asexual and sexual reproduction. | SC.F.2.4.1.a  
prepares microscope slides to illustrate the mechanisms of asexual and sexual reproduction.  
SC.F.2.4.1.b  
debates the advantages of asexual and sexual reproduction. | 1, 2, 4, 7 |
| | SC.F.2.4.2  
knows that every cell contains a “blueprint” coded in DNA molecules that specify how proteins are assembled to regulate cells. | SC.F.2.4.2.a  
uses computer simulations to build proteins from amino acids using the information from a piece of deoxyribonucleic acid (DNA). | 1, 2, 4, 7 |
| | SC.F.2.4.3  
understands the mechanisms of change (e.g., mutation and natural selection) that lead to adaptations in a species and their ability to survive naturally in changing conditions and to increase species diversity. | SC.F.2.4.3.a  
uses appropriate simple organisms to develop an understanding of the relationship between genotype and phenotype.  
SC.F.2.4.3.b  
describes a scenario in which changing environmental conditions affect the survival of a species and relates the diversity of that species to its chances for long-term survival. | 1, 2, 4, 6, 7 |
## G. How Living Things Interact With Their Environment

1. The student understands the competitive, interdependent, cyclic nature of living things in the environment.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades PreK-2</strong></td>
<td>SC.G.1.1.1 knows that environments have living and nonliving parts.</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.1.2 knows that plants and animals are dependent upon each other for survival.</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.1.3 knows that there are many different plants and animals living in many different kinds of environments (e.g., hot, cold, wet, dry, sunny, and dark).</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.1.4 knows that animals and plants can be associated with their environment by an examination of their structural characteristics.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample Performance Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement of the benchmarks may be demonstrated when the student</td>
</tr>
</tbody>
</table>

| SC.G.1.1.1.a compares, contrasts, and classifies the characteristics of living and nonliving things. |
| SC.G.1.1.2.a constructs food webs to show interrelationships between living things. |
| SC.G.1.1.3.a prepares dioramas of different places with the appropriate plants and animals. |
| SC.G.1.1.3.b explains how desert organisms differ from rain-forest organisms and compares their environments. |
| SC.G.1.1.4.a constructs a diorama depicting a habitat of choice and designs a food chain appropriate to this habitat. |
| SC.G.1.1.4.b compares and describes the features of plants and animals that help them to live in different environments. |

<table>
<thead>
<tr>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td>1, 2, 4, 8</td>
</tr>
<tr>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td>1, 2, 4, 5, 6, 7</td>
</tr>
<tr>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### G. How Living Things Interact With Their Environment

1. The student understands the competitive, interdependent, cyclic nature of living things in the environment.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.G.1.2.1 knows ways that plants, animals, and protists interact.</td>
<td>SC.G.1.2.1.a with other students in a small group, writes the script and acts out a play demonstrating the impact of a natural disaster (e.g., hurricane, tornado, or flood) on all living things in an ecosystem, with emphasis placed on the interrelationships of organisms and how the fate of one affects the others.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC.G.1.2.1.b identifies and compares the ways that protists help and/or harm plants and animals.</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.2.2 knows that living things compete in a climatic region with other living things and that structural adaptations make them fit for an environment.</td>
<td>SC.G.1.2.2.a uses native plants to explain the regional climate and geography.</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.2.3 knows that green plants use carbon dioxide, water, and sunlight energy to turn minerals and nutrients into food for growth, maintenance, and reproduction.</td>
<td>SC.G.1.2.3.a grows plants through a complete life cycle and experiments to identify the factors essential to plant life.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td>1, 2, 4</td>
</tr>
<tr>
<td>1, 2, 4</td>
</tr>
</tbody>
</table>
### G. How Living Things Interact With Their Environment

1. The student understands the competitive, interdependent, cyclic nature of living things in the environment.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 3-5</strong></td>
<td>SC.G.1.2.4 knows that some organisms decompose dead plants and animals into simple minerals and nutrients for use by living things and thereby recycle matter.</td>
<td>SC.G.1.2.4.a investigates the extent to which everyday waste products (e.g., yard clippings, paper, plastic materials, and cans) decay naturally, keeps records of observations, and uses findings to make specific suggestions on how to improve the appearance of the local environment.</td>
<td>1, 2, 4, 5, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.2.5 knows that animals eat plants or other animals to acquire the energy they need for survival.</td>
<td>SC.G.1.2.5.a constructs a simple food chain for a specific habitat, shows how organisms are linked, and discusses the possible consequences arising from a break or interruption to the chain. [SC.G.1.2.5.b with other students in a small group, invents and makes models of plants with special adaptations against predators (e.g., a lawnmower-proof plant or one that grazers will not eat).]</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.2.6 knows that organisms are growing, dying, and decaying and that new organisms are being produced from the materials of dead organisms.</td>
<td>SC.G.1.2.6.a examines garden soil and isolates, identifies, and quantifies the contents.</td>
<td>1, 2, 3, 4</td>
</tr>
</tbody>
</table>
### G. How Living Things Interact With Their Environment

1. The student understands the competitive, interdependent, cyclic nature of living things in the environment.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.G.1.2.7 knows that variations in light, water, temperature, and soil content are largely responsible for the existence of different kinds of organisms and population densities in an ecosystem.</td>
<td>SC.G.1.2.7.a designs and makes a model of a fictitious organism that possesses adaptations enabling it to succeed in unusual habitats (e.g., the bottom of the ocean, another planet, a cave, or a subterranean environment) and defends the needs and/or benefits of each adaptation. SC.G.1.2.7.b with other students in a small group, designs and makes a model of a local ecosystem and explains how the communities, populations, and individuals interact.</td>
<td>1, 2, 4, 7, 1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
### G. How Living Things Interact With Their Environment

1. The student understands the competitive, interdependent, cyclic nature of living things in the environment.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.G.1.3.1</td>
<td>SC.G.1.3.1.a describes the interaction of a virus and its host.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.3.1.b uses common items to design a model of a virus.</td>
<td>1, 2, 4, 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC.G.1.3.2</td>
<td>SC.G.1.3.2.a compares structural, behavioral, and physiological adaptations of birds in the same environment.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.3.3</td>
<td>SC.G.1.3.3.a prepares a dichotomous key for the plants collected around the school community.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
</tbody>
</table>
# G. How Living Things Interact With Their Environment

1. The student understands the competitive, interdependent, cyclic nature of living things in the environment.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.G.1.3.4 Knows that the interactions of organisms with each other and with the nonliving parts of their environments result in the flow of energy and the cycling of matter throughout the system.</td>
<td>SC.G.1.3.4.a charts and compares cycles of living (biotic) and nonliving (abiotic) parts of the environment.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.3.5 Knows that life is maintained by a continuous input of energy from the sun and by the recycling of the atoms that make up the molecules of living organisms.</td>
<td>SC.G.1.3.5.a applies and explains the concept of flow of energy and cycling of matter through an ecosystem to a local habitat.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
</tbody>
</table>
G. How Living Things Interact With Their Environment

1. the student understands the competitive, interdependent, cyclic nature of living things in the environment.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.G.1.4.1 knows of the great diversity and interdependence of living things.</td>
<td>SC.G.1.4.1.a diagrams a food web and describes what occurs when species are removed from the population. SC.G.1.4.1.b describes the negative impact of some human beings on biodiversity.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.4.2 understands how the flow of energy through an ecosystem made up of producers, consumers, and decomposers carries out the processes of life and that some energy dissipates as heat and is not recycled.</td>
<td>SC.G.1.4.2.a gives an example of a biological situation that clearly demonstrates that matter recycles and energy flows. SC.G.1.4.2.b studies a school yard plot to determine the components of an ecosystem.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.1.4.3 knows that the chemical elements that make up the molecules of living things are combined and recombined in different ways.</td>
<td>SC.G.1.4.3.a predicts where the oxygen he or she inhaled last night may be in the morning.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades</td>
<td>The student</td>
<td>Achievement of the benchmarks may be demonstrated when the student</td>
<td></td>
</tr>
<tr>
<td>PreK-2</td>
<td>SC.G.2.1.1 knows that if living things do not get food, water, shelter, and space, they will die.</td>
<td>SC.G.2.1.1.a discusses the limited natural resources that are required for life.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC.G.2.1.1.b demonstrates or describes proper care of a classroom pet and/or plant.</td>
<td></td>
</tr>
<tr>
<td>Grades</td>
<td>SC.G.2.1.2 knows that the activities of humans affect plants and animals in many ways.</td>
<td>SC.G.2.1.2.a with other students in a small group, explores human activities around the school grounds and suggests how these activities may affect the plants and animals that live there.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
## G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Standards</th>
</tr>
</thead>
</table>
| Grades 3-5 | SC.G.2.2.1<br>knows that all living things must compete for Earth's limited resources; organisms best adapted to compete for the available resources will be successful and pass their adaptations (traits) to their offspring. | SC.G.2.2.1.a<br>with other students in a small group, uses populations of brine shrimp, radish seeds, or other rapidly reproducing organisms to make observations, collect data, and make inferences about the results of uncontrolled growth in a population with limited resources in its environment. The student then reports on the processes used and the findings.  
SC.G.2.2.1.b<br>works in small groups to design an energy-conservation public-service announcement, using a variety of communication and media formats. The student then presents the announcement to the class, the whole school, and/or the community.  
SC.G.2.2.1.c<br>participates in an aluminum-recycling drive or a roadside or coastal clean-up project. | 1, 2, 4, 5, 6, 7, 8, 9 |
## G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 3-5</strong></td>
<td>SC.G.2.2.2 knows that the size of a population is dependent upon the available resources within its community.</td>
<td>SC.G.2.2.2.a reports on the limited resources that are used by living things in order to survive. SC.G.2.2.2.b discusses the resources that limit the size of particular populations.</td>
</tr>
<tr>
<td></td>
<td>SC.G.2.2.3 understands that changes in the habitat of an organism may be beneficial or harmful.</td>
<td>SC.G.2.2.3.a writes a story about an organism whose habitat has changed, describing the consequences of this change to the organism. SC.G.2.2.3.b explains how damage caused by rodents can be reduced by using poisons but how their use may harm other plants or animals.</td>
</tr>
</tbody>
</table>

Goal 3 Standards

1, 2, 4

1, 2, 4

1, 2, 4, 7

1, 2, 4, 7
# G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.G.2.3.1 knows that some resources are renewable and others are nonrenewable</td>
<td>SC.G.2.3.1.a identifies the resources that may be renewed and compares these with resources that are renewed in their community.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.2.3.2 knows that all biotic and abiotic factors are interrelated and that if one factor is changed or removed, it impacts the availability of other resources within the system.</td>
<td>SC.G.2.3.2.a with others in a small group, develops a game in which the participants compete for resources that are limited and must be recycled.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
## G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td>SC.G.2.3.3 &lt;br&gt;knows that a brief change in the limited resources of an ecosystem may alter the size of a population or the average size of individual organisms and that long-term change may result in the elimination of animal and plant populations inhabiting the Earth.</td>
<td>SC.G.2.3.3.a &lt;br&gt;takes any finite resource (e.g., coal, oxygen, phosphate, or oil) and researches its natural sources, degree of availability, commercial uses, impact on the environment, and recycling potential.</td>
<td>1, 2, 4, 7, 9</td>
</tr>
<tr>
<td></td>
<td>SC.G.2.3.4 &lt;br&gt;understands that humans are a part of an ecosystem and their activities may deliberately or inadvertently alter the equilibrium in ecosystems.</td>
<td>SC.G.2.3.4.a &lt;br&gt;researches the impact of human activities on a natural environment and suggests consequences of this activity.</td>
<td>1, 2, 4, 5, 6, 7</td>
</tr>
</tbody>
</table>
## G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| Grades 9-12 | SC.G.2.4.1  
knows that layers of energy-rich organic materials have been gradually turned into great coal beds and oil pools (fossil fuels) by the pressure of the overlying earth and that humans burn fossil fuels to release the stored energy as heat and carbon dioxide. | SC.G.2.4.1.a  
with other students in a small group, builds an artificial coal bed in the laboratory, subjects it to heat and pressure, measures the amount of energy stored with a bomb calorimeter, and reports on the processes used and the findings. | 1, 2, 3, 4, 5, 6, 7, 8, 9 |
|           | SC.G.2.4.2  
knows that changes in a component of an ecosystem will have unpredictable effects on the entire system but that the components of the system tend to react in a way that will restore the ecosystem to its original condition. | SC.G.2.4.2.a  
uses two or more data sources to conduct an environmental impact study of a local region and reports on the findings.                                                                                                         | 1, 2, 4, 6, 7    |
## G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.G.2.4.3 understands how genetic variation of offspring contributes to population control in an environment and that natural selection ensures that those who are best adapted to their surroundings survive to reproduce.</td>
<td>SC.G.2.4.3.a compares characteristics of species that live on Earth in great numbers with those whose numbers are decreasing.</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td></td>
<td>SC.G.2.4.4 knows that the world ecosystems are shaped by physical factors that limit their productivity.</td>
<td>SC.G.2.4.4.a prepares climatograms and compares these with graphs depicting species diversity.</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC.G.2.4.4.b uses native plants to explain the regional climate and geography.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.G.2.4.5 understands that the amount of life any environment can support is limited and that human activities can change the flow of energy and reduce the fertility of the Earth.</td>
<td>SC.G.2.4.5.a with other students in a small group, raises generations of fruit flies with nutrient agar in a closed environment until the food is gone, compares this to the use of natural resources on Earth by the human population, and reports on processes used and findings.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
## G. How Living Things Interact With Their Environment

2. The student understands the consequences of using limited natural resources.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.G.2.4.6</td>
<td>SC.G.2.4.6.a with other students in a small group, participates in role playing and/or case studies involving the consequences of human impact on the environment, presenting evidence supporting or refuting both sides of environmental conservation and economic-development issues. SC.G.2.4.6.b researches and role-plays activities that allow the development of a sense of responsibility for future generations to conserve what's left of Earth's natural resources. SC.G.2.4.6.c determines cause-and-effect relationships (e.g., predator-prey or climate-population), while tracing the flow of energy and the cycling of matter through the food web, and predicts the impact of introducing new species into an ecosystem, given the populations and other pertinent data about an ecosystem.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>

1, 2, 4, 7 | 1, 2, 4, 7 |
H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.H.1.1.1</td>
<td>knows that in order to learn, it is important to observe the same things often and compare them.</td>
<td>SC.H.1.1.1.a makes observations and lists new things learned. 1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.1.2</td>
<td>knows that when tests are repeated under the same conditions, similar results are usually obtained.</td>
<td>SC.H.1.1.2.a reaches into a bag containing 25 blue marbles and 25 white marbles and selects marbles in groups of ten without looking into the bag and compares the number of blue and white marbles in each sample. 1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.1.3</td>
<td>knows that in doing science, it is often helpful to work with a team and to share findings with others.</td>
<td>SC.H.1.1.3.a compares the number of observations in the school yard that can be made by one student with the number that may be made if class data is pooled. 1, 2, 4, 7</td>
</tr>
</tbody>
</table>
H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC.H.1.1.4</td>
<td>knows that people use scientific processes including hypotheses, making inferences, recording and communicating data when exploring the natural world.</td>
<td>SC.H.1.1.4.a views videos of different kinds of scientists at work and lists the scientific processes they use.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>

| SC.H.1.1.5 | uses the senses, tools, and instruments to obtain information from his or her surroundings. | SC.H.1.1.5.a makes valid observations of common substances and identifies the senses and tools used. | 1, 2, 4, 7       |
## H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 3-5</strong></td>
<td>SC.H.1.2.1 knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.</td>
<td>SC.H.1.2.1.a compares recorded observations with other students to verify accuracy. SC.H.1.2.1.b with other students in a small group, develops a game that requires each participant to record the events of the same staged phenomena and compares the records for accuracy.</td>
<td>1, 2, 4, 7, 8</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.2.2 knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.</td>
<td>SC.H.1.2.2.a produces oral and computer-generated written reports, diagrams, charts, maps, graphs, mathematical equations, and visual demonstrations of research.</td>
<td>1, 2, 3, 4, 5, 6</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.2.3 knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.</td>
<td>SC.H.1.2.3.a analyzes the conclusions of members of a team and reaches consensus.</td>
<td>1, 2, 4, 8</td>
</tr>
</tbody>
</table>
H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goals Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.H.1.2.4 knows that to compare and contrast observations and results is an essential skill in science.</td>
<td>SC.H.1.2.4.a reads an article on the research of several teams of scientists on the same question and reports on how the data and results compare. SC.H.1.2.4.b designs an investigation for the class to do in groups and compares the data from each group's trial.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.2.5 knows that a model of something is different from the real thing, but can be used to learn something about the real thing.</td>
<td>SC.H.1.2.5.a develops models of the water cycle.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td>SC.H.1.3.1 knows that 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.</td>
<td>SC.H.1.3.1.a identifies a scientific theory proposed in the early 1800s, compares it with the current modified theory on the topic, and hypothesizes reasons for the revision.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.3.2 knows that the study of the events that led scientists to discoveries can provide information about the inquiry process and its effects.</td>
<td>SC.H.1.3.2.a with other students in a small group, creates models to illustrate how people from other cultures throughout history have studied a particular natural phenomena.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9, 10</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.3.3 knows that science disciplines differ from one another in topic, techniques, and outcomes but that they share a common purpose, philosophy, and enterprise</td>
<td>SC.H.1.3.3.a defines the common purpose, philosophy, and task to find answers to scientific questions.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.H.1.3.4 knows that accurate record keeping, openness, and replication are essential to maintaining an investigator’s credibility with other scientists and society.</td>
<td>SC.H.1.3.4.a reports on the credibility of the findings of published scientists (e.g., on superconductivity).</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.3.5 knows that a change in one or more variables may alter the outcome of an investigation.</td>
<td>SC.H.1.3.5.a experiments with the removal or addition of variables to determine the consequences.</td>
<td>1, 2, 3, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.3.6 recognizes the scientific contributions that are made by individuals of diverse backgrounds, interests, talents, and motivations.</td>
<td>SC.H.1.3.6.a role plays a particular scientist to depict the background, interests, talents and motives of that person. SC.H.1.3.6.b identifies scientists employed by industries in the community, researches their backgrounds, interests, and motivations, and reports their findings. SC.H.1.3.6.c identifies famous women and African-American scientists and inventors who made our lives better.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>

Sunshine State Standards: Science, 1996
H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.H.1.3.7 knows that when similar investigations give different results, the scientific challenge is to verify whether the differences are significant by further study.</td>
<td>SC.H.1.3.7.a compares the differing results of two similar investigations and determines possible explanations for the differences, then designs and conducts a new investigation based on these explanations in order to determine the validity of the data.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.H.1.4.1: The student knows that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.</td>
<td>SC.H.1.4.1.a formulates a testable hypothesis supported by the knowledge and understanding generated by an experiment.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.4.2: The student knows that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge.</td>
<td>SC.H.1.4.2.a engages in a debate on changes and continuity that are persistent features of science.</td>
<td>1, 2, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.4.3: The student understands that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth.</td>
<td>SC.H.1.4.3.a compares closely aligned theories and identifies ways to test the validity of these theories.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## H. The Nature of Science

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.H.1.4.4 knows that scientists in any one research group tend to see things alike and that therefore scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis.</td>
<td>SC.H.1.4.4.a reviews scientific publications on a topic, identifies the conclusions of the researcher in the articles cited, and compares the findings of these different investigations.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.4.5 understands that 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 from many contributors.</td>
<td>SC.H.1.4.5.a discusses the big new ideas in science today and traces their origins and development.</td>
<td>1, 2, 4</td>
</tr>
</tbody>
</table>
**H. The Nature of Science**

