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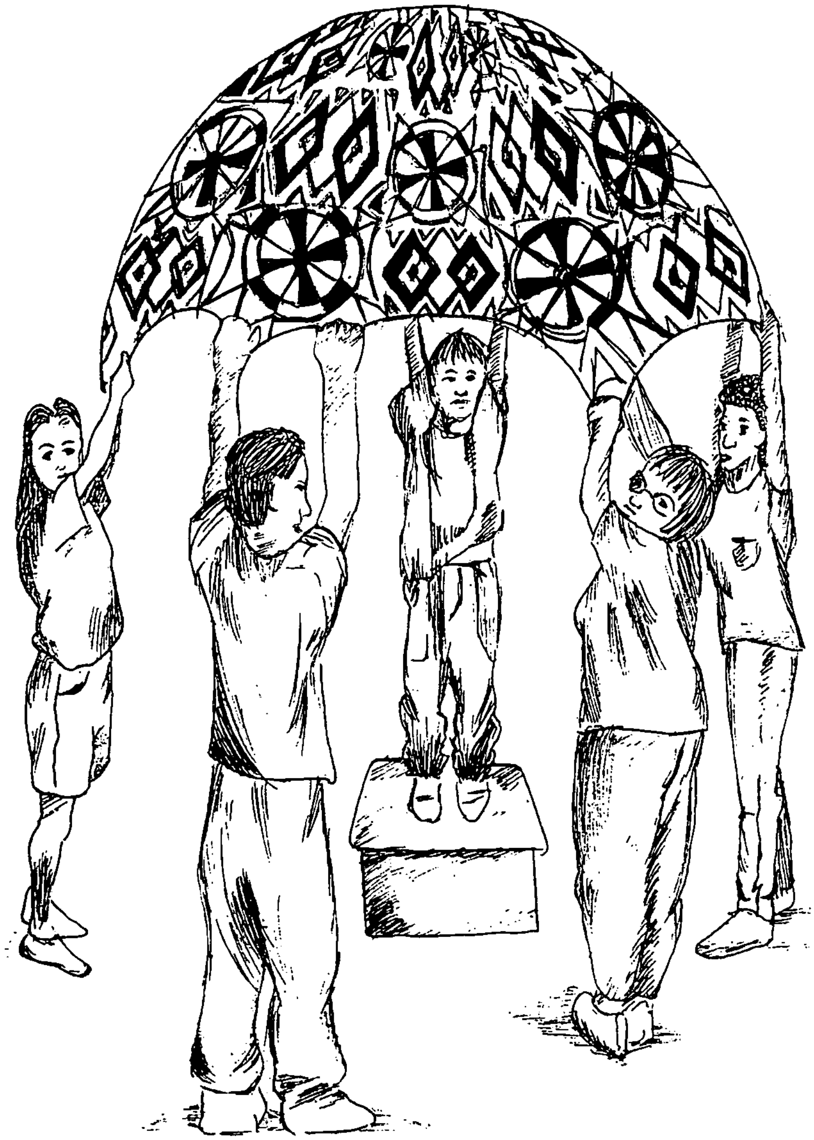
ABSTRACT

The Rhode Island Science Framework presents a rationale for the importance of science within the K-12 school curriculum; suggests ways in which science teaching and learning can be supported by the larger system; addresses issues related to science content, assessment of science learning, evaluation of a school's or district's science program; and provides resources for information and technical assistance. The science framework links directly to and expands upon the state's Common Core of Learning as it relates to science education. The contents of this report include descriptions of the Common Core of Learning and the Science Framework; explanations of the philosophy of and definitions for the Science Framework; a list of selected Benchmarks; discussion of insights from research into learning and teaching science, and teaching science in an inclusive way; explanations of techniques for organizing the school system to support quality science education; descriptions of methods for assessment and science program evaluation; and a list of resources for Rhode Island schools. (WRM)

Science Literacy for ALL Students



The Rhode Island Science Framework

Published by the
Rhode Island Department of
Elementary and Secondary Education

Science Literacy for ALL Students

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Elementary and Secondary Education

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COVER ART:

Lay Thet, 9th grade student and Marjorie Gallo, teacher
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The Rhode Island Common Core of Learning and the Rhode Island Science Framework

The Rhode Island Science Framework is the product of the work of hundreds of individuals over a three year period. It presents a rationale for the importance of science within the K-12 school curriculum, suggests ways in which science teaching and learning can be supported by the larger system, and addresses issues related to science content, assessment of science learning, evaluation of a school's or district's science program, and provides resources for information and technical assistance.