1. The student uses the scientific processes and habits of mind to solve problems.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 9-12</strong></td>
<td>SC.H.1.4.6 understands that in the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism and that 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.</td>
<td>SC.H.1.4.6.a selects and describes several scientific theories that were ridiculed as preposterous by some but are now supported with convincing evidence.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.1.4.7 understands the importance of a sense of responsibility, a commitment to peer review, truthful reporting of the methods and outcomes of investigations, and making the public aware of the findings.</td>
<td>SC.H.1.4.7.a reviews and edits the laboratory reports of peers.</td>
<td>1, 2, 4, 5, 8</td>
</tr>
</tbody>
</table>
## H. The Nature of Science

2. The student understands that most natural events occur in comprehensible, consistent patterns.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades PreK-2</strong></td>
<td>SC.H.2.1.1 knows that most natural events occur in patterns.</td>
<td>SC.H.2.1.1.a traces and reports on the visibility of the moon for 28 nights.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### H. The Nature of Science

2. The student understands that most natural events occur in comprehensible, consistent patterns.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 3-5</td>
<td>SC.H.2.2.1 knows that natural events are often predictable and logical.</td>
<td>SC.H.2.2.1.a predicts the changes in weather based on the appearance of the clouds.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>

Achievement of the benchmarks may be demonstrated when the student...
H. The Nature of Matter

2. The student understands that most natural events occur in comprehensible, consistent patterns.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 6-8</td>
<td>SC.H.2.3.1 recognizes that patterns exist within and across systems.</td>
<td>SC.H.2.3.1.a uses one or two explanatory models from her or his own learning in science to demonstrate that patterns are within and across systems.</td>
<td>1, 2, 4, 5, 6, 7</td>
</tr>
</tbody>
</table>
## H. The Nature of Science

2. The student understands that most natural events occur in comprehensible, consistent patterns.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.H.2.4.1 knows that scientists assume that the universe is a vast system in which basic rules exist that may range from very simple to extremely complex but that scientists operate on the belief that the rules can be discovered by careful, systemic study.</td>
<td>SC.H.2.4.1.a develops and records in a journal alternative interpretations based upon experimental evidence collected.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.2.4.2 knows that scientists control conditions in order to obtain evidence, but when that is not possible for practical or ethical reasons, they try to observe a wide range of natural occurrences to discern patterns.</td>
<td>SC.H.2.4.2.a describes scientists’ efforts to predict the weather using computer modeling of weather conditions.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### H. The Nature of Science

3. The student understands that science, technology, and society are interwoven and interdependent.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades PreK-2</td>
<td>SC.H.3.1.1 knows that scientists and technologists use a variety of tools (e.g., thermometers, magnifiers, rulers, and scales) to obtain information in more detail and to make work easier.</td>
<td>SC.H.3.1.1.a selects the appropriate tool for collecting information.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
### H. The Nature of Science

3. The student understands that science, technology, and society are interwoven and interdependent.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The student</td>
<td>Achievement of the benchmarks may be demonstrated when the student</td>
<td></td>
</tr>
<tr>
<td>Grades 3-5</td>
<td>SC.H.3.2.1</td>
<td>understands that people, alone or in groups, invent new tools to solve problems and do work that affects aspects of life outside of science.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.1.a</td>
<td>describes the research and development done by a company in the production of a new product.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.1.b</td>
<td>compares the information that can be gained by a team to the information that can be gained by an individual.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.2</td>
<td>knows that data are collected and interpreted in order to explain an event or concept.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.2.a</td>
<td>compares the results of an investigation that involves more than one strategy and tests for discrepant events or results.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.3</td>
<td>knows that before a group of people build something or try something new, they should determine how it may affect other people.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.3.a</td>
<td>makes valid observations of common substances.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.4</td>
<td>knows that through the use of science processes and knowledge, people can solve problems, make decisions, and form new ideas.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.2.4.a</td>
<td>gives examples of how the processes of science can be used to select a new pair of tennis shoes.</td>
<td>1, 2, 4, 7</td>
</tr>
</tbody>
</table>
## H. The Nature of Science

3. The student understands that science, technology, and society are interwoven and interdependent.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td>SC.H.3.3.1 knows that science ethics demand that scientists must not knowingly subject coworkers, students, the neighborhood, or the community to health or property risks.</td>
<td>SC.H.3.3.1.a debates the safety of deoxyribonucleic acid (DNA) research based on published reports.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.3.2 knows that special care must be taken in using animals in scientific research.</td>
<td>SC.H.3.3.2.a discusses the ethical treatment for animals in research.</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.3.3 knows that 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.</td>
<td>SC.H.3.3.3.a identifies the risks to cancer patients receiving radiation treatment.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.3.4 knows that technological design should require taking into account constraints such as natural laws, the properties of the materials used, and economic, political, social, ethical, and aesthetic values.</td>
<td>SC.H.3.3.4.a with other students in a small group, develops, produces, tests, and markets a simple product.</td>
<td>1, 2, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>
### H. The Nature of Science

3. The student understands that science, technology, and society are interwoven and interdependent.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 6-8</strong></td>
<td>SC.H.3.3.5 understands that contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times and are an intrinsic part of the development of human culture</td>
<td>SC.H.3.3.5.a researches a third-world society and compares its use of technology with the use of technology in the United States</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.3.6 knows that 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</td>
<td>SC.H.3.3.6.a identifies technology that is readily available as a result of scientific discoveries in the Space Program</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.3.7 knows that computers speed up and extend people's ability to collect, sort, and analyze data; prepare research reports; and share data and ideas with others.</td>
<td>SC.H.3.3.7.a enters, sorts, analyzes, and graphs data using computer software</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 4, 7, 10</td>
</tr>
<tr>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td>1, 2, 4, 6, 7</td>
</tr>
</tbody>
</table>
H. The Nature of Science

3. The student understands that science, technology, and society are interwoven and interdependent.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 9-12</td>
<td>SC.H.3.4.1 knows that performance testing is often conducted using small-scale models, computer simulations, or analogous systems to reduce the chance of system failure.</td>
<td>SC.H.3.4.1.a uses a computerized architectural design (CAD) program to determine the stress on bridge support.</td>
<td>1, 2, 3, 4, 6, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.4.2 knows that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science.</td>
<td>SC.H.3.4.2.a compares the problems that had to be solved to make the first airplane flights with the problems that had to be solved to make airplanes fly faster than the speed of sound.</td>
<td>1, 2, 4, 7</td>
</tr>
<tr>
<td></td>
<td>SC.H.3.4.3 knows that scientists can bring information, insights, and analytical skills to matters of public concern and help people understand the possible causes and effects of events.</td>
<td>SC.H.3.4.3.a reviews and discusses the efforts of scientists over the past three centuries to inform the public about environmental, political, and economic consequences of population growth.</td>
<td>1, 2, 4</td>
</tr>
</tbody>
</table>
### H. The Nature of Science

3. The student understands that science, technology, and society are interwoven and interdependent.

<table>
<thead>
<tr>
<th>Level</th>
<th>Benchmark</th>
<th>Sample Performance Descriptions</th>
<th>Goal 3 Standards</th>
</tr>
</thead>
</table>
| Grades 9-12    | **SC.H.3.4.4**
knows that funds for science research come from federal government agencies, industry, and private foundations and that this funding often influences the areas of discovery. | **SC.H.3.4.4.a**
selects one science topic that is actively being researched and determines the sources of funding for the research and who will benefit from new discoveries. | 1, 2, 4           |
|                | **SC.H.3.4.5**
knows that the value of a technology may differ for different people and at different times.                                                                                                         | **SC.H.3.4.5.a**
compares the communication methods people use in cities of Bombay, Sao Paolo, and New York. | 1, 2, 4, 7       |
|                | **SC.H.3.4.6**
knows that scientific knowledge is used by those who engage in design and technology to solve practical problems, taking human values and limitations into account.                                      | **SC.H.3.4.6.a**
identifies practical problems that are solved with technology and describes the effect of the solutions on human values. | 1, 2, 4, 7       |
**Chapter 4: Teaching and Learning**

**Chapter Highlights**
- New Approaches to Teaching and Learning
- Instructional Strategies for the 21st Century
- Infusing a Multicultural Perspective
- Snapshot of an Effective Science Classroom
- Teaching Diverse Students
  - Diverse Needs
  - Developmental Differences
  - Learning Preferences
  - Students With Disabilities
  - Students Who Are Limited English Proficient
  - At-Risk Students
- Putting These Ideas to Work

**New Approaches to Teaching and Learning**

Florida’s education reform initiative calls on educators to redesign their instructional programs so that every student achieves high academic standards. This redesign may include the structure and context of the learning environment and the use of materials, equipment, and resources. School and district leaders must encourage change and look for creative approaches to teaching and learning. Sequencing of courses may be altered; science instruction may be integrated with other areas of the curriculum; schools and communities may form partnerships; classrooms may be modified to include community settings, museums, nature centers, and other cultural institutions; and electronic networks may link students and teachers across America and to other countries.
Learning theories and instructional practices can inform these new approaches. A tremendous amount of research is available to educators on how children learn and on how to design effective learning environments. This chapter highlights key elements that can help educators, through further investigation, collaborative consideration, implementation, and evaluation, to develop the best learning environments for their unique students.

**Developing a Learning-Centered, Authentic Environment**

Attempts to improve science teaching must be based on an understanding of how students learn. Learning is a natural process of discovering and constructing meaning from information and experience, filtered through the learner's unique perceptions, thoughts, feelings, and beliefs. The learner grapples with new knowledge until it makes sense and fits into his or her world of understanding.

Based on this knowledge of the learning process, educators are encouraged to design science curricula that allow students to encounter ideas, events, and materials in real-world contexts. Children learn most effectively when actively involved in a subject rather than just hearing or reading about it. Classrooms that are limited to the exclusive use of textbooks, lectures, and paper-and-pencil tasks do not tend to be as successful as those that actively engage students in the learning process. Curiosity, creativity, and higher order thinking are stimulated when experiences are based on real, complex, and relevant ideas and materials. This immersion in direct experience should be balanced with opportunities for learners to reflect, discuss, and connect concepts with what they have felt, thought, and learned.

Identifying students' interests and questions also helps engage students in the learning process by stimulating the natural curiosity that students bring to school. Children learn best when called upon to make choices and assume more responsibility for their own learning, while the teacher provides support and guidance.

Some of the most efficient learning occurs when students are collaborating with each other in pairs or small groups. Providing students with the opportunity to interact with others in a variety of settings can enhance knowledge and understanding. Feedback from fellow students can help students clarify areas of understanding as well as misconceptions and questions. Collaborative work can also encourage
students to take intellectual risks. Students might pose their own problems, devise their own approaches to problem solving, clarify and defend their conclusions, explore possibilities, and use the results to make informed decisions. Students learn the valuable skill of working effectively with others to solve problems and perform investigations, a skill that will be useful in the workplace and in many other areas of their lives.

Providing a Supportive Environment

The teacher is key to creating a supportive, effective learning environment. Teachers provide this kind of environment when they maintain fair, consistent, and caring policies that respect the individuality of students and focus on individual achievement and cooperative teamwork. Students’ learning is enhanced when others see their potential, genuinely appreciate their unique talents, and accept them as individuals. In such an environment, students can learn the skills of being responsible for themselves, making decisions, working cooperatively, negotiating conflicts, and taking risks; students also have more freedom to do quality work on their own initiative. In addition, a teacher who creates a supportive environment for students can reduce the negative effect of factors that can interfere with learning, such as low self-esteem; lack of self-control; lack of personal goals; expectations of failure or limited success; and feelings of anxiety, insecurity, or pressure. A supportive learning environment and a variety of teaching strategies that promote exploration, discussion, and collaborative learning will help ensure that all children have the opportunity to see themselves as capable students, successful in learning science.

Instructional Strategies for the 21st Century

In each science classroom, there is a diverse pool of talent and potential. The challenge is to structure the learning environment so that each student has the freedom to use his or her unique strengths to learn or perform and to be urged,
inspired, and motivated to reach high academic standards. Because all children do not learn in the same way and have varying backgrounds and experiences, flexible and innovative approaches are needed.

To support innovative science classrooms, the instructional strategies on the following pages are provided as examples of the many kinds of strategies that educators might use as they work toward providing the most useful and engaging educational experiences possible. After further investigation, teachers may use these and other instructional strategies for independent or group work. They can creatively adapt and refine them to best fit the needs of the students and the instructional plan, perhaps incorporating several of these strategies into a single lesson or using them in collaboration with a colleague.
COOPERATIVE LEARNING: A strategy in which students work together in small groups to achieve a common goal. Cooperative learning involves more than simply putting students into work or study groups. Teachers promote individual responsibility and positive group interdependence by making sure that each group member is responsible for a given task. Cooperative learning can be enhanced when group members have diverse abilities and backgrounds.

HOW DO YOU USE IT?
After organizing students into groups, the teacher thoroughly explains a task to be accomplished within a time frame. The teacher facilitates the selection of individual roles within the group and monitors the groups, intervening only when necessary, to support students working together successfully and accomplishing the task.

WHAT ARE THE BENEFITS?
- fosters interdependence and pursuit of mutual goals and rewards
- develops communication and leadership skills
- increases the participation of shy students
- produces higher levels of student achievement, thus increasing self-esteem
- fosters respect for diverse abilities and perspectives

There are numerous cooperative learning strategies that educators can use to enhance student learning. Four of these strategies are offered on the next two pages: Jigsawing; Corners; Think, Pair, and Share; and Debate.
**Cooperative Learning Strategies**

### Jigsawing

**What is it?** A cooperative learning strategy in which everyone becomes an “expert” and shares his or her learning so that eventually all group members know the content.

**How do you use it?**
The teacher divides students into groups; each group member is assigned a numbered section or a part of the material being studied. Each student meets with the students from other groups who have the same number. This new group learns together, develops expertise on their material, and then plans how to teach the material to members of their original groups. Students return to their original groups and teach their area of expertise to the other group members.

**What are the benefits?**
- builds depth of knowledge
- discloses a student’s own understanding and resolves misunderstanding
- builds on conceptual understanding
- develops teamwork and cooperative working skills

### Corners

**What is it?** A cooperative learning strategy, similar to jigsawing, for learning about a topic and sharing that learning.

**How do you use it?**
The teacher assigns small groups of students to different corners of the room to examine a particular topic. They discuss various points of view concerning the topic. Corner teams discuss conclusions, determine the best way to present their findings to the class, and practice their presentation.

**What are the benefits?**
- elicits diverse points of view
- develops communication skills, especially listening and taking turns
- allows opportunities for shy students to function positively in small groups
Cooperative Learning Strategies (continued)

<table>
<thead>
<tr>
<th>THINK, PAIR, AND SHARE</th>
<th>HOW DO YOU USE IT?</th>
<th>WHAT ARE THE BENEFITS?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHAT IS IT?</strong> A cooperative learning strategy for helping students develop their own ideas and build on the ideas of colearners.</td>
<td>Students reflect on a topic and then pair up to discuss, review, and revise their ideas. They share their ideas with the class.</td>
<td>• helps develop conceptual understanding of a topic&lt;br&gt;• develops the ability to filter information and draw one’s own conclusions&lt;br&gt;• develops the ability to consider other points of view</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEBATE</th>
<th>HOW DO YOU USE IT?</th>
<th>WHAT ARE THE BENEFITS?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHAT IS IT?</strong> A cooperative learning strategy in which students participate in organized presentations of various viewpoints.</td>
<td>Students form teams to research and develop their viewpoints on a particular topic or issue. The teacher provides the structure in which students will articulate their viewpoints.</td>
<td>• develops the ability to organize information&lt;br&gt;• develops the ability to filter ideas and draw conclusions&lt;br&gt;• provides opportunities for students to practice articulating their own ideas and building persuasive arguments</td>
</tr>
</tbody>
</table>
**BRAINSTORMING:** A strategy for eliciting ideas from a group.

<table>
<thead>
<tr>
<th>HOW DO YOU USE IT?</th>
<th>WHAT ARE THE BENEFITS?</th>
</tr>
</thead>
</table>
| Students contribute ideas related to a topic. All contributions are accepted without initial comment. After the list of ideas is finalized, students categorize, prioritize, and defend selections. | • reveals background information and knowledge of a topic  
• discloses misconceptions  
• helps students relate existing knowledge to content  
• strengthens listening skills  
• stimulates creative thinking |

**FIELD EXPERIENCE:** A planned learning experience for students to observe, study, and participate in a setting off the school grounds, using the community as a laboratory.

<table>
<thead>
<tr>
<th>HOW DO YOU USE IT?</th>
<th>WHAT ARE THE BENEFITS?</th>
</tr>
</thead>
</table>
| Teachers and students plan and structure the experience before the visit and engage in follow-up activities after the trip. | • develops organizational and planning skills  
• develops observational skills  
• gives students an authentic educational experience |

**FREE WRITING:** A strategy for encouraging students to express ideas in writing.

<table>
<thead>
<tr>
<th>HOW DO YOU USE IT?</th>
<th>WHAT ARE THE BENEFITS?</th>
</tr>
</thead>
</table>
| After reflecting on a topic, students respond in writing for a brief time to a prompt, a quote, or a question. | • develops the ability to link previous knowledge and experience to a topic  
• develops creative and critical thinking skills  
• provides opportunities to express and share ideas in written form  
• encourages students to value the written word |
**K-W-L (KNOW-WANT TO KNOW-LEARNED):** An introductory strategy that provides a structure for recalling what students know regarding a topic, noting what students want to know, and finally listing what has been learned and is yet to be learned.

**How do you use it?**

Before engaging in an activity, reading a chapter, listening to a lecture, or watching a film or presentation, the teacher lists on the board under the heading “What We Know” all the information students know or think they know about a topic. Then, the teacher lists all the information the students want to know about a topic under “What We Want to Know.”

While engaging in the planned activity, the students research and read about the topic, keeping in mind the information they had listed under “What We Want to Know.”

After completing the activity, the students confirm the accuracy of what was listed and identify what they learned, contrasting it with what they wanted to know. The teacher lists what the students learned under “What We Learned.”

**What are the benefits?**

- builds on prior knowledge
- develops predicting skills
- provides a structure for learning
- develops research skills
- develops communication skills in cooperative groups
- strengthens teamwork skills

**Learning Log:** A strategy to develop structured writing. An excellent follow-up to K-W-L.

**How do you use it?**

During different stages of the learning process, students respond in written form under three columns:

- “What I Think”
- “What I Learned”
- “How My Thinking Has Changed”

**What are the benefits?**

- bridges the gap between prior knowledge and new content
- provides a structure for translating concepts into written form
**GRAPHIC ORGANIZERS:** A strategy in which teachers and students transfer abstract concepts and processes into visual representations.

**How do you use it?**
The teacher provides a specific format for learning, recalling, and organizing.

**What are the benefits?**
- helps students visualize abstract concepts
- helps learners organize ideas
- provides a visual format for study

---

**Graphic Organizer Strategies**

**CONSEQUENCE DIAGRAM/DECISION TREES**

**What is it?**
A graphic organizer strategy in which students use diagrams or decision trees to illustrate real or possible outcomes of different actions.

**How do you use it?**
Students visually depict outcomes for a given problem by charting various decisions and their possible consequences.