The science framework links directly to, and expands upon, the state's Common Core of Learning as it relates to science education. The Common Core forms the remainder of this opening chapter within the framework.

In 1992 the Board of Regents and the Commissioner of Elementary and Secondary Education convened Rhode Island's Common Core of Learning team, composed of over 100 parents, educators, civic, business, and corporate leaders. Together they researched the issues and conducted focus groups around the state. This work led to the development of a survey asking *"what should all young adults in Rhode Island know and be able to do to meet the responsibilities and challenges of the 21st century?"*.

The responses were tabulated and distilled into a document which represents the collective thinking of the citizens of our state about the goals of education, and is included here in its entirety.

The respondents identified four major goals of education in Rhode Island:

Communication: reading, writing, speaking, listening and conversing effectively.
Problem Solving: viewing learning as a lifelong process in which problem solving complements the body of knowledge by helping students acquire and apply new knowledge.
Body of Knowledge: acquiring ideas and skills that have been passed on by past generations and that form the base for the future progress of society.
Responsibility: accepting responsibility for one's self, one's learning, and one's role in society.

These areas are four dimensions of a whole, rather than discrete segments that can be selected piecemeal. They balance knowledge of content, skills and attitudes. Thus, students in their science studies concurrently should acquire a body of knowledge while communicating their learning, solve current science- and technology-related problems, and take responsibility for their learning while also engaging in socially responsible behavior. The learning goals of the Common Core form the basis for the development of more explicit state curriculum documents such as this science framework. (The mathematics framework and a draft language arts framework are also presently available.)

The science framework, referencing the Benchmarks for Science Literacy of the American Association for the Advancement of Science which it adopts as a base, can be conceptually linked to the four main areas of the Common Core of Learning in the following manner:

Communication: Benchmarks chapters 8 and 12
Problem Solving: Benchmarks chapter 1, 2, 3, and 12
Body of Knowledge: Benchmarks chapters 1 through 10
Personal and Social Responsibility: Benchmarks chapters 3, 6, 7, and 12

DEVELOPING A COMMON CORE OF LEARNING

A Report On What We Heard

Revised, Fall 1995

Published by the
Rhode Island Department of
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* * PREAMBLE * *

● ●

What the best and wisest parent wants for his own child, that must the community want for all of its children.

--- John Dewey

● ●

Historically, Rhode Island has expected much from its educational system. In the future we will expect even more. The needs of a changing society place new and greater demands on students and on schools. Both must prepare for a future we cannot truly envision. Schools must prepare students not only to work, but to live, in the 21st century.

It is important to ask how well our current educational system has served Rhode Island, and how it must be improved and changed. Our speculations about life in the future are tested against what sociologists, economists, scientists and artists tell us that we may expect. Each of us filters these ideas through our own cultural, political and family experiences. We question what we will require from our educational institutions. How will we earn our livelihoods? What advances in technology, transportation, health, the arts and recreation will influence the way we live?

Developing A Common Core of Learning - A Report on What We Heard pays its respects to our past at the same time that it represents our promise to the future. ALL KIDS, not just some kids, deserve the best education. With this in mind together we will create an educational system that renews our society and prepares Rhode Island for the future.

INTRODUCTION ...

Three important events provide the foundation of Rhode Island's Common Core of Learning. The nation's Governors drafted "America 2000" goals (now called *Goals 2000*) in 1989. In March 1994, these national educational goals were finally enacted into law. At the state level, the 21st Century Commission and the Rhode Island Skills Commission each drafted plans for the restructuring of Rhode Island's educational system and called for the citizens of the state to establish learner goals and high standards of performance for all of our students.