**What are the benefits?**
- helps in transferring learning to application
- aids in predicting with accuracy
- develops the ability to identify the causes and effects of decisions

---

![Consequence Diagram/Decision Trees](image-url)
**Flowchart**

**What is it?** A graphic organizer strategy used to depict a sequence of events, actions, roles, or decisions.

<table>
<thead>
<tr>
<th><strong>How do you use it?</strong></th>
<th><strong>What are the benefits?</strong></th>
</tr>
</thead>
</table>
| Students structure a sequential flow of events, actions, roles, or decisions graphically on paper. | • fosters logical and sequential thinking  
• focuses on connections  
• develops the ability to identify details and specific points  
• develops organizational skills  
• aids in planning  
• provides an outline for writing |

![Flowchart Diagram](image-url)
**Graphic Organizer Strategies (continued)**

<table>
<thead>
<tr>
<th><strong>VENN DIAGRAM</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHAT IS IT?</strong> A graphic organizer strategy, derived from mathematics, for creating a visual analysis of information representing the similarities and differences among, for example, concepts, objects, events, and people.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>HOW DO YOU USE IT?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Using two overlapping circles, students list unique characteristics of two items or concepts (one in the left part of circle and one in the right); in the middle they list shared characteristics. More than two circles can be used for a more complex process.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>WHAT ARE THE BENEFITS?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• helps students organize knowledge and ideas</td>
</tr>
<tr>
<td>• helps students develop a plan for writing</td>
</tr>
<tr>
<td>• helps students compare and contrast</td>
</tr>
<tr>
<td>• develops the ability to draw conclusions and synthesize</td>
</tr>
<tr>
<td>• stimulates higher cognitive thinking skills</td>
</tr>
</tbody>
</table>

![Venn Diagram](image-url)
Graphic Organizer Strategies (continued)

**WEBBING**

**WHAT IS IT?** A graphic organizer strategy that provides a visual picture of how words or phrases connect to a topic.

**HOW DO YOU USE IT?**
The teacher lists a topic and builds a web-like structure of words or phrases that students call out as being connected to a topic. Students can also use this strategy individually in planning writing or in studying for a test.

**WHAT ARE THE BENEFITS?**
- provides opportunities for the visual learner to “recall” the connections for later use
- helps students use and share their prior knowledge
- helps students identify patterns of information
INTERVIEWS: A strategy for gathering information and reporting.

**HOW DO YOU USE IT?**
Students prepare a set of questions and a format for the interview. After conducting the interview, students present their findings to the class.

**WHAT ARE THE BENEFITS?**
- fosters connections between ideas
- develops the ability to interpret answers
- develops organizational and planning skills
- develops problem-solving skills
**DIALOGUE JOURNALS:** A strategy in which students use journals as a way to hold private conversations. Dialogue journals are a vehicle for sharing ideas and receiving feedback through writing.

**How do you use it?**
Students write on topics on a regular basis, and the teacher responds with advice, comments, and observations in a written conversation. Younger children can begin by writing a few words and combining them with pictures.

**What are the benefits?**
- develops communication and writing skills
- creates a positive relationship between the teacher and the student
- increases student interest and participation
- allows the student to direct his or her own learning

**MINI-MUSEUMS:** A strategy for creating a focused exhibit.

**How do you use it?**
Students work in groups to create exhibits that represent, for example, a display of several electrical experiments that demonstrate concepts related to electricity.

**What are the benefits?**
- develops critical thinking skills
- develops the ability to select important high points
- encourages creativity and individuality
- deepens knowledge of a subject

**MODELS:** A simplified representation of a concept. It may be concrete, such as a ball and stick model of an atom, or abstract like a model of weather systems.

**How do you use it?**
Students create a concrete product that represents an abstract idea or a simplified representation of an abstract idea.

**What are the benefits?**
- facilitates understanding of conceptual ideas
THE LEARNING CYCLE: A sequence of lessons designed to have students engage in exploratory investigations, construct meaning out of their findings, propose tentative explanations and solutions, and relate concepts to their own lives.

**How do you use it?**
The teacher engages the learners with an event or question to draw their interest, evoke what they know, and connect that with new ideas. The students explore the concept, behavior, or skill with hands-on experience. They explain the concept, behavior, or skill and define the terms, then use the terms to explain their exploration. Through discussion, the students expand the concept or behavior by applying it to other situations.

**What are the benefits?**
- encourages students to construct their own understanding of concepts
- provides hands-on experiences to explore concepts, behaviors, and skills
- develops the ability to share ideas, thoughts, and feelings

PROBLEM SOLVING: A learning strategy in which students apply knowledge to solve problems.

**How do you use it?**
The students discover a problem; problems can be constructed by the teacher or can be real-world problems suggested by the students. The students define the problem, ask a question about the problem, then define the characteristics of possible solutions, which they research. They choose a promising solution that best fits the criteria stated in the definition of solutions, then test the solution. Finally, they determine if the problem has been solved.

**What are the benefits?**
- allows students to discover relationships that may be completely new to them
- adapts easily for all grade levels and special-needs students
- develops the ability to construct new ideas and concepts from previously learned information, skills, and strategies
PREDICT, OBSERVE, EXPLAIN: A strategy in which the teacher shows the class a situation and asks students to predict what will happen when a change is made.

**How do you use it?**
The teacher shows students a situation and asks them to predict what will happen when some change is made. Students observe what happens when the change is made. The class then discusses the differences between their predictions and the results.

**What are the benefits?**
- encourages higher level thinking
- develops the ability to draw conclusions and synthesize

REFLECTIVE THINKING: A strategy in which students reflect on what was learned after a lesson is finished, usually by writing about what was learned.

**How do you use it?**
Two possible approaches to reflective thinking are (1) students can write in a journal the concept learned, comments on the learning process, questions or unclear areas, and interest in further exploration, all in the students' own words; (2) students can fill out a questionnaire addressing such questions as Why did you study this? Can you relate it to real life?

**What are the benefits?**
- helps students assimilate what they have learned
- helps students connect concepts to make ideas more meaningful
LITERATURE, HISTORY, AND STORYTELLING: A strategy in which history is brought to life through the eyes of a historian, storyteller, or author, revealing the social context of a particular period in history.

HOW DO YOU USE IT?
The teacher locates books, brochures, and tapes relevant to science with the help of the media specialist. People in the local community may be able to contribute some relevant information or materials. Museums, zoos, botanical gardens, parks, and bookstores are excellent sources of information. The teacher assigns students to prepare reports on the “life and times” of scientists during specific periods of history that are important to the subject being studied. Another strategy is to ask students to write about their own observations and insights after the writing lesson is over.

WHAT ARE THE BENEFITS?
- personalizes science learning
- allows students to connect science to its social and historical context
LABORATORY INVESTIGATION: A strategy that involves students with their environment. The student proposes a question, develops a hypothesis, explores methods of investigating the question, chooses one of the methods, then conducts research and draws conclusions based on the information gathered.

**HOW DO YOU USE IT?**

- Ask a question. (“When does the grass grow best?”)
- Focus the question. (“What is the effect of sunlight on grass growth?”)
- Develop a hypothesis. (“Grass growth is positively affected by sunlight.”)
- Conduct the investigation. (This is a good place to use cooperative learning strategies, measurement skills, and inquiry.)
- Analyze the data collected and draw conclusions from the results. (Appropriate mathematical tools could be introduced here.)
- Report the results orally, in writing, or with a picture.

**WHAT ARE THE BENEFITS?**

- helps students visualize science concepts and participate in science processes
- students can experience the way some scientists work
- students can learn there may not be an answer to a question or there may be many answers
- develops process skill
Infusing a Multicultural Perspective

Florida students appreciate their own culture and the culture of others, understand the concerns and perspectives of members of other ethnic groups, reject the stereotyping of themselves and others, and seek out and utilize the views of persons from diverse ethnic, social, and educational backgrounds.

Florida’s System of School Improvement and Accountability, Goal 3, Standard 10

Ethnic and cultural diversity enrich the American society and provide a basis for societal cohesiveness and survival. An effective program of multicultural education integrates a sensitive and thorough study of ethnic and cultural content into the curriculum. A carefully designed and continuous curriculum (preschool through 12th grade) can create the multicultural literacy so necessary for a healthy nation. Each cultural group has its own set of values and perspectives. Many of these values are shared with other cultures and form the basis of American national unity. Each cultural group has also made its own unique contribution to the American society and to the world. Because it is essential that all members of our society develop an understanding of the values and perspectives of racial, ethnic, and cultural groups, schools are restructuring their curricula to infuse multicultural perspectives into everyday instruction.

The presence of students with different cultural and family backgrounds, interests, and values in the same class encourages all students to develop a multicultural perspective. Learning settings that respect diversity encourage social competence and moral development. Students learn what they live. They learn to respect individual differences by understanding how others think and feel. Activities that promote empathy, understanding, and respect for differing points of view promote a multicultural perspective without negating one’s own point of view. Students learn to view concepts, issues, events, and themes from the perspective of diverse ethnic and cultural groups. Because the classroom is a model community, students gain the experience of living as responsible citizens in a diverse, democratic society.

Each student brings a wealth of culture that can be recognized, appreciated, and included as part of the instructional content. Teachers can focus on fostering understanding, appreciation, and respect for people of other cultural, language, socioeconomic, religious, or ethnic backgrounds, using the strengths and
backgrounds of their own students to enhance the school experience for all. Teachers can design learning activities that prepare students to communicate and work with others, achieving common goals in a culturally diverse environment. Schools can restructure their curricula to ensure that all students, regardless of background or ethnicity, will achieve high academic standards and be able to function successfully in the workplace. The final goal will be for students to have the cultural knowledge, positive attitudes, and motivation that will allow them to participate in a global community in which every person is respected, appreciated, and honored.

Snapshot of an Effective Science Classroom

The following vignette is offered as an example of integrated, real-world educational experiences that teachers might create for students, using a variety of instructional strategies.

Mrs. Miller's third-grade class is studying a unit on insects. Sally is showing the class a cocoon she found in her backyard and Tyler is showing the class part of a beehive he found. The students crowd around to see and touch them. Mrs. Miller asks, "What do you think is inside the cocoon?" Sally says, "It might be a butterfly." Mrs. Miller asks the whole class, "What do you know about butterflies?" As the students answer the question, Mrs. Miller writes what they say on the blackboard, accepting all answers without commenting on their correctness. Then Mrs. Miller asks the class, "What do you want to know about butterflies?" Maya, a new student from South America, says that she knows there is a butterfly that travels from her country to the United States and she wants to know what kind it is. Seth says, "I want to find out exactly when and where Maya's butterfly goes." Sally wants to know how long butterflies stay in cocoons. As Suzi looks at a poster of butterflies on the wall, she tells Mrs. Miller that she wants to find out why there are so many colors in butterfly wings. Hands fly up as the class gets more and more excited about what they want to learn about butterflies and Mrs. Miller writes all their questions on the blackboard.

Mrs. Miller repeats this same discussion about bees, listing what the students know and want to know on the blackboard. For example, they know a hive is where a colony of bees lives, and they want to know what different shapes of hives there are, how the bees build them, and what they look like inside. Then Mrs. Miller divides the students into two groups according to their interests; one group will research butterflies and the other group will research bees. Mrs. Miller pairs Maya with Seth so they can find out together about the South American butterfly's migration and so that Seth can help Maya with her reading. She pairs Ben, a more advanced
reader, with Tyler, who struggles with reading. The students meet with their groups, divide up the learning tasks, and excitedly begin their research, using the classroom’s ample resource material to pursue their questions. Some students choose books; others use the computer’s encyclopedia, search the Internet, or watch videos.

The next day, Mrs. Miller draws a Venn diagram on the blackboard and leads a class discussion about the similarities and differences between bees and butterflies. Then she asks the students to write a brief report on what they have learned.

In this example, the teacher is using authentic, real-world learning experiences and building on the students’ high degree of curiosity to create a rich learning experience. Using the K-W-L strategy, she reveals the students’ prior knowledge and focuses the students’ interests to create a cooperative learning project. The teacher also pairs up students to support the learning process and uses Maya’s unique background knowledge to enrich the experience for all. The Venn diagram and the written report provide effective instructional strategies that support students in synthesizing and integrating what they have learned.

Teaching Diverse Students

Schools must accommodate a diversity of student abilities, disabilities, interests, cultural backgrounds, and other factors that affect student performance in school. It is important for all educators to be aware of the characteristics of their students and vary their teaching strategies to meet students’ individual needs. Many instructional strategies that have been developed and used by teachers for interacting with students with special needs have proven effective for other students as well.

Increasing ethnic and cultural diversity promises to continue enriching life in the United States. This has important implications for education. As diversity in the school population grows, it becomes more and more evident that all students, regardless of their race, ethnicity, culture, and class, must acquire the knowledge and competencies necessary for functioning effectively with one another. All students must develop the knowledge and competencies necessary to participate successfully in their communities, in the workplace, and in society.
Adapting Instruction for the Diverse Needs of Learners

Given the focus on creating learning-centered classrooms, the unique characteristics of individual learners must guide curriculum planning and affect both the learning environment and the teacher’s role in facilitating the learning process. As curricula and learning environments are redesigned, and as teachers plan and teach, it is important to keep in mind that learners

• come to the educational setting with unique knowledge, experiences, and explanations about the world;
• come from many cultures and backgrounds;
• have diverse needs and values;
• actively participate in learning
• have a variety of interests; and
• have a variety of opinions and ideas about school, science, and the world.

Creating an effective learning environment that can address these diverse needs, backgrounds, and learning styles starts with understanding those needs.

Adapting Instruction for Developmental Differences

Children learn best when material is appropriate to their developmental level and challenges their intellectual, emotional, physical, and social development. Children grow through a series of definable, though not rigid, stages. Schools should demonstrate awareness and understanding of the developmental differences among all, including those children with special emotional, physical, or intellectual challenges as well as those with special abilities. Exploring the developmental differences of children in-depth is beyond the scope of this framework. Much research is available in this broad area.
Adapting Instruction for the Individual Learning Process

Children naturally develop unique capabilities and talents. They acquire preferences for how they learn and the pace at which they learn. There are many forms of intelligence and many ways by which people know, understand, and learn about the world. Seven types of intelligences have been identified by Howard Gardner (1985):

- verbal/linguistic,
- logical/mathematical,
- visual/spatial,
- body/kinesthetic,
- musical/rhythmic,
- interpersonal (dealing with other people), and
- intrapersonal (knowing oneself).

Each student has a learning style that consists of a unique combination of these intelligences. It is important for teachers to understand the learning styles of their students so that they can structure their teaching in a way that incorporates these seven ways of knowing. The science program that matches teaching to learning styles allows students to process material more efficiently, thereby reaching all students and providing the opportunity for deeper and more thorough learning.

There are many other strategies for adapting instruction and the learning environment for students with different needs. One strategy might be to challenge students with open-ended problems to which they can respond on a variety of levels. By encouraging students to explore on their own and by frequently reinforcing their discoveries, teachers can enhance learning. Some students may need additional opportunities to practice previously mastered information. Instruction might take place in the form of individual activities, group activities, games, class discussions, or projects involving multiple skills. It may also be advantageous to vary class grouping to accommodate different tasks or learning styles.

Adapting instruction for the individual needs of students does not mean lowering expectations or having different academic criteria. The teacher’s high expectations for academic success play an influential role in the way other students accept a student who has unique needs. This, in turn, can have an impact on a child’s self-image, affecting his or her eagerness and ability to learn.
Accommodating Students with Disabilities

Teachers who believe that all students can learn create a supportive learning environment for students with disabilities. In addition, modifications in assignments, courses, instructional methods, instructional materials and resources, and assessment methods can help enhance the learning experience for these students. Course modifications may be made to basic or vocational education courses in the regular classroom or in the exceptional student education classroom; these modifications are described in the State Board of Education Rule 6A-6.0312, FAC. Educators may modify a course by increasing or decreasing instructional time, that is, adjusting the time allotted for completing an assignment or a course or adjusting the length of class assignments. The format of the instruction can also be adapted or changed. This might include the use of hands-on materials, audio-visual media, instructional technology (including computers), and the use of specially designed materials such as the Parallel Alternative Strategies for Students (1992-1995), developed for Florida schools.

Quite often modifications that are effective for students with disabilities work well for other students in the class. Specially designed teaching strategies can be easily integrated into the classroom to enhance the content being presented, to assist with assignments, and to organize the content being learned. Testing modifications, such as flexible scheduling, recorded answers, use of mechanical aids, or revised formatting, are helpful for all students.

Accommodating the needs of students with disabilities may include many other modifications. For example, there are students who need special communication systems in order to participate in classes. Students with hearing impairments may need the assistance of an interpreter or note-taker, or both. Computerized devices can help students with disabilities perform written and oral communication. Students with visual disabilities may require access to Braille and other adaptive technology.

When the needs of learners with disabilities are accommodated by modifying instructional methods, assessment methods, and the physical environment and by providing a supportive environment, such students are able to excel. They can develop a greater capacity to take an active role in the learning process and focus on their strengths, which helps them achieve a higher level of knowledge, skills, and competencies in science.
Accommodating Limited English Proficient (LEP) Students

Limited English Proficient (LEP) students are similar in most ways to students whose heritage language is English: They learn at different rates, have various interests and characteristics and different personalities, and bring vast differences in background knowledge and experiences to the learning situation. All are unique. However, language and culture add other dimensions to their uniqueness.

Problems may surface because these learners may use another language at home as they are learning English at school. Thus there may be a psychological “pull” between two worlds; these students often feel that their native language is “wrong.” Because self-concept is influenced by the attitudes of others, negative attitudes from family, friends, and school personnel may result in LEP students feeling isolated and overwhelmed with the new environment, new sounds, and the new culture. Many cultural references, idiomatic expressions, and multiple meanings of words that are known to most literate English-speaking students may be foreign to LEP students. An example might be the sign, “Fine for Loitering.” If the LEP student has learned the meaning for “fine” as “it is all right to do something,” the sign would convey an entirely different meaning than the idea of having to pay money for loitering. All of these concerns may cause barriers to learning.

From the perspective of the teacher, teaching a multilingual class requires more time and more effort because all students may not have similar background knowledge. Teachers must be flexible, willing to learn and grow, be able to adapt and accept LEP students, and value others’ languages and cultures. Many cultures have an entirely different view of education, including the role of the teacher and the student, the environment for learning, and materials used.

The following discussion of characteristics or behaviors educators may see in LEP students is not meant to be a complete list or indicate that LEP students are progressing in language development in the same way and at the same rate. Each student is unique, and educators will need to consider the needs of each student individually.
As LEP students begin to learn English, they may

- remain silent; this should be accepted as a stage of language learning;
- depend on body language, gestures, or paralanguage (words or phrases such as “huh?,” “unh-unh,” and “uh-oh” usually accompanied by a facial expression and/or a gesture);

  The teacher’s consistency in structure, use of gestures, paralanguage, and body language is paramount.
- be actively listening as they silently translate;

  It is essential to remember that these students are not deaf and to wait for students to take the time they need to understand and formulate what they have to say.
- misinterpret body language or gestures;

  For example, a teacher’s motioning for a student to move toward her or him by using the forefinger may be viewed as a demeaning gesture in certain cultures.
- have limited school experience; and

  Some LEP students enter our school systems without much prior experience in school due to a number of factors in their native country.
- exhibit extremes of behavior: frustration, nervousness, fear, and self-consciousness.

As LEP students progress to an intermediate level in their English language skills, they may

- make unsystematic and random language errors that may lead to misunderstanding;

  Teachers should correct errors within the area of instruction rather than attempting to correct all errors. The latter leads to further frustration and an interruption in the thinking process of communication.
• exhibit social language skills in English that exceed language abilities necessary for academic success;

Some young people quickly learn conversational English and mimic the actions of their peers, yet may have difficulty reading and writing appropriately. Conversely, some students are able to read and write in English, yet may have difficulty speaking.