In 1992, the Board of Regents and the Commissioner of Elementary and Secondary Education convened Rhode Island's Common Core of Learning Team, comprised of over 100 parents, educators, civic, business and corporate leaders. Together they researched the issues and conducted focus groups around the state. This work led to the development of a survey printed in five languages, and 200,000 were distributed throughout the state. It asked, *"What should all young adults in Rhode Island know and be able to do to meet the responsibilities and challenges of the 21st Century?"*

The responses were tabulated. Writers drawn from the larger team distilled the collected thoughts expressed by the respondents into Rhode Island's Common Core of Learning. This document represents the collective thinking of the citizens of our state about the goals of education.

The respondents identified four major goals of education in Rhode Island:

> ***Communication*** - reading, writing, speaking, listening and conversing effectively.
>
> ***Problem Solving*** - viewing learning as a lifelong process in which problem solving complements the body of knowledge by helping students acquire and apply new knowledge.
>
> ***Body of Knowledge*** - acquiring ideas and skills that have been passed on by past generations and that form the base for the future progress of society.
>
> ***Responsibility*** - accepting responsibility for oneself, one's learning, and one's role in society.

These areas are four dimensions of a whole rather than discrete segments that can be selected piecemeal. They balance knowledge of content, skills and attitudes. Thus, students in their studies concurrently acquire bodies of knowledge while communicating new learning, solving current problems and taking on responsibilities related to their learning. These goals form the basis for developing more explicit curriculum documents.

Rhode Island's Common Core of Learning is intended to guide schools and classroom teachers in the design of curriculum and instruction. It has a second and equally important purpose: to provide a forum for discussion among educators and the general public. We must share a common vision and direction for education in our state if it is to serve us all equally well.

COMMUNICATION

"It is imperative that good oral and written communication skills are stressed." (respondent #00361)

"Communication via written words, oral expression or computer transmission will be a necessity in the 21st century." (respondent #02584)

One of the hallmarks of an educated person is the ability to read, write, speak, listen, and converse effectively. People with well-developed communication skills understand others and express themselves well. In addition, they give and receive constructive feedback, adapting their words and actions as reason and circumstances dictate.

Students who have acquired a common core of communication skills will...

Read widely and attentively by ...

- Reading for a variety of purposes: to gain understanding, to appreciate the experience of others, to gather information and to enjoy leisure time.
- Building meaning while reading, determining the relative importance of ideas and connecting what is read to prior knowledge, other sources and their own experiences.
- Reading critically: distinguishing fact from opinion, identifying inconsistencies and recognizing bias.
- Utilizing reference materials, both print and electronic (e.g. dictionaries, encyclopedias, atlases, and original sources via Internet) and features of written and electronic texts (e.g. tables of contents, indices, chapters, headings and electronic search strategies).
- Following written instructions.

Write persuasively and expressively by ...

- Writing for a variety of purposes and audiences.
- Writing as a way of discovering and clarifying ideas.
- Engaging in a process that involves planning, organizing, revising and editing one's own writing.
- Supporting ideas through the use of facts, examples, quotations and arguments.

- Gathering information, taking accurate notes and summarizing accurately, noting sources properly.
- Using correct spelling, punctuation, grammar and other language conventions.
- Making use of print and electronic reference tools, such as handbooks and grammar and spelling checking programs, to locate language conventions.
- Using technology and software including text, data, graphics and communication, to produce documents.

Speak, listen and converse intelligently by ...

- Listening and conversing in order to share information, build relationships and promote understanding
- Engaging constructively in oral exchange of ideas.
- Asking and answering questions.
- Delivering oral presentations to a group, using appropriate language, information, gestures and media.
- Conducting and being the subject of an interview.
- Forming, expressing, and defending a point of view.
- Giving, understanding and following spoken instructions.
- Listening carefully and giving constructive feedback.
- Communicating with others using electronic media (e.g., audio, video, Internet).
- Communicating with others in more than one language.
- Communicating with people from various social, occupational and cultural groups.
- Working to clarify misunderstandings and to resolve conflicts peacefully and democratically.
- Understanding the impact of one's language on others.

PROBLEM SOLVING

"They should be able to reason a problem out in a step-by-step fashion until a worthwhile solution is reached." (respondent #00527)

A rapidly changing world requires all people to be lifelong learners and problem solvers. Along with the common body of knowledge and skills needed for a productive life, students need to learn continuously and apply what they have learned critically and creatively to solve real life problems. Lifelong learning and problem solving are not separate from the common body of knowledge that comprises the content of schooling; rather, they complement it by helping students to acquire new knowledge and to apply it in original and effective ways.

Students who have acquired a common core of problem solving skills will ...

Learn continuously by ...

- Setting high standards in developing personal learning goals.
- Accepting and pursuing challenges - stretching personal limits.
- Working cooperatively and/or independently as the situation demands.
- Using learning approaches that are suitable to personal, community, and work related settings.
- Giving, receiving, and evaluating constructive criticism.
- Learning from failure.

Solve problems effectively by ...

- Defining a problem, posing meaningful questions, generating and testing alternative hypotheses, establishing criteria for measuring success, and determining a course of action.
- Planning and organizing a problem solving task requiring multiple steps, sustained concentration and long term commitment.
- Demonstrating flexibility, inventiveness and persistence, revising a problem solving plan as needed.
- Seeking advice and information, presenting data and analyses, persuading others of a particular course of action and modifying plans in light of the input of others.

- Using appropriate techniques and technologies in acquiring new knowledge and skills and in researching and solving a problem.
- Observing, selecting and recording meaningful data.
- Accessing, applying, interpreting, recording, evaluating and integrating information from a variety of sources and subject areas.
- Questioning the validity of sources, recognizing fallacies, detecting a writer's or a speaker's point of view and examining how facts and language are being used.
- Considering and weighing diverse perspectives, then defending a decision to accept, reject or modify each.
- Employing a range of strategies, including those which involve the application of technologies.
- Evaluating the quality and success of their own work.

BODY OF KNOWLEDGE

"Successful education can be a blend of teamwork, skills, historical knowledge, scientific application, including the use of technology and multicultural awareness. The elements are not presented piecemeal but are taught in context." *(respondent #01937)*

People today build upon the ideas and skills of the civilization that went before them. This Body of Knowledge forms the base for schooling in the modern world. This schooling relies on a knowledge of human thought and creativity from historical, scientific and social perspectives. The focus here is the application of knowledge in improving the quality of life for the individual in the community, workplace and society. The statements in this section are not intended to be an exhaustive catalog of subjects or precise content standards, but they suggest the general knowledge that all students should acquire and be able to apply.

Students who have acquired this body of knowledge will ...

Know about themselves by ...

- Understanding the workings of the human body and mind in order to maintain personal health.
- Applying information and skills that enable successful functioning in everyday tasks.
- Developing skills necessary for employment.

Know about others by ...

- Understanding the American political system in order to fulfill the duties of citizenship for personal and community purposes.
- Understanding the principles of the American economic system that allows the individual to participate in and benefit from that system.
- Showing an appreciation of their own culture and the culture of others, knowing the influence of cultural differences upon human interaction and having the ability to employ this understanding in improving cross-cultural relations.
- Understanding the influence of religious views and values on past and present society.

- Developing an understanding of literature and the arts as a reflection of values shaped by social or historical forces.

- Appreciating the major art forms: drama, dance, music and the visual arts.

- Having a basic understanding of the history and structure of the English language.

Know about the natural world by ...

- Demonstrating an understanding of people's relationship to the environment, the influence of the environment on human life and the use of the environment in conserving and improving life.

- Understanding key concepts of mathematics, science and technology; the relationships between and among them; and their strengths and limitations.

- Recognizing the impact of technology on the workplace and society, including implications for the environment.

- Recognizing the importance of mathematics, science and technology in daily life.

- Interacting and communicating confidently with others in using mathematics, science and technology to ask and answer relevant questions.