• exhibit limited but continuing progress in vocabulary, control of sentence structure, ability to read with comprehension, and the ability to express ideas;

It is important for teachers to continually provide opportunities for expansion of vocabulary and for use of vocabulary that has different meaning in specific contexts.

• generate language to ask and answer questions without being able to expand or explain; and

Teachers should provide opportunities for LEP students to learn how to ask and answer questions that do not have a “yes” or “no” answer.

• require an extended period of time to translate information.

As LEP students move into the advanced level of language development and learning, they can begin to apply reading and writing skills to acquire information in academic areas and in real-life situations. These students may

• frequently choose to use more than one language to communicate;

Teachers should learn to rephrase what the student has said in a correct model and focus on the use of English.

• exhibit oral fluency but still lack higher level, content-specific language and writing skills; and

• make inaccurate inferences from cultural, linguistic, and intellectual experiences.
Teaching Strategies

To support teachers of all subject areas in choosing effective strategies to use in working with Limited English Proficient students in their classes, the following suggestions are provided. It is important to remember that strategies may be introduced, extended, and expanded at all levels according to the interests and abilities of the learners.

At the **beginning** level, teachers may

- provide opportunities for students to hear and practice language in context with others;
  
  Remember that students need to listen to other students, other teachers, and people in the community to practice the sorting out of inflection, stress, intonation, and accent.

- provide a learning buddy or mentor;
  
  Peer support builds much needed friendships and understanding beyond academic areas.

- involve parents and community members; cultural exchange builds understanding;

- categorize words and ideas, which provides “hooks” for learning;

- use visual aids; label classroom items; match words with pictures, items, colors, and symbols;
  
  This helps students become familiar with physical areas of the school, for example, restrooms, the library, and the gym.

- provide opportunities for students to learn and respond to the usual classroom directions, for example, “raise your hand,” or “put your name in the upper-right-hand corner”; and

- use repetition and consistency in instructions and gestures.
At the **intermediate** level, teachers may

- set reachable goals and expect students to be accountable;
  
  Teachers should demonstrate the correct model and expectations in the initial stages of an assignment or project.

- encourage students to ask questions to clarify their understanding;
  
  Making mistakes is seen as a step in the learning process, not something to be avoided.

- obtain background information about language and culture to avoid embarrassing situations;

- speak clearly and at a normal pace with normal stress and intonation;

- check for understanding, as early clarification paves the way for success;

- present key words and ideas orally, on the chalkboard, and with the use of visual aids, before introducing new concepts; and

- use diaries, journals, or picture collages.
  
  As learners have opportunities to express themselves in various ways, anxiety lessens.

At the **advanced** level, teachers may

- provide examples when making assignments for book reports, class logs, lab reports, and research assignments; a visual goal helps with understanding;
use cooperative learning groups; and

Collaboration within the science class is a particularly useful instructional approach with students. For example, written and oral language develop, build, and “fine tune” from trial and error in collaborating groups. As students listen and participate, they learn to use gestures, tone, stress, and inflection to develop the “whole” of language, no matter what the content might be.

ask students to explain what they have heard or read and where they have seen words, phrases, or situations; this provides opportunities for expanding ideas and oral expression.

Generally, and across all subject areas, teaching LEP students requires

• knowledge of language development and language acquisition;

• the ability to adapt content to students’ needs and levels of learning;

• a willingness to learn about cultural differences and similarities;

• flexibility and sensitivity;

• a philosophy that learning takes place in every situation and in every environment;

• a belief that everyone learns from mistakes and from one another; and

• an encouraging, nurturing attitude.

Understanding and being sensitive to the needs of students who are learning English as a second language is important. Using effective strategies to support them as they learn science will help ensure an environment that will provide successful experiences for LEP students.
Accommodating At-Risk Students

Students at risk of leaving school before graduation are a special challenge to the classroom teacher. Poor academic performance, as measured by being overage for a particular grade, in conjunction with grade retention and traditional and alternative assessments, has been cited as an accurate indicator of which students may drop out of school. Students who have difficulty meeting the required academic performance levels and who fall behind their peers often see little possibility of catching up; they may be at a high risk of not graduating.

Teachers can raise the level of student motivation by consistently modeling interest in the subject, tasks, and class assignments. They can also create classroom activities in which at-risk students are more likely to be successful and are able to tap into their own intrinsic level of motivation.

Teaching Strategies

Some strategies that have been effective in targeting at-risk students are the following:

• offering limited choices when it comes to alternatives for homework or long assignments;

• using active learning situations such as games, projects, group work, discussions, experiments, board work, creative seat work, and simulations (for example, mock elections, role playing, trials, and plays);

• providing concrete rather than abstract instruction, for example, physical objects, pictures, maps, diagrams, and colors as well as stories and anecdotes, because loading instruction with many examples makes the lesson come to life;

• using puzzles, brain teasers, and games to help students learn facts and figures;

• using short tasks and assignments, which provide more opportunity for completion, giving at-risk students a sense of accomplishment;
• having students compare their current efforts to their previous work rather than to the work of other students;

• avoiding class announcements of poor performance; avoiding posting or calling out grades;

• avoiding situations in which individuals compete openly in class; using, instead, group competitions in which teams are carefully designed so that the at-risk student is likely to meet success;

• helping students to concentrate on the task and its completion rather than on the consequences of failure;

• helping students evaluate situations in which they have been successful; helping students analyze unsuccessful situations and determine why they were unsuccessful; helping students focus on the path to success;

• teaching test-taking skills and avoiding timed tests;

• giving pretests so that students can make positive posttest comparisons, thus treating tests as opportunities for assessing learning rather than measuring ability;

• creating pretesting structures, for example, by providing study guides and outlines and teaching note-taking and outlining skills; and

• providing immediate feedback on student work by circulating around the classroom and monitoring students’ efforts on the spot, and promptly returning homework, assignments, and exams.

At-risk students, faced with a problem they have difficulty solving, often give up and simply go on to the next problem, or worse yet, do not even try to solve the problem and end up selecting answers randomly. The ability to persist can be taught. To encourage at-risk students to persist, teachers might

• carefully monitor students at work, coaxing them to continue working and to keep at it;
• help students set objectives and goals that bring immediate results;

• help students see that each new, small success brings them closer to their goals and makes them stronger;

• use contract learning, in which students have limited choices that move them step by step toward completion of course objectives;

• offer make-up exams, credit for effort, extra credit options, and extra practice opportunities;

• offer opportunities to rewrite or correct until revisions are completed; and

• help students retrace their work to find errors, analyze problems, and reread portions they have skipped in order to answer the questions.

The Dropout Prevention Act of 1986, Section 230.2316, Florida Statutes, was enacted to authorize and encourage school boards to establish Dropout Prevention Programs. These programs are designed to meet the needs of students who are not effectively served by traditional programs in the public school system. This includes students who are unmotivated, unsuccessful, truant, pregnant and/or parenting, substance abusers, and disruptive, as well as those who are in shelters.

Strategies used in these programs that have been found to be effective could prove successful in a more traditional setting. These include

• instructional strategies and tools such as cooperative learning, computer-assisted instruction, authentic/alternative assessment, critical thinking, and graphic organizers;

• competency-based curriculum which allows students to work at their own pace;

• flexible scheduling or use of time;

  Students “declare” a schedule and attend, even though it may be beyond the traditional school day. Competency-based curriculum delivered through computer-assisted instruction is well suited to this strategy.
• career awareness and on-the-job training for employability skills;

• experiential learning and hands-on activities;

• mentoring and nurturing;

• course modifications;
  
  Course modifications allow at-risk students to compress or extend the period of time it takes to master material in a given course, to respond to a variety of assessments, to demonstrate mastery, and/or to be offered interdisciplinary or intradisciplinary units of instruction through the integration of more than one course description. This gives the overage-for-grade students an opportunity to catch up with their own grade peers.

• summer bridge programs;
  
  Summer bridge programs allow overage-for-grade students to catch up with their own grade peers by attending a rigorous summer session and then being promoted to the next grade level.

• collaborative teaching that combines two classes;
  
  In one model of collaborative teaching, the dropout prevention teacher furnishes expertise in course content, while the specific learning disability teacher offers expertise in course modification.

• thematic units in which teachers identify common themes and realign student performance standards to reflect the theme;
  
  In some models, teachers work together to identify aspects of their discipline that have commonalities; in other models, teachers work separately without any attempt to connect with other subject areas.
• peer counseling and student conflict mediation;

One model pairs at-risk ninth graders with twelfth graders who are selected according to leadership skills and their potential to serve as role models, and who are trained in peer counseling strategies including listening, questioning, paraphrasing, and feedback. These older students also provide academic tutoring and use a variety of peer counseling strategies designed to help the ninth grader become successful in an academic curriculum that addresses social, individual, school, and family concerns; topics could include drug and alcohol abuse, family relations, academic motivation, and coping with stress.

• student support and assistance components, which serve students who are eligible for dropout prevention programs and who are in need of academic or behavioral support;

Students are served in traditional classes through a flexible schedule of auxiliary services, including supplemental materials or alternative strategies to assist with course modification, behavior management, or alternative assessment. Instructional aides or case managers can also be used to support teachers, students, and parents.

• GED/H SCT Exit Option; and

This program allows currently enrolled, dropout-prevention students to earn a standard high school diploma by enrolling in courses for credit that lead to a standard high school diploma and work to master the individual course student performance standards. To enter the program, these students must be behind the class with whom they entered kindergarten and demonstrate probability for success on the GED through documentation of a high score on a standardized test; to complete the program, students must complete required courses and pass the H SCT and the GED tests.

• coordination with other agencies, such as social service, law enforcement, prosecutorial, and juvenile justice agencies as well as community-based organizations.
Putting These Ideas to Work

Current educational philosophy recommends that educators focus on developing a learning-centered curriculum, which includes a number of key ideas:

• The teacher is a facilitator (a “guide on the side” versus “the sage on the stage”).
• The student is a discoverer of knowledge within his or her learning community. This involves students listening to others and learning to filter information and draw conclusions, versus simply taking in a body of knowledge imparted by the teacher.
• The community is a rich resource.
• Real-world learning experiences help students apply knowledge and skills; this helps prepare them for daily living and future employment.

Using the curriculum frameworks as a guideline, local educators will make the final choices regarding how to teach the essentials. These choices will include the themes and topics by which to teach academic standards, the day-to-day content of instruction, the types of materials and resources used, and the teaching strategies that are appropriate for the individual needs of the students and for the teacher’s own strengths. The result of a thoughtfully designed curriculum is students who have the ability to achieve high academic standards and who can be better prepared to live as responsible, effective, and productive citizens within a global society.
Instruction that prepares students for the 21st century should focus on

- high academic standards with expectations of high achievement for every student;
- a learning-centered curriculum with the teacher as a facilitator of learning;
- learning based on constructing meaningful concepts from facts;
- learning science in its real-world contexts;
- making connections within science and with other content areas;
- relating science to the students’ world;
- active, hands-on learning in the classroom;
- more student responsibility and choice;
- students inquiring, problem solving, conjecturing, inventing, producing, and finding answers;
- students working and learning cooperatively;
- accommodating individual student needs, whether cultural, developmental, or cognitive;
- infusing a multicultural perspective;
- expanding resources to include local and global communities;
- using technology to support instruction; and
- relating classroom learning to the skills students will need to function successfully in their communities, in the workplace, and in society.
Chapter 5: Curricular Connections Through Instruction

Chapter Highlights

- Curricular Connections and Transfer of Learning
- Models for Curricular Connections in Instruction
  - Infusion
  - Parallel Instruction
  - Multidisciplinary Instruction
  - Transdisciplinary Instruction
- Planning an Interdisciplinary Unit

Why should teachers try to connect science to other subject areas? There are at least three compelling reasons for doing so. First, life does not occur in neat, subject-matter packets. A single incident, such as a hurricane, affects a region in many ways. It destroys homes, cultural resources, and businesses; damages the environment; upsets the economy; interrupts school and school programs; tests government emergency response policies; and demands immediate solutions to problems that will have a long-term aesthetic and economic impact upon the quality of life in a community. To address these complex issues, citizens must integrate and use knowledge and skills from a variety of subject areas. Second, making connections among subject areas creates a greater sense of meaning for students; for example, a process they learn in science helps them better understand social studies. Finally, today’s teachers face the challenge of an ever-expanding curriculum. Although the expansion of the curriculum results in part from important mandates from the state level, most of it results from the simple fact that information in the modern world is expanding at a phenomenal rate. This expansion of information underscores the importance of stressing connections among subject areas.
Curricular Connections and the Transfer of Learning

Connecting important concepts from different disciplines has a number of beneficial effects. One of the most important effects is that it facilitates the transfer of learning. A disappointing fact about education in America is that students frequently demonstrate that they understand something in one setting, but fail to understand the same concept in another setting. Educators refer to this occurrence as a lack of transfer of learning. For example, a student might show that he or she understands how to construct a well-organized paragraph in a language arts class, but fails to see how that very concept applies to writing a lab report in science class. By forging connections among subject areas in the classroom, students have a better chance of recognizing that what they learn in school has applications beyond the classroom. This transfer of learning is illustrated in the following example:

Meisha’s kindergarten teacher, Ms. Malkoski, explains to Meisha and her classmates that all scientists use the scientific processes of observing, recording, and communicating when they explore the world around them. To illustrate, Ms. Malkoski shows the children three short videos on different types of scientists: an environmental engineer examining soil samples, NASA scientists analyzing Shuttle flight data, and archaeologists recording details of their latest find. The children discuss how these scientists were alike and different. One similarity that the children agree upon is that these people were all careful observers and recorders of what they saw.

After school, Meisha goes with her mother and little brother to the pediatrician’s office. Meisha’s brother Matthew has a fever. Meisha notices how Dr. Corren listens thoughtfully to Matthew’s heartbeat and lungs, carefully examines Matthew’s ears, nose, and throat, and then makes notes of his examination in a special file. It occurs to Meisha that Dr. Corren must be a kind of scientist, too, although until today, she had never thought of her doctor in that way.

Curricular connections also encourage teachers to work in a collaborative mode. Most teachers have heard the expression, “Teaching is one of the most isolated professions in the world.” Fortunately, it doesn’t have to be. A science teacher who decides to use content from social studies creates a reason to interact with the social studies teacher. The interaction among teachers from different content areas can take many forms, depending on the model that is being used for making curricular connections.
Models for Curricular Connections in Instruction

Several strategies will be overviewed in this chapter; curriculum developers and teachers may want to explore these strategies in greater depth. Four effective models of curricular connections are infusion, parallel instruction, multidisciplinary instruction, and transdisciplinary instruction. After further exploration of these models, individual school staff must determine whether any or all of these models will work in their setting.

Infusion

In infusion, a teacher in a given subject area integrates another subject area into his or her instruction.

Students in Mrs. Tammi’s combined fifth- and sixth-grade science class are learning about the importance of energy conservation. Students learn about different forms of fuel and energy used in the world today. Students keep a personal record of their own energy consumption, noting the kind and amount of energy used. Students discover that they use much more energy than they had been aware of using.

To add a historical perspective, Mrs. Tammi shows a film that depicts family life in colonial America. Afterwards, she asks the class to identify the types of energy consumption shown and how fuel was used by early settlers. She leads a class discussion on how fuel and its use affected the settlers’ daily lives and how changes in fuel production and consumption have shaped contemporary life.

Parallel Instruction

In parallel instruction, teachers from different subject areas focus on the same theme, concept, or problem. Each discipline is taught separately, but teachers must plan together to identify the common element and determine how the concept, theme, or problem will be addressed in each subject area. Homework and assignments commonly vary from subject area to subject area, but all reflect the common theme, project, problem, or concept being addressed.
High school teachers decide to explore the theme of balance as it applies to the content areas of science, social studies, language arts, health, the arts, and mathematics. Although each subject area deals with "balance" in different ways, teachers meet prior to the unit to collaborate on ways that the concept might be presented and to ensure that the concept will be reinforced in each subject area.

In science, students explore the importance of balance in nature and the environmental consequences that result when certain aspects of nature are not in balance. Specifically, students focus on clean air standards and methods of lowering levels of air particulates to maintain a healthy balance. Groups of students visit industrial sites in the area and measure levels of particulate matter in the air at these sites, noting prevailing winds and how these might affect air quality in their neighborhoods. Students present their findings to an EPA representative who had visited their class to speak about local efforts to keep the air clean.

Social studies teachers discuss the concept of checks and balances built into American government. Students also study how checks and balances are factors in creating the federal budget. The students contact the congressperson representing their area; she speaks to the social studies classes about her budgeting experiences as a member of the Ways and Means Committee.

In language arts, students are in the midst of studying persuasive techniques and debate. Topics for debates have "balance" as their focus; these include eliminating certain federal programs as a means of balancing the budget, hunting as a means of balancing predators and prey, the pros and cons of balancing school populations through enforced busing, and balancing environmentalists' concerns with those of pleasure boaters on environmentally delicate intracoastal waterways.

Health classes study the importance of balance in diet and exercise. Students keep track of their diets for a week and are surprised to note the differences between what they typically ate and the balanced diet recommended by the American Dietary Association. They also track whether their leisure time includes a balanced amount of exercise. A panel consisting of a physician, physical therapist, and dietitian from the local hospital speaks to health classes on food addictions and how imbalances in food-group intake can affect physical and emotional health.

The art teacher takes his students to the museum; students work in groups to identify and critique the use of balance and symmetry in a variety of artwork and sculpture they had seen during their field trip. Next, they design their own artwork to illustrate the concept of balance; these pieces are displayed throughout the building.
In mathematics, students investigate the concept of balance in a number of areas. One of these involves how balance is a critical factor that architects and engineers apply in the design of multilevel structures and bridges. Students also study how statisticians use measures of central tendency to display the balance and dispersion in sets of data. Students create drawings and graphs to demonstrate what they have learned; for example, one group gives a class presentation explaining the relationship between the size and depth of a foundation and the number of floors of a building.

**Multidisciplinary Instruction**

As with parallel instruction, within multidisciplinary instruction two or more subject areas address a common concept, theme, or problem. The subject areas are taught separately for the most part, but a common assignment or project links the various disciplines. Teachers must plan together to identify how the concept, theme, or problem will be addressed in each subject area, construct the common project, determine how the project will be divided among the subject areas, and determine how students will work together on the project.

As part of their middle school’s celebration of Earth Day, the sixth-grade arts, health education, science, and language arts teachers collaborate on a common project. Specifically, they want students to learn and then demonstrate an understanding of the importance of environmental clean-up by writing and producing a research-based, original play to be presented to the student body.

Each teacher presents material and activities students can use as a basis for their script. Through the study of health, the students visit local landfills. Representatives from waste-hauling companies explain how the community’s waste is handled and how much recycling is actually taking place. In science, students conduct a “river watch,” assessing the amount of pollution in a local waterway and cleaning up refuse along the banks. In music, students create a song to be performed as the play opens; the musical work features sounds produced by objects
recycled during river watch clean-up efforts. In language arts, students work in groups to create the story line and write the script of the play based on all that they had learned. On Earth Day, the play is produced for the entire student body and is also videotaped for broadcast over the school’s cable network so that others in the community can benefit from seeing it.

**Transdisciplinary Instruction**

Within transdisciplinary instruction, two or more subject areas address a common concept, theme, or problem; however, the subject areas are presented in an integrated fashion. Classes in the subject areas meet at a common time; teachers integrate planning and team-teach all lessons. Commonly, a major project is the focus of the unit.

Science, social studies, health, language arts, and vocational teachers with a common set of students develop and team-teach a three-week unit entitled *The Good Life*. Teachers meet during their common planning period to design meaningful content and experiences aimed at helping their students carefully consider and define their vision of “the good life.” The teachers conclude that students’ understanding of the material will be best assessed in two forms: as their final project, students are required to express their vision in writing and by designing a computer simulation of an ideal community.

Classes meet in two-hour blocks during the unit. To gain a historical and philosophical perspective on the topic, students read Utopian literature on various views of the good life. From their reading and class discussions, they learn what people of different cultures and historical periods defined as the good life. They learn about communities that tried but failed to create a Utopian society and consider why these communities were not successful.

Students also spend class time examining their families’ and community’s values and how these contribute to their own vision of the good life. They study healthy lifestyles that contribute to the good life and the biological principles underlying healthy diet and exercise. They explore environmental concerns and the tradeoffs between environmental degradation and the good life. A city planner visits the class to explain how planning can contribute to health, happiness, and well-being. Students visit Celebration City, Disney World’s model community.

After thoroughly reviewing what they have learned, students work in groups to design computer simulations that depict their ideal community. Each student also writes a persuasive essay defining and defending his or her vision of the good life, citing evidence gathered during the unit as support.
Planning an Interdisciplinary Unit

One of the most effective ways to plan a unit that fosters connections is to focus on creating projects that involve content from different subject areas. As we have discussed, projects are a central part of both multidisciplinary and transdisciplinary instruction. Below is a simple three-step process that can be used to develop projects that forge curricular connections.

**Step #1: Select benchmarks from two or more subject areas that will be integrated into the project.**

For example, assume that a science teacher sets out to construct a project that incorporates a benchmark from science with a benchmark from language arts. She would first consult chapter 3 of this framework and select a benchmark. For example, she might select the following benchmark, which can be found under the standard “The student understands the interaction and organization in the Solar System and the Universe and how this affects life on Earth”:

**Science benchmark:** The student knows that available data from various satellite probes show the similarities and differences among planets and their moons in the Solar System.

The teacher would then consult the framework for a second content area—language arts, for example. The teacher might pick the following benchmark which can be found under the reading standard: “The student constructs meaning from a wide range of texts”:

**Language Arts benchmark:** The student locates, organizes, and interprets written information for a variety of purposes, including classroom research, collaborative decision making, and performing a school or real-world task.

These two benchmarks— one from science, one from language arts— would form the basis for the project. It is important to realize that all benchmarks must be selected with a great deal of attention to their relatedness. In other words, not all pairs of benchmarks make a good match. The two benchmarks correlate because both benchmarks require students to integrate knowledge into activities involving critical
responses. If a teacher tries to force a connection between benchmarks from different content areas, the resulting project will be artificial and will run the risk of confusing students.

**Step #2: Identify an interesting question or questions that can be asked about the benchmarks that have been selected.**

One way to help students explore the relationship between benchmarks is to ask a question that will naturally integrate the benchmarks. The following is a list of useful questions to consider:

- What is the underlying pattern?
- How are these things similar and different?
- What groups can these things be put into? What rules or characteristics have been used to form groups?
- What conclusions can be formed about this information?
- What is the evidence for this position and how good is it?
- What specific rules are operating here? Based upon those rules, what must happen or what will probably happen?
- Are there errors in reasoning that have been made? Are there errors being performed in a process?
- Is there a hidden relationship here? What is the abstract pattern or theme that is at the heart of the relationship?
- Are there different perspectives on an issue that should be explored?
- Is there some new idea or new theory that should be described in detail?
- Is there something that happened in the past that should be studied?
- Is there a possible or hypothetical event that should be studied?
- Is there an obstacle that must be overcome?
- Is there a prediction that can be generated and then tested?
- Can this skill or process be used to accomplish something or better understand something?

**Note:** Adapted from Marzano, Pickering, & McTighe. (1993). Assessing Student Outcomes.

To illustrate how a question from this list can be used, consider the two benchmarks on the previous page.
A question that could address these benchmarks is “Is there a possible event that should be studied?” In other words, is there a question related to the composition of the planets in the Solar System that could be examined through the study of literature?

**Step #3: Identify a product or products that incorporate the benchmarks that have been selected.**

With the content benchmarks selected and an interesting question identified, the next step is to identify the product or products that best suit the project. It is useful to consider four types of products: (1) conclusions, (2) processes, (3) artifacts, and (4) affective responses. It is important to remember that some products may not be applicable to all subject areas.

**Conclusions** are generalizations that have been constructed as a natural consequence of studying some issue or topic. For example, in science, students could study the types and amounts of energy currently being used in their homes and form conclusions about the levels of energy efficiency in their homes. When students report their conclusions, they commonly are expected to provide evidence and support. This may be in the form of oral or written reports, videotapes, audiotapes, charts, and graphs.

**Processes** are sets of actions that are the natural consequences of solving a problem or accomplishing a goal. For example, in science students might be asked to develop a detailed process for conducting a laboratory experiment that will demonstrate how catalysts function in chemical reactions. Processes are commonly demonstrated along with an explanation of how the process works and why it is effective. If the process cannot actually be demonstrated, it is sometimes simulated.

**Artifacts** are physical products that are natural outcomes of solving a problem or accomplishing a goal. For example, in science, students might be asked to build a pulley that can lift a load.

**Affective representations** are illustrations of emotional responses that result from studying some issue. They take many forms including paintings, murals, sculptures, models, collages, sketches, and personal essays. Models, personal essays, and sketches in particular may be used as products in science. For example, after studying about
the effects of industrial pollution on community health, students might be asked to write a personal essay that depicts their feelings about the issue.

Of these four types of products, a conclusion seems to be the one best suited for the project regarding the study of a scientific hypothesis through literature. That is, the project requires students to study the compositions and various phenomena of the planets in the Solar System, use literary information to study a hypothetical situation, and generate conclusions about that situation using evidence based on their scientific knowledge. With the benchmarks selected, an interesting question identified, and a type of product selected, the teacher would then write the project as a set of directions to the students. Those directions might read as follows:

We have been studying the chemical compositions of the planets in our Solar System, using the satellite data we collected from the Internet. I would like you to consider if human beings could establish colonies on any other planets or on the planets' satellites. As you consider this question, I want you to look at some of the literary works you are studying in your science fiction unit in Language Arts. How do science fiction writers explain how human beings could live on other planets in our Solar System? For example, how does Ray Bradbury explain life on Venus in his story “All Summer in a Day”? You can choose any story that shows human beings living on other planets in our Solar System for this study.

Your assignment is to examine the scientific data you collected about the planet depicted in the story you chose. Then, I’d like you to answer the following questions: Would it be possible for human beings to create a colony on this planet? Are there regions on that planet that might be able to support human life someday, given the right technology? What kind of technology do you envision would be necessary to sustain human life on that planet? After you answer these questions, I want you to form a conclusion about the living situation described in the story you just read. Given your knowledge about the planet you’ve studied, would it be possible for people to live on the planet as described by the author in the story? Be prepared to use evidence to support your position. You will then present your conclusion to the class, using whatever supporting materials that you think will help your presentation, such as pictures, drawings, or models.

As this example illustrates, creating a project that involves benchmarks from different subject areas is a complex process. However, it is worth the effort in terms of student motivation and learning.
**Key Chapter Points**

- There are four basic ways in which curricular connections can be forged: infusion, parallel instruction, multidisciplinary instruction, and transdisciplinary instruction.

- A three-step process can be used for constructing projects that forge curricular connections.

- Curricular connections make learning more meaningful for students.
Chapter 6: Assessment

CHAPTER HIGHLIGHTS
• The Assessment Process
• Different Types of Classroom Assessment
• The Use of Assessment Rubrics
• The Florida Writes Rubrics

Assessment of student academic achievement is a fundamental component of Florida’s school improvement and accountability initiative. Assessment provides essential information on the effectiveness of our reform efforts and on the level of student achievement of Florida’s academic standards. Assessment processes are varied and include the use of standardized tests as well as other formal and informal methods to build a web of useful information about student achievement.

Florida schools will be held accountable for student achievement through the collection and analysis of academic assessment information from the state, district, school, and classroom levels and the public reporting of results. One highly visible part of the education accountability program will be a statewide, externally mandated assessment system measuring student progress in reading, writing, and mathematics in a context of high-level thinking and problem solving. This state test will provide an external “spot check” on the first four standards of Goal 3. This system will be criterion referenced and will include performance-oriented items. It will be administered at three levels: elementary, middle, and high school.

A statewide assessment program, however, is not adequate by itself to provide all of the information on student knowledge and skills needed at the local level. This can only be provided through the proper use of classroom assessment procedures. The focus of this chapter is classroom assessment, one of the teacher’s most complex and most important responsibilities. This chapter presents overviews of various strategies for classroom assessment. Curriculum and assessment developers and teachers should explore these strategies in greater depth through other more-detailed sources.
Classroom assessment refers to the tasks, activities, or procedures designed to obtain accurate information about student academic achievement. Assessment helps answer these questions: What do students know and what are they able to do? Are the teaching methods and strategies effective? What else can be done to help students learn?

Good science assessment reflects the organization and structure of knowledge and the process of investigating the natural world. Classroom assessment activities should be systematic, ongoing, and integrated into the process of instruction and learning. This dynamic relationship results in a continuous process of refining goals as the teacher works with the entire class and with individual students. In fact, the term assessment comes from the Latin assidere, which means “to sit beside.” This meaning creates a picture of the teacher and the student working together to continually improve the processes of teaching and learning. To assess also means to analyze critically and judge definitively. This meaning emphasizes the teacher's responsibility to make judgments about students' achievement based on careful consideration of obtained information.

Authenticity in classroom assessment activities is desired whenever possible. That is, assessment activities should not only examine simple recognition or recall of information, but should also determine the extent to which students have integrated and made sense of information, whether they can apply it to situations that require reasoning and creative thinking, and whether they can use their knowledge of science to communicate their ideas. Using authentic (i.e., realistic) assessment activities will help reveal whether or not students have learned to do these things. The strategies presented in this chapter will encourage the linkage of curriculum, instruction, and assessment.

The Assessment Process

Mr. Garcia could not understand why Lawanda was getting such poor grades on her chemistry test. Her lab work was above average and she could explain the “how and why” of every experiment. Lawanda said she was never any good at taking tests.
In recent years, our knowledge of how students learn has increased; for example, we have learned that students acquire knowledge and skills in widely diverse ways. Knowing this, however, only serves to increase the complexity of student assessment. Because all students do not learn in the same way and because increasing numbers of our students come to school from situations that seriously affect their prospects for success, innovative approaches to instruction and assessment are needed to meet their needs.

The process of assessment is not complete without the communication of results. Timely feedback from assessment is important to positively influence student performance and instruction. Comments about student progress may be formal or informal and should emphasize what students have done successfully and what they have achieved. The process should include opportunities for the student to comment on his or her own progress and for the student's family to be involved in and informed about the assessments. Summary results of classroom assessments should be shared with other educators, citizens, and decision makers, where appropriate, and used by educators to improve instruction.

**Different Types of Classroom Assessment**

The unique nature of science calls for using multiple forms of assessment to clearly evaluate each student's progress as well as the impact of instructional strategies. The task of teachers and assessment specialists is to use the most effective and valid forms of assessment for the particular educational setting, for the type of knowledge, skill, or ability being assessed, and for the individual student. Developing a variety of assessment options allows the teacher to match the assessment to the student's ability to demonstrate knowledge to verify that learning has taken place. For example, suppose Lawanda's knowledge of chemistry was tested in the laboratory. How can the instructional and learning process influence the assessment method?

Even when a variety of options is available, modifications for specific students may also be necessary. Modifications that are made in the classroom for the instruction of special needs students often can be applied to assessment procedures. For example, it may be more effective to allow a student the opportunity to give an oral presentation rather than a written report.
When written tests are used to assess student performance, test administration can be modified in a variety of ways, including flexible scheduling and flexible settings. Students may perform better if not hampered by artificial time limits or disrupted by other students in the class. Using a revised format that may allow the student to listen to test questions rather than read them can also improve performance for students with reading disabilities. Recording answers or performances via audiotape or computer programs may help a student demonstrate competency under less stressful circumstances.

Assessment techniques overlap and blend together. Using several forms of assessment provides a broader and more comprehensive picture of the learning and teaching of science. Educators are encouraged to select from among the many innovative assessment strategies available, a number of which are described below.

**Traditional Assessment**

Traditional assessment is a term often used to describe the means of gathering information on student learning through techniques such as multiple-choice, fill-in-the-blank, matching, or true/false questions, and essays. These approaches are particularly useful in assessing students’ knowledge of information, concepts, and rules.

Because factual knowledge of information is one important aspect of science, carefully designed multiple-choice, true/false, and matching questions can enable the teacher to quickly assess the building blocks of the science curriculum. Examples of such skills include the following: Can the student recognize important terms, relationships, and symbols? Does the student recognize how knowledge is organized into patterns, how generalizations are formed from evidence, how events are understood in chronological order, how frames of reference inform decision making, and how predictions can be made from data?

Effective assessment evaluates knowledge of facts as well as their connection to a broader body of knowledge. Proficiency in science depends on the ability to know and integrate facts into larger constructs and to use the tools, procedures, and reasoning processes of science.
Assessment Alternatives

There are many “alternatives” to traditional assessment that can be used to broaden the scope of the teacher’s classroom assessment activities. In some of these alternative assessment forms, students perform self-evaluations of their work. In others, teachers make informal observations about students' knowledge, skills, and performance that relate to subject-area topics.

The following list of alternative assessment techniques is by no means exhaustive. New assessment techniques are continually being developed to measure students' progress toward achieving new academic performance standards and benchmarks.

**Performance assessments** require the student to create a product or construct a response that demonstrates a skill or an understanding of a process or concept. Performance assessments are commonly presented to students as projects that are done over an extended period of time and require that students locate, gather, organize, interpret, and present information. Typically, the project or product of the assessment is rated by the teacher or team of teachers using clearly delineated criteria.

Mr. Lessing wants to assess his students' understanding of essential concepts about force and motion. He has his high school students design and build model cars propelled by energy stored in metal-coil springs. The students “race” the cars, then measure the distance travelled and the speed. They record results in an electronic database and analyze their findings using mathematical formulas. Mr. Lessing evaluates the students' data and their conclusions to determine each student's level of understanding of key concepts.

**Authentic assessments** are a form of performance assessment structured around a real-life problem or situation. Although traditional multiple-choice questions can describe real-life situations, the term “authentic assessment” usually is applied to performance assessments.

Mr. Koyama asks his students to consider how the concept of waste decomposition can be applied to improving the environment. For their final class project, Maria and Jessica decide to research how community waste can be transformed into compost for fertilizer. They use the Internet to locate information about composting methods and practices, and they visit a local composting plant to observe operations and ask questions. They meet periodically with Mr. Koyama to
inform him of their progress. Maria and Jessica create a plan for developing a home compost heap and give a multimedia presentation to the class. During their presentation, they explain how waste should be collected, how microorganisms break down the waste, and the ways in which home compost heaps could lessen the burden of waste disposal on local landfills. Mr. Koyama takes notes during their presentation on how Maria and Jessica communicate their proposal to an audience. When Mr. Koyama assesses their written plan, he pays close attention to how well Maria and Jessica have applied the concepts about the cycle of production, consumption, and decomposition taught in class to a local community issue. Mr. Koyama meets with Maria and Jessica to give them feedback on both their class presentation and their written project.

**Teacher observation** is a form of data collection in which the instructor observes students performing various activities without interrupting the students' work or thoughts. Teachers use checklists, rating scales, or notebooks to record their judgment about students' competence in specific standards or benchmarks.

Ms. Kline's class is halfway through a unit on the properties of matter. Ms. Kline wants to make an informal assessment of her students' understanding of key concepts and their performance of basic laboratory skills. She observes Charlie as he works with crystals. Ms. Kline makes notes on her checklist as she watches Charlie classify them by shape and color and listens as Charlie explains his findings to his partner. Through her observation of Charlie at work, Ms. Kline determines that he has a firm understanding of the concepts she has taught.

**Interviews** require students to respond verbally to specific oral questions. The instructor asks questions, interprets answers, and records results. This form of assessment also allows a teacher to discuss student answers, to probe for more complete responses, and to identify misconceptions so they can be corrected. Correction should be postponed until the interview is completed to encourage the free flow of ideas and to reduce student apprehension.

After a laboratory activity in his chemistry class, Mr. Maloney asks Monique detailed questions about the uses of radioactive isotopes and the benefits and dangers of this technology. Monique's answers reflect her understanding of the risk factors involved in the use of isotopes, but Mr. Maloney notes some misconceptions she has about how isotopes work. After the interview, Mr. Maloney again explains to Monique essential concepts related to how isotopes work. Monique demonstrates her increased understanding of isotopes during the next laboratory activity.
Conferencing involves a two-way dialogue between a teacher and students or among students for the purpose of evaluating progress on a specific standard or benchmark or on a project.

Mr. Moyo has given his students the assignment of graphing the Moon’s orbit around the Earth. His students use radar data of the distance between the Earth and the Moon at various points in the lunar cycle, plot the points on graph paper, and measure the pattern of the orbit. After making his graph, Richard approaches Mr. Moyo to report a discovery he has made. Richard explains to Mr. Moyo that his graph demonstrates that the orbit of the Moon is not a true circle, but an ellipse. After their conversation, Mr. Moyo notes on his checklist Richard’s ability to make inferences based on his analysis of data.

Self-assessment enables students to examine their own work and reflect upon their accomplishments, progress, and development. The teacher may supply the student with assessment criteria or assist students in developing their own. This form of assessment assists students in developing the critical thinking and evaluative skills that lead to effective problem solving and independent learning.

Mrs. Christiansen wants her students to apply their knowledge about the processes of scientific investigation to the development of independent projects. Roberto has developed a hypothesis for how to use hydroelectric energy to power a light display. After consulting with Mrs. Christiansen, Roberto designs and builds a hydroelectric device for the local science fair. The project is well regarded and complimented by the judges. After the science fair, Mrs. Christiansen encourages Roberto to assess his project by answering the following questions on videotape: How did he develop his hypothesis for the project? What were the methods he used to test his hypothesis? What problems did he encounter as he designed and constructed his device? What has he learned about scientific investigation? How has he applied concepts of scientific enterprise? What are the practical applications for his findings? What kind of follow-up investigations could he make?

Peer assessment involves students evaluating each other’s work using objective criteria. It requires students to reflect on the accomplishments of their classmates. By assessing others’ work, students often see alternative reasoning patterns and develop an appreciation for diverse ways of approaching and solving problems.
In Mr. Blackwell’s biology class, groups of students make multimedia presentations about the anatomy and physiology of the digestive system. The students hold a discussion after the group presentations in which they assess each group’s demonstration of key concepts and how well each group communicated its information. The class provides constructive feedback to each group. Mr. Blackwell finds that this procedure helps focus student attention on the presentations and increases the quality of student-to-student questions.

**Portfolio assessment** is a purposeful collection of a student’s work that provides a long-term record of the student’s best efforts, progress, and achievement in a given area. Materials included may be decided on by the student, the teacher, or both. Depending on the intent, portfolios can serve as the basis for assessing individual student growth over time on given standards and benchmarks, or for assessing learning specific to the objectives addressed in a theme or unit. It is important to note that, although a portfolio can be used as an effective instructional tool, its use as an assessment tool demands a clear understanding of purpose, specification of the desired portfolio contents, and a definition of the methods of rating the individual components of the portfolio.