- Using scientific processes, mathematical reasoning and technology to solve problems and build an understanding of the natural world.

RESPONSIBILITY

"I believe that all young adults should #1 learn how to accept responsiblility for their actions both academically and socially." (respondent #00142)

A pillar of the Common Core of Learning must be responsibility. The 21st Century will require citizens to take responsibility for themselves, their learning and their society. By gaining an awareness of their responsibilities to themselves as individuals and to society as a whole, the youth of Rhode Island will be better equipped to meet the challenges of tomorrow.

All Rhode Islanders, therefore, must be encouraged to take responsibility for their lives and the role each will play in society. As lifelong learners they will act on goals that they set for themselves, develop healthy habits and establish positive relationships, at home, in the workplace and in the community. They will develop personal characteristics that enable them to become good citizens, family members, and parents, as well as productive workers.

Students who exhibit responsible behavior will ...

Accept personal responsibility for the well being of self and society by ...

- Developing habits to ensure physical, emotional and mental health.
- Making informed career and life decisions.
- Developing strategies to manage stress.
- Coping successfully with negative peer pressure and media influences.
- Making and keeping healthy relationships.
- Buying and consuming responsibly.
- Understanding how technology affects human culture, the workplace and the environment.
- Being aware of our interdependence with the environment.

Work responsibly in groups and as an individual by ...

- Working cooperatively with others in achieving a group decision or goal.
- Sharing, delegating, leading, contributing and following through.
- Respecting opposing points of view.
- Carrying through responsibilities and completing tasks.
- Knowing how and when to negotiate or compromise to reach a consensus.
- Using technology appropriately.

Responsibility (continued)

Acquire the necessary skills, competencies and personal qualities to succeed in the workplace by ...

- Understanding the multiple pathways through which one may prepare for various careers.
- Applying the body of knowledge, communication and problem solving approaches appropriately in one's occupations.
- Understanding the value of labor and developing a work ethic.
- Managing time and resources effectively.
- Being flexible in adapting to new situations, analyzing information, and solving problems through the use of existing and emerging technology.
- Setting high personal standards for quality work which satisfies the needs of clients and customers.
- Demonstrating dependability, honesty, productivity, leadership and initiative.

Show tolerance for human diversity by ...

- Learning about differences among people, religions and cultures.
- Understanding the causes of prejudice and its contribution to social injustice.
- Showing courtesy towards others.
- Respecting the rights of all people.

Understand the importance of family and community by ...

- Practicing the duties and responsibilities of citizenship.
- Engaging in meaningful service to the community.
- Understanding the ethical dimensions of citizenship and parenting.

Respond to challenges with integrity, honesty, and courage by ...

- Maintaining high standards of academic honesty.
- Acting in an honest manner when dealing with others.
- Accepting responsibility for personal decisions and actions.
- Setting priorities and accepting responsibilities in the home, family and community.

Display a strong sense of self-worth and personal competence by ...

- Exhibiting self-respect and respect for others.
- Relying on strong interpersonal skills.
- Setting challenging, realistic goals.
- Knowing his or her own heritage.
- Developing and pursuing personal interests and goals.

2

Philosophy and Definitions

Rhode Island, as other states throughout the nation, is setting higher expectations for student achievement. Students should graduate from high school with the skills, knowledge, and motivation to succeed in life and work. Unless we set high standards for all children, and give each one the support they need to achieve those standards, we will not be educating all our students. If our children are to be healthy and productive citizens, they must receive the education and practice in the skills necessary for future success.

Setting high learning standards raises the expectations of all people involved in our educational systems - students, parents, teachers, administrators, and the business community. New methods of instruction and assessment must be established to successfully achieve the new higher learning standards. International and national competition requires that we train our people to use thinking skills more effectively.

"Student achievement must ultimately be the measure of accountability for schools."

Reaching for High Standards. Student Performance in Rhode Island, RIDE, 1994, p. 1)

Student performance should be assessed by both traditional and alternative methods. Individual student achievement should be monitored by work in ongoing projects, cooperating performance in group problem solving and by a portfolio of personal work.