Javier has been keeping a record of the weather for the past two weeks. He consults with his teacher, Mrs. Calderon, before putting together his science portfolio that he is developing for the year. Javier decides to include in his portfolio the pictures he drew of a thunderstorm, the graphs he made of the daily temperature, and the report he wrote about hurricanes. Javier writes an introduction page for his portfolio in which he discusses what he has learned about weather patterns this term. Mrs. Calderon includes in Javier’s portfolio a written review of her assessment of Javier’s progress.
What could go into a science portfolio?

A portfolio should capture the richness, depth, and breadth of a student’s learning within the context of the instruction and the learning that takes place in the classroom. Elements of a portfolio can be stored in a variety of ways; for example, they can be photographed, scanned into a computer, or videotaped. The possible elements of a portfolio include the following selected student products:

<table>
<thead>
<tr>
<th>Written Presentations</th>
<th>Media Presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• expressive (diaries, journals, writing logs)</td>
<td>• videotapes</td>
</tr>
<tr>
<td>• transactional (letters, surveys, reports, essays)</td>
<td>• films</td>
</tr>
<tr>
<td>• dioramas</td>
<td>• audiotapes</td>
</tr>
<tr>
<td>• models</td>
<td>• slides</td>
</tr>
<tr>
<td>• mock-ups</td>
<td>• photo essays</td>
</tr>
<tr>
<td>• displays</td>
<td>• print media</td>
</tr>
<tr>
<td>• bulletin boards</td>
<td>• computer programs</td>
</tr>
<tr>
<td>• charts</td>
<td></td>
</tr>
<tr>
<td>• replicas</td>
<td></td>
</tr>
</tbody>
</table>

Journals are a form of record keeping in which students respond in writing to specific probes or questions from the teacher. The probes focus student responses on knowledge or skill specific to a standard or benchmark. Journals of accomplishments can also be used informally to assess the development of writing skills. As with portfolios, whether a journal becomes an assessment tool depends upon how it is organized and evaluated.

Mrs. Whitfield’s elementary class is studying energy use in the home. Jodie uses a journal to record the types of energy her family uses every day. She records how long appliances such as the television and home computer are left on each day and if lamps are turned off when family members leave the room. Jodie notices from her records that her family could be more efficient in their use of energy at home. In her journal, Jodie writes how her family members could conserve energy by turning off appliances and lights when leaving the room. After reading Jodie’s
observations, Mrs. Whitfield notices Jodie’s concerns about her family’s energy usage. At Mrs. Whitfield’s suggestion, Jodie uses her observations to create a home energy-conservation plan.

In science, the teaching strategy and the learning process often dictate the method of assessment. If hands-on activities were used to teach the content, then alternative forms of assessment may be more appropriate than a paper-and-pencil quiz. Assessment should be understandable, measure what students know, reflect what was taught, be free of cultural biases, and be used to improve teaching and learning. The format and content of assessment should encourage students to view science as exciting, relevant, and applicable.

After reviewing the work of all the students, Mr. Garcia discovered several students who, like Lawanda, had performed well on laboratory activities but did poorly on his multiple-choice tests. He decided that the problem-solving process and the course content were equally important and gave them equal weight when evaluating student progress.

**The Use of Assessment Rubrics**

An assessment rubric is a set of rules used to rate a student’s proficiency on performance tasks (for example, essays, short-answer exercises, projects, and portfolios). Rubrics can be thought of as scoring guides that permit consistency in assessment activities. A rubric often consists of a fixed scale describing levels of performance and a list of characteristics describing performance for each of the points on the scale. Rubrics provide important information to teachers, parents, and others interested in what students know and can do. Most often, scoring rubrics are developed by a teacher or team of teachers, but it may be desirable in some instances to involve students in the creation of the rubrics. Different scoring rubrics are usually developed for each assessment activity, although if the activities are similar enough, a single rubric can be applied.

For an example of a carefully developed six-point scoring rubric for use in a writing performance assessment, see the Florida Writes rubrics at the end of this chapter and see publications describing the Florida Writes statewide assessment program. Less formal rubrics that might be used with a middle school classroom assignment are shown in the following example:
Mr. Freer's eighth-grade students are studying how force affects the motion of objects. During the instructional unit, students conduct experiments in which they collect data on the motion of various objects and how that motion is affected when various forces act upon the objects. Mr. Freer will use traditional-style tests to measure students' factual knowledge. However, he also wants students to demonstrate their ability to create experiments that show how forces act on moving objects, to speak effectively to classmates, and to prepare a written report of the project. With the students' involvement, agreement is reached that the class assignment will be for students to work in pairs to create an experiment and prepare a class presentation in which they will demonstrate the experiment and explain the forces at work. Each pair of students will complete a final written report after their presentation. In their report, they will include the mathematical calculations they used to measure the forces and use graphs to show the data they collected.

Mr. Freer creates a five-category checklist to be used to monitor whether each student performs all required dimensions of the assignment. He also creates five-point scoring rubrics to evaluate the proficiency of each student's class presentation and written report.

The simple checklist might look like this:

<table>
<thead>
<tr>
<th>Student Name &amp; Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment created on schedule?</td>
</tr>
<tr>
<td>Calculations completed?</td>
</tr>
<tr>
<td>Graphs completed?</td>
</tr>
<tr>
<td>Presentation delivered to class?</td>
</tr>
<tr>
<td>Paper completed on time?</td>
</tr>
</tbody>
</table>
Teacher Rubrics

Three simple five-point scoring rubrics are presented below and on the following pages as examples of how teachers might evaluate three important elements of the experiment and the classroom presentation. These rubrics have specific descriptions only at the extremes and mid-point. A “4” and a “2” can be used to indicate performances that fall between these extremes.

Element 1: Organization of Presentation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well organized; logical; maintained audience interest; important facts included.</td>
<td>5</td>
</tr>
<tr>
<td>Some disorganization of content or some content omitted; audience generally interested in flow of ideas; most important facts present.</td>
<td>3</td>
</tr>
<tr>
<td>Little relevant content; disorganized; difficult to understand; audience not interested.</td>
<td>1</td>
</tr>
</tbody>
</table>
Element 2: Use of the Scientific Method

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets up and carries out an experiment that tests a prediction related to force and motion; experiment is a complete and valid test of student’s prediction and includes a control; experiment addresses all important questions raised by the prediction; experiment provides complete and accurate quantitative data.</td>
<td>5</td>
</tr>
<tr>
<td>Sets up and carries out an experiment that tests a prediction related to force and motion; experiment is a fair test of the prediction; experiment addresses the most important questions raised by the prediction; experiment provides accurate quantitative data.</td>
<td>3</td>
</tr>
<tr>
<td>Sets up and carries out an experiment that does not test the central features of the prediction; experimental design is seriously flawed and the collection of accurate quantitative data is unlikely.</td>
<td>1</td>
</tr>
</tbody>
</table>
Element 3: Material Content of Experiment

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrates a thorough understanding of concepts and facts related to force and motion; provides insights into how force affects the motion of objects; connects knowledge to other subject areas.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Displays a complete and accurate understanding of how force affects the motion of objects.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Demonstrates severe misconceptions about how force affects the motion of objects.</td>
<td>1</td>
</tr>
</tbody>
</table>

Similar scoring rubrics would be necessary to evaluate the written report required of each student.
Student Rubrics

Students may also be asked to evaluate their own presentations. The rubrics created by the teacher can be rewritten as self-assessment rubrics for students so that students have the opportunity to evaluate their own performances on a scale similar to their teacher's. The three student self-assessment rubrics presented below and on the following page have been modified from the above rubrics.

Element 1: Organization of Presentation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>My presentation was well organized and logical; I kept the interest of the audience; I included the important facts.</td>
<td>5</td>
</tr>
<tr>
<td>My presentation was sometimes disorganized; sometimes I forgot to mention some important facts; the audience was generally interested in my speech; I included the most important facts.</td>
<td>3</td>
</tr>
<tr>
<td>My presentation wasn't very organized and I didn’t mention the important facts. The audience didn’t seem to be interested.</td>
<td>1</td>
</tr>
</tbody>
</table>
Element 2: Use of the Scientific Method

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>I set up and carried out an experiment that tested my prediction related to force and motion; my experiment addressed all the important questions that were raised by my prediction; I used my knowledge of mathematics to analyze complete and accurate data from my experiment.</td>
<td>5</td>
</tr>
<tr>
<td>I set up and carried out an experiment that tested my prediction related to force and motion; my experiment addressed most of the important questions that were raised by my prediction; I used my knowledge of mathematics to review accurate data from my experiment.</td>
<td>4</td>
</tr>
<tr>
<td>I set up and carried out an experiment that didn’t test the central features of my prediction; I wasn’t able to collect accurate quantitative data from my experiment.</td>
<td>3</td>
</tr>
</tbody>
</table>

Element 3: Material Content of Experiment

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>I understand how force affects the motion of objects; I know how knowledge of force and motion can be connected to other subject areas.</td>
<td>5</td>
</tr>
<tr>
<td>I understand how force affects the motion of objects.</td>
<td>4</td>
</tr>
<tr>
<td>I don’t really understand how force affects the motion of objects.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
The Florida Writes Rubrics

Another kind of rubric is used by the Florida Writes writing assessment program to assess the quality of student writing. Teachers can use this rubric to assess writing in the science classroom and to prepare students for success on the state writing assessment. These rubrics are presented on the following pages.
Florida Writes Rubric: Grade 4

<table>
<thead>
<tr>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6 Points</strong></td>
<td>The writing is focused on the topic, has a logical organizational pattern (including a beginning, middle, conclusion, and transitional devices), and has ample supporting ideas or examples. The paper demonstrates a sense of completeness or wholeness. The writing demonstrates a mature command of language, including precision in word choice. Subject/verb agreement and verb and noun forms are generally correct. With few exceptions, the sentences are complete, except when fragments are used purposefully. Various kinds of sentence structures are used.</td>
</tr>
<tr>
<td><strong>5 Points</strong></td>
<td>The writing is focused on the topic with adequate development of supporting ideas. There is an organizational pattern, although a few lapses may occur. The paper demonstrates a sense of completeness or wholeness. Word choice is adequate but may lack precision. Most sentences are complete, although a few fragments may occur. There may be occasional errors in subject/verb agreement and in standard forms of verbs and nouns, but not enough to impede communication. The conventions of punctuation, capitalization, and spelling are generally followed. Various kinds of sentence structures are used.</td>
</tr>
<tr>
<td><strong>4 Points</strong></td>
<td>The writing is generally focused on the topic, although it may contain some extraneous or loosely related information. An organizational pattern is evident, although lapses may occur. The paper demonstrates a sense of completeness or wholeness. In some areas of the response, the supporting ideas may contain specifics and details, while in other areas, the supporting ideas may not be developed. Word choice is generally adequate. Knowledge of the conventions of punctuation and capitalization is demonstrated, and commonly used words are usually spelled correctly. There has been an attempt to use a variety of sentence structures, although most are simple constructions.</td>
</tr>
<tr>
<td><strong>3 Points</strong></td>
<td>The writing is generally focused on the topic, although it may contain some extraneous or loosely related information. Although an organizational pattern has been attempted and some transitional devices have been used, lapses may occur. The paper may lack a sense of completeness or wholeness. Some supporting ideas or examples may not be developed with specifics and details. Word choice is adequate but limited, predictable, and occasionally vague. Knowledge of the conventions of punctuation and capitalization is demonstrated, and commonly used words are usually spelled correctly. There has been an attempt to use a variety of sentence structures, although most are simple constructions.</td>
</tr>
<tr>
<td>Score</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>2 Points</strong></td>
<td>The writing may be slightly related to the topic or may offer little relevant information and few supporting ideas or examples. The writing that is relevant to the topic exhibits little evidence of an organizational pattern or use of transitional devices. Development of supporting ideas may be inadequate or illogical. Word choice may be limited or immature. Frequent errors may occur in basic punctuation and capitalization, and commonly used words may be frequently misspelled. The sentence structure may be limited to simple constructions.</td>
</tr>
<tr>
<td><strong>1 Point</strong></td>
<td>The writing may only minimally address the topic because there is little, if any, development of supporting ideas, and unrelated information may be included. The writing that is relevant to the topic does not exhibit an organizational pattern; few, if any, transitional devices are used to signal movement in the test. Supporting ideas may be sparse, and they are usually provided through lists, clichés, and limited or immature word choice. Frequent errors in spelling, capitalization, punctuation, and sentence structure may impede communication. The sentence structure may be limited to simple constructions.</td>
</tr>
</tbody>
</table>
| **Unscorable** | The paper is UNSCORABLE because  
- the response is not related to what the prompt requested the student to do.  
- the response is simply a rewording of the prompt.  
- the response is a copy of a published work.  
- the student refused to write.  
- the response is illegible.  
- the response is incomprehensible (words arranged in such a way that no meaning is conveyed).  
- the response contains an insufficient amount of writing to determine if the student was attempting to address the prompt.  
- the writing folder is blank. |
Florida Writes Rubric: Grade 8

<table>
<thead>
<tr>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Points</td>
<td>The writing is focused, purposeful, and reflects insight into the writing situation. The paper conveys a sense of completeness and wholeness with adherence to the main ideas, and its organizational pattern provides for a logical progression of ideas. The support is substantial, specific, relevant, concrete, and/or illustrative. The paper demonstrates a commitment to and an involvement with the subject, clarity in presentation of ideas, and may use creative writing strategies appropriate to the purpose of the paper. The writing demonstrates a mature command of language (word choice) with freshness of expression. Sentence structure is varied, and sentences are complete except when fragments are used purposefully. Few, if any, convention errors occur in mechanics, usage, and punctuation.</td>
</tr>
<tr>
<td>5 Points</td>
<td>The writing focuses on the topic, and its organizational pattern provides for a progression of ideas, although some lapses may occur. The paper conveys a sense of completeness or wholeness. The development of the support is ample. The writing demonstrates a mature command of language, including precision in word choice. There is variation in sentence structure, and, with rare exceptions, sentences are complete except when fragments are used purposefully. The paper generally follows the conventions of mechanics, usage, and spelling.</td>
</tr>
<tr>
<td>4 Points</td>
<td>The writing is generally focused on the topic but may include extraneous or loosely related material. An organizational pattern is apparent, although some lapses may occur. The paper exhibits some sense of completeness or wholeness. The support, including word choice, is adequate, although development may be uneven. There is little variation in sentence structure, and most sentences are complete. The paper generally follows the conventions of mechanics, usage, and spelling.</td>
</tr>
<tr>
<td>3 Points</td>
<td>The writing is generally focused on the topic but may include extraneous or loosely related material. An organizational pattern has been attempted, but the paper may lack a sense of completeness or wholeness. Some support is included, but development is erratic. Word choice is adequate but may be limited, predictable, or occasionally vague. There is little, if any, variation in sentence structure. Knowledge of the conventions of mechanics and usage is usually demonstrated, and commonly used words are usually spelled correctly.</td>
</tr>
</tbody>
</table>
### Florida Writes Rubric: Grade 8 (continued)

<table>
<thead>
<tr>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Points</td>
<td>The writing is related to the topic but includes extraneous or loosely related material. Little evidence of an organizational pattern may be demonstrated, and the paper may lack a sense of completeness or wholeness. Development of support is inadequate or illogical. Word choice is limited, inappropriate, or vague. There is little, if any, variation in sentence structure, and gross errors in sentence structure may occur. Errors in basic conventions of mechanics and usage may occur, and commonly used words may be misspelled.</td>
</tr>
<tr>
<td>1 Point</td>
<td>The writing may only minimally address the topic. The paper is a fragmentary or incoherent listing of related ideas or sentences or both. Little, if any, development of support or an organizational pattern or both is apparent. Limited or inappropriate word choice may obscure meaning. Gross errors in sentence structure and usage may impede communication. Frequent and blatant errors may occur in the basic conventions of mechanics and usage, and commonly used words may be misspelled.</td>
</tr>
</tbody>
</table>
| Unscorable| The paper is UNSCORABLE because  
- the response is not related to what the prompt requested the student to do.  
- the response is simply a rewording of the prompt.  
- the response is a copy of a published work.  
- the student refused to write.  
- the response is illegible.  
- the response is incomprehensible (words are arranged in such a way that no meaning is conveyed).  
- the response contains an insufficient amount of writing to determine if the student was attempting to address the prompt.  
- the writing folder is blank. |
Florida Writes Rubric: Grade 10

<table>
<thead>
<tr>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Points</td>
<td>The writing is focused and purposeful, and it reflects insight into the writing situation. The organizational pattern provides for a logical progression of ideas. Effective use of transitional devices contributes to a sense of completeness. The support is substantial, specific, relevant, and concrete. The writer shows commitment to and involvement with the subject and may use creative writing strategies. The writing demonstrates a mature command of language with freshness of expression. Sentence structure is varied, and few, if any, convention errors occur in mechanics, usage, punctuation, and spelling.</td>
</tr>
<tr>
<td>5 Points</td>
<td>The writing is focused on the topic, and its organizational pattern provides for a logical progression of ideas. Effective use of transitional devices contributes to a sense of completeness. The support is developed through ample use of specific details and examples. The writing demonstrates a mature command of language, and there is variation in sentence structure. The response generally follows the conventions of mechanics, usage, punctuation, and spelling.</td>
</tr>
<tr>
<td>4 Points</td>
<td>The writing is focused on the topic and includes few, if any, loosely related ideas. An organizational pattern is apparent, and it is strengthened by the use of transitional devices. The support is consistently developed, but it may lack specificity. Word choice is adequate, and variation in sentence structure is demonstrated. The response generally follows the conventions of mechanics, usage, punctuation, and spelling.</td>
</tr>
<tr>
<td>3 Points</td>
<td>The writing is focused but may contain ideas that are loosely connected to the topic. An organizational pattern is demonstrated, but the response may lack a logical progression of ideas. Development of support may be uneven. Word choice is adequate, and some variation in sentence structure is demonstrated. The response generally follows the conventions of mechanics, usage, punctuation, and spelling.</td>
</tr>
<tr>
<td>2 Points</td>
<td>The writing addresses the topic but may lose focus by including extraneous or loosely related ideas. The organizational pattern usually includes a beginning, middle, and ending, but these elements may be brief. The development of the support may be erratic and nonspecific, and ideas may be repeated. Word choice may be limited, predictable, or vague. Errors may occur in the basic conventions of sentence structure, mechanics, usage, and punctuation, but commonly used words are usually spelled correctly.</td>
</tr>
</tbody>
</table>
Florida Writes Rubric: Grade 10 (continued)

| 1 Point | The writing addresses the topic but may lose focus by including extraneous or loosely related ideas. The response may have an organizational pattern, but it may lack a sense of completeness or closure. There is little, if any, development of the support, and the support may consist of generalizations or fragmentary lists. Limited or inappropriate word choice may obscure meaning. Frequent and blatant errors may occur in the basic conventions of sentence structure, mechanics, usage, and punctuation, and commonly used words may be misspelled. |
| Unscorable | The paper is UN SCORABLE because  
- the response is not related to what the prompt requested the student to do.  
- the response is simply a rewording of the prompt.  
- the response is a copy of a published work.  
- the student refused to write.  
- the response is illegible.  
- the response is incomprehensible (words are arranged in such a way that no meaning is conveyed).  
- the response contains an insufficient amount of writing to determine if the student was attempting to address the prompt.  
- the writing folder is blank. |
**Key Chapter Points**

- Assessment processes seek to measure students' acquisition and application of skills and aspects of knowledge and its connections.

- Assessment activities in the classroom should be integral, ongoing parts of the instruction and learning process.

- Teachers should use a variety of assessment methods and modifications to address different learning styles and student needs.

- Teachers have a wide variety of options for collecting information on the degree to which students have acquired and can apply knowledge and skills specific to science.

- Assessment activities will produce useful information to the degree that they are carefully planned, well organized, and consistently applied.

- Accurate assessment of student achievement provides a sound basis for classroom instructional decisions.
Chapter 7: The Learning Environment

CHAPTER HIGHLIGHTS
- Design of Facilities
- Safety
- Scheduling
- Learning Resources
- Selection of Materials
- Using Technology
- Snapshot of an Effective Science Classroom

Goal 4: School boards provide a learning environment conducive to teaching and learning.

Florida’s System of School Improvement and Accountability

Twenty-first-century classrooms envisioned by Florida’s education reform initiative allow students to experience learning in its real-world context. These active learning environments extend beyond the four walls of the classroom into the home, the local community, and even the larger global community. Teachers are encouraged to incorporate more community projects and more interaction with their local communities. For example, teachers may provide opportunities for students to participate in job-shadowing programs with community leaders and members of the business community. Local citizens may be invited into classrooms to share knowledge, skills, or ideas and to participate in classroom projects. Students may also have direct access to the global community via computers, satellite transmissions, teleconferencing, and other technology, enabling them to work with other students and experts across the state, in other states, or in other countries.
Design of Facilities

There are many factors to consider in designing a physical environment that facilitates the most effective learning. The ideal science room supports active learning and encourages open-ended investigation. To learn the processes of science, students must participate in hands-on science activities. This requires an environment that is convenient, safe, and supplied with the necessary materials and equipment. It has enough space for the free and flexible movement needed for a wide variety of learning approaches, such as cooperative learning, project work, and learning centers. Classroom furnishings may consist of tables and chairs, or desks and work areas that can be arranged and rearranged. The acoustics need to facilitate both classroom interaction and quiet time for reflection. Classrooms should have adequate storage and security for equipment and supplies. Special consideration should be given to the proper storage of computers and laboratory tools and chemicals; this includes maintaining appropriate distances between electronic equipment and laboratory chemicals. In addition, science rooms should have appropriate technology support facilities, such as network access ports and electrical power outlets with ground fault circuit interrupters. Teachers also need a carefully designed space for research, planning, collaboration with other teachers, and reflection. The elements considered in the physical design of classrooms can apply in designing the teacher’s space as well.

The elementary classroom should be rich with opportunities for science learning. There should be many curiosities to observe and handle. Safe areas to maintain aquaria, plants, and animals are encouraged. Instruments, models, a source of water, materials that support hands-on activities, and places for project displays are also important. In some elementary schools, a single room may be designated as a science room, where classes are scheduled on a regular basis. This room may have a full-time science resource teacher or it may be a laboratory facility shared by all teachers. If it is a separate room, there should be a qualified person in charge and present when children are there. Middle and high school science facilities should be dedicated to science and used in the process of developing skills for discovery and problem solving.

Educators should become familiar with the legal requirements concerning students with disabilities (I.D.E.A. and Rehabilitation Act, Section 504), which state that classrooms must accommodate disabled students. The Americans with Disabilities
FLORIDA CURRICULUM FRAMEWORK

Act describes people as disabled if they have a physical or mental impairment that substantially limits one or more activities. There are many possible adaptations to the classroom, hallway, cafeteria, vocational workshop, or other areas of the school that can meet the needs of students with disabilities. These might include ramps, elevators, and raised work spaces for students who use wheelchairs; sound-absorbing materials to reduce reverberation for hearing-impaired students; and sufficient lighting for students with visual impairment. An excellent resource for providing nonrestrictive environments is Guidelines for Effective Mainstreaming in Science (Mastropieri and Scruggs, 1993).

Local school districts have many factors to consider when evaluating what is needed for the design or redesign of facilities. These factors might include local needs and goals, budgets, instructional methods, adaptations to meet the needs of individual students, potential changes in student enrollment, and flexibility to allow for changes to meet new conditions in the future.

Safety

Goal 5: Communities provide an environment that is drug-free and protects students' health, safety, and civil rights.

Florida's System of School Improvement and Accountability

Schools should incorporate safety and health practices into the school environment. A safe, secure, learning environment for all students is an essential responsibility of the whole school community. A manual specifying safety policies and regulations and incorporating state and federal policies is available in all schools. The design of science facilities must meet the standards for safety as stated in the administrative rules and statutes of the Florida State Board of Education. The publication Science Safety, No Game of Chance: A School Safety Manual, produced by the Florida Department of Education, has been provided to each school district and should be referenced for specific safety information.

One aspect of school safety involves the physical environment. It should provide safe, clean facilities that meet all legal requirements. The environment should be free of odors, allergens, and harmful chemicals such as asbestos. To provide safety in the physical environment for students with disabilities, adaptations may be necessary,
such as flashing fire alarms and special procedures for evacuation. A second aspect of school safety involves the supervision of students. Teachers must be aware of and understand safety procedures inside the school building, on school grounds, on field trips, and at special school events. Science activities conducted away from the classroom, such as science fairs and field trips, need to be carefully planned and examined for possible hazards. A third aspect of safety involves providing an environment in which everyone is safe from verbal, physical, and psychological harm. Teachers should also be prepared to use strategies for crisis intervention and conflict resolution.

Science teachers should be informed about safety procedures through inservice and safety manuals. Science teachers must be trained in the following:

- safe handling of substances on the Florida Substance List
- appropriate use and handling of chemicals, glassware, specimens, and safety equipment
- proper emergency procedures
- supervision of students at work

Laboratory experiences are an essential component of the science curriculum and additional safety requirements and procedures must be in place and implemented. Qualified instructors must be present during all laboratory and field exercises. Supervision must be constant and vigilant. It is important to frequently review safety rules about laboratory behavior and procedures. When working with equipment, tools, or chemicals, specific and clear instructions must be given when an item is used for the first time, and then repeated each time the students work with that material or equipment. Proper attire should be worn by teachers and students when laboratory exercises are in progress. Florida Statute (F.S. 232.45) requires that teachers, students, and visitors wear appropriate eye protection during laboratory exercises. In addition, for teachers of the biological sciences, a manual is available, Planning and Conducting Dissection Laboratories, which has specific cautions and suggestions for working with specimens.

Science teachers who use chemicals in the laboratory must have a knowledge of their potential hazards. Vital information on chemicals in the form of Material Safety Data
Sheets is available from the manufacturer or vendor and must be kept on file. This information should be understood before using the materials. Safety precaution signs in science rooms should be easily visible; their messages should be clear and easily understood. For those teachers who wish to avoid working with large quantities of concentrated solutions, kits of commercially prepared solutions for the most common procedures are now available with clear safety precautions and spill instructions. Disposal of chemicals could present a risk to the environment and should be closely monitored by environmental protection agencies. Care and knowledge must be used when discarding chemicals and equipment.

**Scheduling**

Adequate time is essential for quality instruction and learning in order for students to achieve high academic standards. Students need sufficient time for concentrated involvement in learning experiences or projects. They may need time for extended discussions, experimentation, comprehension, and reflection.

Florida's education reform initiative envisions that a strong element of the school improvement process will be provided by the local school community. This will have a significant effect on teachers' work schedules and on the time teachers spend in pre-planning, instruction, assessment, and evaluation of classroom activities. For example, professional educators will need time to research new instructional approaches and to further develop integrated, meaningful lesson plans. Teachers may need additional time for selecting teaching materials, designing student assessment strategies, and structuring specific learning experiences. Time must also be available for conferencing with other teachers, counselors, psychologists, and administrators, and for communicating with parents.

Another aspect of scheduling involves the range of teacher responsibilities and class size, both of which can have a significant impact on the classroom environment. No single formula is adequate to determine the appropriate work load for teachers or the appropriate class size for all schools and districts. Generally, an acceptable range is established at the district level, taking into consideration the characteristics of the unique student population, the composition of individual classes, funding levels, current and planned education reforms, extra duties and activities teachers undertake, and the organization and administration of the school.
To increase the effectiveness of the way time is used for teaching and learning, local school districts and schools are investigating ways to amend their present time structures. For example, educators are using block scheduling, year-round calendars, combined courses, and other strategies.

**Learning Resources**

Classrooms today are alive with activity and use a broad range of resources: from simple construction paper and crayons, baby food jars, buttons and other manipulatives, newspapers, films, and textbooks to electronic encyclopedias, graphing calculators, equipment and software for teleconferencing and satellite transmissions, and sophisticated laboratory devices. There may be colorful displays on the walls, maps to pull down, globes to touch, a variety of primary and secondary source materials, including art prints and music, and a generous supply of literature reflecting science topics. Computer stations with multimedia capabilities, software, and up-to-date instructional materials are used to encourage active and authentic learning and assist in research and in the production of learning projects.

Instructional materials, assistive technology, and equipment are available for students with a variety of special needs. For example, for students with visual impairment, Braille and large-print books can be obtained through the Florida Instructional Materials Center. Adaptive computers, low-vision optical aids, and print-enlarging equipment are also available for vision-impaired students. Close-captioned videos for students with hearing impairments are developed at the Florida School for the Deaf and the Blind. As with instructional modifications, these specialized materials can often benefit students with learning difficulties who do not qualify for exceptional-student education programs.

**Selection of Materials**

The careful selection of instructional materials that support the development of conceptual understanding and encourage active learning is critical to a successful science program. Teachers play a central role in the selection of instructional materials both for the overall school and for their classrooms. Whenever possible, teachers should collaborate to consider books, resources, and other major purchases for the school or district.
In developing their instructional plans, teachers consider a wide range of materials for use in their classrooms. In addition to textbooks, useful materials include supplementary trade books, reference materials, posters, supplies, audiovisual materials, computer software, and multimedia materials and supplies. Teachers should base their selection of classroom materials on the instructional plan and the specific needs of the students. They might examine the content and presentation of the materials from many different perspectives, including the vision and goals of the local school, the goals of their specific instructional plan, and the school budget. Educators should refer to state guidelines and district policies as possible resources for evaluating and selecting specific materials.

**Using Technology**

The use of technology is already changing the world of business and industry and is transforming our schools as well. Because technology is such a powerful tool for teachers and students, opportunities for training in its use and applications should be a part of all education programs. Achieving high levels of skill in the use of technology will help students reach Florida’s high academic standards and contribute to their success in the workplace. The application of technology in a classroom can benefit students in a multitude of ways. For example, it can

- give students more control and involvement in their own learning process;
- promote investigative skills;
- serve as an access to almost unlimited sources of information;
- provide students with skills to measure, monitor, and improve their own performance and develop competencies for the workplace;
- make learning more interesting for students;
- enable students to communicate with people from many parts of the world, bringing the sights, sounds, and thoughts of another language and culture into the classroom;
- provide opportunities to apply knowledge to simulated or real-life projects;
- prepare students for a high-tech world of work; and
- expand laboratory experiences for students that reflect the way scientists work.
There are many ways to use technology to help students learn science. Sensors that are electronically connected to computers can be used to measure physical properties, such as temperature, pressure, pH, and electrical current. Video discs and CD-ROMs contain libraries of information that are available to researchers in seconds. Technology can transform the science room into a multimedia learning center, giving teachers and students access to word processing, presentation tools, graphics, media integration, desktop publishing, and telecommunications resources. Computer simulations can replace activities that may be too dangerous or time consuming to do in the laboratory. Students can mirror the way scientists work as they use word processing; collect, store, and analyze data; manage data bases; develop spread-sheets as part of laboratory analysis; and create final reports. Students can participate in global science investigations through electronic bulletin boards that link classrooms to practicing scientists in the field.

Distance learning uses communications technology to bring teaching and learning together through the transmission of information or expertise from one location to another. The use of this technology allows students to interact directly with teachers, experts, and students outside of their community.

Distance learning technologies are a valuable resource for science education; they can enrich and enhance the learning experience for all students. Using the same technology that distributes most broadcast and cable TV signals, satellite-based distance learning services can reach hundreds or thousands of receiving sites located all over the United States. Some cable companies have developed services targeted specifically to educators and students. Through microwave systems and fiberoptic cables, distance learning programming can be more readily distributed to remote areas. Educators with computers and modems have access to an increasingly large selection of on-line data resources and dial-up bulletin boards. These services typically offer electronic mail, research databases, forums, and discussion groups for a variety of special interests.

Using telecommunications, students in Clearwater can exchange ideas with students in Ocala, Miami, and Pensacola, in other communities across Florida, in other states, and in other countries. Students can participate in a study or presentation in another location. A class of fifth graders will better understand dinosaurs by asking questions
as they watch a paleontologist reconstruct a dinosaur skeleton in a museum thousands of miles away. These examples are not futuristic visions. They are typical experiences happening right now in schools across the country.

One technological tool that promises to have innovative applications in the classroom is the use of live interactive video over an electronic on-line network. This technology can provide opportunities for students to take electronic “field trips” to the bottom of the ocean, to the rain forests, to the Arctic, or to outer space.

As technology evolves, it will be essential to evaluate which new tools will be most useful in the educational setting, given program goals, ever-expanding student needs, and existing equipment. Educators will need to keep up with the variety of technologies and their applications. New equipment and software programs become available at a rapid rate; the best choice for today may be quickly outmoded. Therefore, any recommendations for specific hardware or software programs should be flexible, forward thinking, and based on extensive research so that money will be well spent. In addition, teachers must make a commitment to become personally adept in using educational technology. They will need to add to and refine their skills on a regular basis by keeping up with new technological developments and exploring additional capabilities of current technology. Appropriate training and support opportunities should be established by administrators for that purpose.

The age of technology affords educators a wealth of choices. As the use of technology expands into education, educators will have more opportunities to discover new ways to explore ideas and meet the diverse individual needs of students. The availability and appropriate use of technology is indispensable in developing programs that will prepare the students of today to face continuing advancements in the workplace and to meet the technological changes that will occur in the 21st century.

**Snapshot of an Effective Science Classroom**

The students in Mr. Thomas’s 11th-grade science class are beginning a project to explore the effects of pollution in their local community. Today, they are spread out along the shore of a local lake, carefully collecting water samples in small jars to take back to the school. Altogether, they have collected water samples from three lakes. Later, in the science laboratory, the students analyze the acidity and oxygen levels of their water samples with electronic sensors and examine
After completing their analysis of the lake water, the students compile their data on the computer and discuss the results. Sean is concerned. "Our tests indicate an extremely high acidity level in all of these lakes," he says. "The lowered level of oxygen is creating an anaerobic environment that is already affecting the amount of microorganisms in the water. Something is definitely polluting our water!" After seeing the results of the lab tests, the students are even more interested in finding out about pollution in their community.

Within a few days, their investigations have led them to research the problems of pollution in other parts of the world as well, using the Worldwide Web. Today, as the computer screen blinks and explodes with data, several teens gather around the monitor and shake their heads. The acid rain data have just arrived from their international partners in Mexico and Sweden. The students are amazed. From Mexico come reported acidity levels twice those found in the Florida lakes and four times those found in Sweden. The students discuss what it all means. Alonzo says, "It's obvious we need global environmental standards. Water and air do not recognize national boundaries. If we continue to allow unregulated industries to pollute the environment, it will damage the environment all over the world." Rodriguez offers another point of view, "I don't think we should blame all the pollution on industry. We are all responsible. We buy and use many products in our homes that are harmful to the environment. We also drive cars." The rest of the class agrees that both boys have a good point. When they all express a desire to do something about this increasing global problem, Mr. Thomas suggests that they brainstorm some ideas about what they could do. Soon the class has devised a plan to prepare a report on acid rain for an upcoming national summit they read about in the paper. John suggests that they include their Mexican and Swedish partners and heads to the computer to send them a message, inviting them to participate. The rest of the class discusses what kind of research they will need to do for the report.

The next day, the students are busy pursuing various research tasks. Cassandra and Sean are sending a message to their Mexican and Swedish partners requesting their national pollution-control regulations. Meanwhile, Taylor and Ashley are using the computer network to locate the federal pollution regulations for the U.S., as well as local regulations for the state of Florida. Alonzo and John are using a computer to access information about the most common causes of acid rain. Rodriguez and Ali are designing a series of experiments, to be performed later in the laboratory, that will allow them to explore the chemical properties of specific substances that are known to contaminate Florida's rivers and lakes.

The results of all of their investigations will be used to prepare the report for the summit. The report will include the data collected, the analysis of the results of their experiments, an evaluation of which pollutants are most harmful to the global environment, and thus most important to control, as well as proposals for global environmental standards, which the
students have negotiated with their Mexican and Swedish counterparts.

These students are learning behaviors and skills needed for success in the 21st century. They are using scientific inquiry and research coupled with technology to solve an authentic problem, working cooperatively with others from diverse cultures and using a variety of knowledge sources. The technology they are using links science with the community and the world. Through this process, students are learning to become active global citizens and lifelong learners.

**Key Chapter Points**

- Community resources and the latest technology should be tapped to bring the world into the classroom, allowing students to encounter learning in real-world contexts.

- Effective facilities are carefully planned, taking into account changes in student enrollments, student abilities, budgets, instructional needs, and the goals of the science program.

- A safe, secure, learning environment is a priority for all students.

- Time can be used creatively, as a flexible resource.

- Classrooms should be rich with learning resources that afford opportunities for observation, manipulation of objects, exploration, experimentation, and discussion.

- The careful selection of instructional materials that effectively support the development of conceptual understanding and encourage active learning is critical to a successful science program.

- As technology expands into education, science educators can discover new ways to explore science ideas and meet the diverse, individual needs of students.
Chapter 8: Professional Development

CHAPTER HIGHLIGHTS

• The Importance of Professional Development
• Rethinking Professional Development
• Preservice Education
• Effective Professional Development
• The Commitment to Lifelong Learning
• Attributes of the Professional Educator

The Importance of Professional Development

Professional development is a continuous improvement process lasting from the time an individual decides to enter the education profession until retirement. It encompasses the processes that educators engage in to initially prepare themselves, continuously update themselves, and review and reflect on their own performance. If educators are to successfully prepare students for the future, they must be prepared for the future themselves. Schools and districts must be committed to offering the highest quality professional development opportunities for their teachers.

Rethinking Professional Development

Just as knowledge and skill requirements are changing for Florida students, so, too, are those for Florida educators. The globalization of commerce and industry, the explosive growth of technology, and the expansion of science knowledge demand that teachers continually acquire new knowledge and skills. The challenge for every avenue of professional development is to provide learning opportunities in which preservice teachers, as well as more experienced teachers, can develop or acquire the necessary knowledge and skills to deal with change and pursue lifelong learning.
Preservice Education

Preservice education encompasses the training, preparation, and courses that future teachers undertake before certification. Research in schools across the nation shows that a crucial component of restructuring education is the teacher preparation program. New teachers must develop the capacity to facilitate student learning and to be responsive to student and community needs, interests, and concerns (Darling-Hammond, 1993). To that end, teacher education programs at the college or university level are encouraged to incorporate the following:

- courses that develop a broad base of competencies, content area knowledge, and experiences for graduates to bring to the teaching profession;
  
  For example, it is important for science teachers to be familiar with the concepts presented at the grade level they teach. Science courses which are appropriate for elementary teachers may not meet the needs of secondary teachers. The ideal teacher preparation program will differentiate between the different types of science teachers. Science teacher education courses at all levels should contain significant laboratory experiences. As integrated science is being proposed by a number of curriculum projects including Project 2061, the National Science Teachers Association, and the National Research Council, the programs for the education of secondary teachers should include program certification in at least two subject areas of science and possibly a new certification for the instruction of integrated science.

- courses that include both theory and practice in teaching a diversity of students, including students with special needs;

- courses that present practical, proven, up-to-date approaches to curriculum, instruction, and assessment;

- an emphasis on teachers developing the ability to understand and nurture the academic, emotional, and physical growth of students;

- experiences that develop effective communication, team-building, and conferencing skills;
• extensive and ongoing student-teaching experiences that are supervised by qualified teachers and college or university personnel; and

• recognition that effective teachers must continue to grow professionally throughout their careers and must be proactive in seeking resources, assistance, and opportunities for growth.

By reexamining beliefs about teaching and learning, education faculties can design and implement improved teacher education programs. The goals of any such program are to produce creative, motivated, knowledgeable, confident, and technologically literate beginning teachers committed to lifelong growth.

Effective Professional Development

The term “professional development” is defined in this framework as those processes that improve and enhance the job-related knowledge and skills of practicing classroom teachers. Professional development provides the continuous, on-the-job training and education needed to improve teaching and, ultimately, student learning. Florida’s school improvement initiative encourages local districts and schools to assume greater responsibility for professional development programs tailored to serve local school improvement efforts. Those educators charged with the design of these programs are urged to reflect upon the following characteristics of useful professional development:

An effective professional development program actively engages educators in the improvement process.

One facet of Florida’s school improvement and accountability initiative is to encourage local teams of educators to identify needs and clarify goals, solve problems, plan programs, monitor them reflectively, and make necessary adjustments. Professional development programs are an ideal way for districts to empower teachers to share in the decision-making processes within their schools and districts. Planners of professional development programs should encourage teachers to actively analyze their work, identify any needs and gaps in knowledge and skill, and provide suggestions about which resources might best close these gaps. Once educators have identified strategies to make school and classroom improvements, administrators and planners should use teacher
expertise, wherever possible, in the preparation and delivery of professional development programs to support these strategies.

**An effective professional development program continually updates the teacher’s knowledge base and awareness.**

Systemic reform requires that teachers incorporate new teaching methods and content to help students achieve Florida’s new rigorous academic standards. Consequently, professional development programs must provide teachers with opportunities to acquire a broad base of new subject-area knowledge and instructional strategies so that Florida educators are better equipped to implement strategies to improve schools and raise achievement.

Educators will also need ongoing training in the use of educational technology. Equally important, professional development program planners are encouraged to work with teachers in identifying changes in student diversity, needs, and problems. If teachers are to successfully engage students in the learning process, they must understand students’ cultural and linguistic backgrounds and life circumstances. In addition, professional development programs will need to address the issue of change: how to incorporate and embrace change in the classroom and how systemic reform impacts teaching methods and curriculum planning.

**An effective professional development program establishes a collaborative environment based on professional inquiry.**

Effective professional development encourages knowledge sharing and other opportunities for teachers to share ideas and experiences. Professional development strategies are most likely to be successful when teachers are encouraged to reflect on their own practices, identify problems and possible solutions, share ideas about instruction, engage in scholarly reading and research, and try out new strategies in their classrooms. Thus, staff networking, clinical education partnerships with universities in peer coaching, and mentoring are important tools to incorporate into long-range professional development planning. Peer coaching offers a nonthreatening environment in which teachers can implement new techniques and ideas and receive feedback from colleagues. Mentoring can be especially beneficial to new teachers; this mutually rewarding relationship with an experienced educator might include an
exchange of teaching materials and information, observation and assistance with classroom skills, or field-testing of new teaching methods.

**An effective professional development program is continuously improved by follow-up.**

Professional development is an ongoing process; it does not simply consist of isolated presentations given by an expert or consultant. Effective inservice includes introductory training as well as a plan for ongoing monitoring, enhancement, and follow-up of learning. Research corroborates the need for follow-up that continues long enough for new behaviors learned during introductory training to be incorporated into teachers’ ongoing practice (Sparks and Loucks-Horsley, 1989). Planners can build this kind of reinforcement into professional development programs in a number of ways, including providing opportunities to practice new methods in coaching situations, arranging for ongoing assistance and support, and systematically collecting feedback from teachers.

**An effective professional development program is actively and continuously supported by administrators.**

Numerous studies (Mcloughlin & Marsh, 1978; Stallings and Mohlman, 1981; Loucks and Zacchie, 1983; Fielding and Schalock, 1985; Loucks-Horsley et al., 1987) reveal that active support by principals and district administrators is crucial to the success of any improvement effort. This supportive role begins with leadership that places a high priority on professional development, promotes communication, and fosters a spirit of collegiality. It extends to the thoughtful allocation of resources, including time. Up-to-date materials, classroom equipment, and time for educators to pursue opportunities for professional development and to practice and implement new teaching strategies are essential to ongoing staff improvement efforts. As Judy-Arin Krupp (1991) suggests, schools should develop a norm for growth... that says staff development is not here to correct defects but to offer opportunities for everyone in the system to grow. Next, we need to recognize that everyone grows differently. We ask, “How can I help you grow as an educator so that we can provide the best possible education for students in this school?” (p. 3)
The Commitment to Lifelong Learning

Effective science educators do not rely solely on inservice programs provided by their schools or districts. They take personal responsibility for planning and pursuing other development activities.

As self-directed learners, quality science educators strive to gain new insights, improve their skills, and broaden their perspectives. They work at the school and district levels to create professional development experiences for themselves and their colleagues. They form alliances with supervisors, professional development specialists, principals, and other educators across all grade levels. They seek out quality workshops and courses. They take advantage of courses offered through technologies, such as on-line learning, interactive videoconferences, satellite teleconferences, and other innovative approaches to their own education. They also engage in experiential learning opportunities, such as “job shadowing” in their discipline or other practical, real-world experience in the community.

A particularly useful tool for professional development in science can be membership in professional organizations. Professional organizations and centers specific to science include the following:

American Association for the Advancement of Science
1333 H St. NW
Washington, DC 20005
(202) 326-6666

Eisenhower National Clearinghouse for Mathematics and Science Education
The Ohio State University
1929 Kenny Road
Columbus, OH 43210-1079
(614) 292-7784 E-mail: info@enc.org.

The Clearinghouse maintains an up-to-date and comprehensive listing of mathematics and science curriculum materials.
Florida Association of Science Teachers  
P.O. Box 3343  
Tallahassee, FL 32315  
(904) 488-6046

National Association for Science, Technology, and Society (NASTS)  
Pennsylvania State University  
133 Willard Building  
University Park, PA 16802  
(814) 865-3044

NASTS promotes examination of the impact of science and technology on society and the environment.

National Center for Improving Science Education (NCISE)  
2000 L St. NW, Suite 603  
Washington, DC 20036  
(202) 467-0652  
http://www.raizen@ncise.org

NCISE provides a range of products and services to policy makers and practitioners who are working to strengthen science education.

National Science Resources Center (NSRC)  
Arts and Industries Bldg., Room 1201  
Smithsonian Institution  
Washington, DC 20560  
(202) 357-2555

The NSRC collects and disseminates information about exemplary teaching resources, develops innovative curriculum materials, and sponsors outreach activities to help school districts develop and sustain hands-on science programs.

National Science Teachers Association  
1840 Wilson Blvd.  
Arlington, VA 22201-3000  
(703) 243-7100
A number of other Florida organizations exist that may be useful sources of information. Current presidents and mailing addresses may be obtained through the Florida Association of Science Teachers:

- Florida Earth Science Teachers Association
- Florida Association for the Education of Teachers of Science
- Florida Marine Science Educators Association
- Florida Foundation for Future Scientists
- Florida Chapter of the American Chemical Society
- Florida Chapter of the American Physics Society

In addition to providing invaluable opportunities for idea sharing and networking with other teachers, many professional organizations also publish journals that feature the latest developments in the field, assess new strategies and methodologies, and highlight new career and training opportunities.

Finally, among the many useful articles and texts available to science educators are the following:


Attributes of the Professional Educator

The goal underlying any Florida professional development program is to prepare educators in the competencies needed to successfully implement Florida's long-term education improvement initiative. Shortly after the creation of Florida's school improvement and accountability initiative, the Education Standards Commission began a project to identify and validate those teacher competencies necessary to successfully implement this initiative. The Commission's efforts focused on the preparation and proficiency of teachers in helping students achieve higher and more rigorous standards. The Commission identified twelve broad principles and key indicators that reflect the high performance standards required of Florida's teachers. These “accomplished practices” are summarized below.

Diversity
The professional educator uses teaching and learning strategies that reflect each student’s culture, learning styles, special needs, and socioeconomic background.

Assessment
The professional educator uses assessment strategies (traditional and alternative) to assist the continuous development of the learner.

Planning
The professional educator plans, implements, and evaluates effective instruction in a variety of learning environments.

Human Development and Learning
The professional educator uses an understanding of learning and human development to provide a positive learning environment that supports the intellectual, personal, and social development of all students.

Learning Environments
The professional educator creates and maintains positive learning environments in which students are actively engaged in learning, social interaction, cooperative learning, and self-motivation.

Communication
The professional educator uses effective communication techniques with students and all other stakeholders.
**Critical Thinking**
The professional educator uses appropriate techniques and strategies that promote and enhance the critical, creative, and evaluative thinking capabilities of students.

**Technology**
The professional educator uses appropriate technology in teaching and learning processes.

**Role of the Teacher**
The professional educator works with various education professionals, parents, and other stakeholders in the continuous improvement of the educational experiences of students.

**Continuous Improvement**
The professional educator engages in continuous professional quality improvement for self and school.

**Knowledge and Understanding**
The professional educator demonstrates knowledge and understanding of the subject matter.

**Ethics and Principles**
The professional educator adheres to the Code of Ethics and Principles of Professional Conduct of the Education Profession in Florida.

In addition, *science educators* possess the following:

- a working knowledge of the nature of science, especially the habits of mind so important to building scientific perspectives and attitudes;

- a general command of the concepts, theories, and laws that frame the life, physical, earth, and space sciences and their relationships and interactions;

- practical experience with technologies that reflect interdisciplinary methods of gathering data about our world through extension of our human senses; and

- a thorough understanding of the global, cultural, and historical contexts in which the scientific enterprise flourishes.
Key Chapter Points

- Florida's school improvement initiative calls on schools to assume greater responsibility for professional development programs.

- If educators are to successfully prepare students for the future, they must be prepared for the future themselves.

- Preservice education should provide education graduates with a broad base of knowledge and skills to facilitate student learning and to be responsive to student and community needs, interests, and concerns.

- Inservice education should continue these efforts in an environment that supports and sustains teachers as individuals and collaborators in the process of systemic reform.

- Professional development programs should be designed to encourage every member of the learning community—teachers, support staff, and administrators—in their pursuit of lifelong learning.

- The role of professional development is to assist educators in developing the accomplished practices necessary to successfully implement Florida's education reform initiative.
The School Advisory Council in the fictitious community of Thunder Bay has formed a Science Improvement Team to revitalize the middle school and high school science programs in order to facilitate a greater involvement of the local community in the districts’ strategies for science education. The Science Improvement Team determines that all Thunder Bay students should understand the basic technologies used on farms and in the local factories, understand the potential of new technologies to contribute to the economic viability of the community, and appreciate the importance of the local industries to the community. Thunder Bay’s Science Improvement Team decides to review the district’s science curriculum and methods of instruction in light of the needs of the local industrial community. The Science Improvement Team includes representatives from Thunder Bay Industries in addition to science teachers, personnel from middle and elementary schools, the principal, teachers from a variety of disciplines, district program supervisors, university faculty, students, parents, and other business and community citizens.

The Nature of School Improvement

The primary goal of Florida’s improvement and accountability legislation is to raise student achievement by returning the problem-solving processes in education to the people closest to the students. This vision of local control can become a reality when individual schools and districts embrace the responsibility of becoming well-informed about the school improvement process, which may be both schoolwide and specifically targeted toward a single program.
In Florida, School Advisory Councils are charged with leading the overall school improvement process by drafting annual plans for raising student achievement and meeting the state education goals and standards in all subject areas. These councils are composed of educators, parents, and community members who are representative of the diverse population served by the school.

The components of the improvement process make up a continuous cycle that entails a thoughtful study of the school program. The improvement process includes the following components: evaluating the results of the existing program in terms of student achievement and identifying areas of concern or areas that need improvement; determining the desired reforms to be undertaken; and implementing and evaluating these reforms. These components of the school improvement process can be applied to subject-area programs as well, both at the district and school levels. This chapter highlights the steps of the improvement process and offers guidelines to local educators as they improve their science programs.

**The Evaluation Process**

The Science Improvement Team meets to discuss the ways in which local industries can play a role in the revitalization of the Thunder Bay science program. For guidance in this process, team members review the locally developed vision statement for Thunder Bay science programs, which highlights student understanding of the relevance of classroom activities to the needs of the local business and industrial communities. The Science Improvement Team learns that students in Thunder Bay middle schools and high schools are currently studying the stages of plant growth and the processes of harvesting oranges. However, the team members also discover that, although robotics are an important part of the manufacturing process at Thunder Bay Industries, not one school in the district has robotics or robotics-simulation equipment and no robotics units are taught in any science class. The Science Improvement Team considers various ways in which local industries can form partnerships with schools so that students can gain exposure to the basic technologies used in industrial environments.

Regular program evaluation ensures that the school implements science programs that raise the achievement of all students, identify and meet the needs of the local community, and focus on content that aligns with state standards. Program evaluation should include, not just inform, all people involved in and affected by the program. To help facilitate this process, districts and schools are encouraged to create Science Improvement Teams.
With the overriding goal of student achievement as a backdrop, one of the Science Improvement Team’s first tasks could be to develop a list of questions or concerns about the science program. These might be organized around the components of this framework; for example, the program’s vision, its reflection of Florida’s Goal 3 standards, its use of innovative instructional strategies, or its connection to other disciplines. The questions might address program purposes, goals, content, context, instructional strategies, assessment methods and results, resources, attitudes of staff and students toward science, and connections to other disciplines. Questions or concerns might also focus on the unique needs of the school or the local community.

During the evaluation process, it is useful to gather data about a variety of dimensions of the science program from as many sources as appropriate and as possible. Some evaluation methods may be informal, part of the day-to-day activity of teaching and learning; others may be more formal, yielding information gathered from a variety of sources, such as

- surveys, questionnaires, and interviews;
- school statistics (for example, enrollment in specific subjects and electives);
- student assessments;
- reports from external evaluators; and
- self-evaluations.

Once information has been collected, the Science Improvement Team should interpret it within the context of the identified questions or concerns and make recommendations for changing the program in order to bring about improvement in identified areas. Team members can also use the data to identify additional questions and concerns.

The process of generating questions and concerns to guide the review of the science program, analyzing existing data, reaching conclusions on which parts need changing, and identifying and testing solutions encourages ownership and shared responsibility for ongoing program improvement. Districts and schools are encouraged to promote and integrate, where appropriate, innovative ideas suggested by those people specifically affected by and involved in the improvements.
Planning Changes for Improvement

The Science Improvement Team schedules meetings with leaders from local industries to determine how robotics technology could be incorporated into Thunder Bay middle and high schools. One team member suggests the school district work with Thunder Bay Industries to develop a summer job-shadowing program in robotics technology for science teachers. A computer simulation of robotics will become part of the computer applications component of the science class. Thunder Bay Industries agrees to install a reconditioned robotics system at the high school. The team writes a comprehensive improvement plan incorporating all of these ideas, including information on available resources and schedules for implementation.

Once areas needing improvement have been identified, the Science Improvement Team can investigate various solutions and then develop a plan to make and implement the changes that will bring about improvement. A clear vision of the desired results is vital. In general, the plan should include a timeline and a division of responsibilities to help assure its completion. It should be flexible and include continuous internal monitoring to determine the effectiveness of the changes to be implemented. The plan should also identify the general elements that will be needed to implement improvements, when each might occur, who will be responsible for what, and what resources are needed. Finally, the plan should align with schoolwide improvement.

It is important to keep in mind that all the additional resources needed may not be readily available. It may take some reallocation, some creative acquisition, some modification of existing resources to “get the job done.” An important part of the plan is monitoring the results of any changes. If changes are not producing intended improvements or if obstacles develop, other approaches can be tried.

Developers of school and district science improvement plans may wish to consider the following questions as they create the plan for improvement:

- Are all the stakeholders involved in the process?
- Is there a consensus about what needs improvement as well as potential strategies to be undertaken?
- Have periodic checks been established to monitor implementation?
- Has a reasonable timeline been set?
- Have measures of adequate progress been clearly defined?
- Are the necessary human and financial resources available to implement the plan?
An important component of the improvement process is gaining the support and endorsement of those administrators who have overall responsibility for providing the resources and services to promote and facilitate the necessary changes. Staff development, different forms of evaluation, and/or different ways of operating in school buildings and classrooms may be required. Thus, administrative support for any improvement plan is critically important.

Once finalized, the improvement plan may be shared with those essential support systems that operate outside of the professional education community. Parents and guardians, elected officials, business and industry leaders, and members of media organizations all have a stake in the school improvement process. By communicating planned program improvements to the public, schools and districts encourage the involvement of all education stakeholders in the processes and operations of education, which in turn fosters the development of a greater sense of community.

**The Implementation Process**

The Science Improvement Team is impressed with the level of community involvement in the implementation of robotics technologies in Thunder Bay science programs. Thunder Bay high school students demonstrate robotics technology at a local science fair. Middle school science students have made field trips to Thunder Bay Industries, and local businessmen and women have made presentations in science classrooms. Two high school science teachers have had the opportunity to incorporate what they had learned in their summer jobs with Thunder Bay Industries into their physical science curriculums.

Implementation is the stage when the vision for improvement becomes a reality. After the Science Improvement Team has gained approval for its plan, it should begin to orchestrate and coordinate activities, strategies, and tactics at the school level. Implementation gives teachers and administrators opportunities to put into practice what they have learned during the improvement process and to work toward achieving the goals set forth in the science program vision statement.

Program improvement necessitates change, which progresses through several stages. People may initially oppose a change until they get enough information to become comfortable. With time, the innovation may even be improved by the very people who were opposed to its implementation.
Taking the Next Step

The community of Thunder Bay is proud of its schools. Students regularly compete in the Florida Science and Engineering Fair and several have experienced the excitement of competing in the International Science and Engineering Fair. The mentor program developed by Thunder Bay Industries and the high school has also won several awards.

As schools improve, so does the community. As the community changes, so does the district’s PreK-12 science program. The process is cyclical, continuous, and mutually beneficial.

The cyclical process of evaluation, planning for improvement, implementing changes for improvement, and monitoring the results of those changes has a number of benefits. It involves a broad representation of the local community. It allows for continual improvements that incorporate advances in technology and gains in scientific knowledge. It provides the opportunity to create programs that meet the unique needs of students, address specific local issues and concerns, and align with state standards.

Ultimately, an ongoing improvement process helps ensure success for each and every Florida student in meeting high academic standards.
**Key Chapter Points**

- In both business and industry and public sector organizations, a collaborative process of sound and systematic program evaluation, planning for improvement, implementation of innovative strategies, and monitoring of results leads to success.

- The overall improvement process being implemented through each School Advisory Council can also be applied to the science program at either the district or school level.

- Reform will happen and be effective in an environment that encourages innovative and proactive thinking.

- To be systemic and successful, school and district programs should be designed with care, include all those concerned about success in education, and provide time for creativity, implementation, practice, reflection, revision, and renewal.
Resources