The creation, dissemination, and implementation of subject matter curriculum frameworks is one set of structural changes needed to clarify and raise expectations for all students. The Science Framework for Rhode Island is intended as a document to be discussed among teachers, administrators, school boards, parents, business leaders, students, and the involved public. The goal of the document is to identify what students should know, perform, and value in science and technology.

This framework is designed to be continually evolving. It appears at a time when our children are faced with great social and economic challenges. According to the University of Rhode Island's Labor Research Center, Rhode Island is undergoing a transformation into a "mature third world economy," dependent upon tourism and low-wage manufacturing for its livelihood. Between 1982 and 1992, Rhode Island lost 28,500 manufacturing jobs from a base of 166,600 positions in manufacturing. From June, 1990 to June, 1992 alone, the state eliminated 40,600 jobs overall, touching every major employment category except service industries and government.

"To meet the challenges of these high performance work places, workers need to know how to read, write, and communicate clearly, perform mathematical calculations, think critically, work as members of a team, take responsibility for quality, inventories, and productivity, solve problems and make decisions. This is a departure from the expectations managers have had of workers under mass production -- and from the skills many of our workers possess today."

... Rhode Island's Choice: High Skills or Low Wages, RI Skills Commission, May 1992.

If Rhode Island is going to reassert its position within national and global economies, higher order thinking skills and knowledge associated with the scientific enterprise are critical. Rhode Island students must have a broad scope of science knowledge and proficiency in the use of technical tools in science learning. They also must be competent in the problem solving skills required by the scientific endeavor. Approximately seventy percent of all jobs by the year 2000 will not require a four-year college degree. It is vital that all students receive effective education in the knowledge and application of science concepts, principles, and practices. This framework speaks to the benchmarks of science learning for all students.

Science is a particular way of learning about, looking at, and knowing the world (Brown, 1994). Science includes:

* asking questions about how the world works

* collecting and analyzing relevant data

* formulating ideas which draw upon the work of others, both past and present

* testing these ideas through prediction and controlled experiments

* communicating the results of one's labor to colleagues around the world for their critique and further refinement

* developing a frame of reference and general disposition toward investigations of the natural world which can be thought of as "habits of mind and affect"

* examining the implications of scientific discoveries on social, economic, and political systems

"The irony is that children start out as natural scientists, instinctively eager to investigate the world around them. Helping them enjoy science can be easy. There's no need for a lot of scientific jargon or expensive lab equipment. You only have to share your children's curiosity."

Mary Budd Rowe, Professor of Science Education, Stanford University in "Teach Your Child to Wonder," Reader's Digest, May 1995, p. 178)

Explanatory frameworks for the natural world that prove fruitful to practicing scientists are accorded the status of theories. Theories are considered temporary and are therefore continually retested and revised (for example, theories of an earth-centered versus a sun-centered universe). Thus, science is a never ending quest to explain the natural world.

"No nation can produce a highly qualified work force without first providing its citizens with a strong general education. All of our young people should start with a solid foundation of knowledge, whether or not they pursue a university degree. We need to set high standards that have real value and insist that virtually all students meet them."

... Rhode Island's Choice: High Skills or Low Wages, RI Skills Commission, May 1992.

The focus of **science education** is not only to produce future scientists. Rather, the preeminent goal is to help all students, as learners and future citizens within a democracy, to be scientifically literate (Matthews, 1994). Scientific literacy includes "being familiar with the natural world and respecting its unity; being aware of some of the important ways in which mathematics, technology, and the sciences depend upon one another; understanding some of the key concepts and principles of science; having a capacity for scientific ways of thinking; knowing that science, mathematics, and technology are human enterprises, and know what that implies about their strengths and limitations; and being able to use scientific knowledge and ways of thinking for personal and social purposes." (Rutherford and Ahlgren, 1990: x). Literacy entails more than head knowledge. It also involves the ability to design and carry out experiments and investigations of the natural world (Hegarty-Hazel, 1990). It includes communicating those results to others in meaningful ways and relating knowledge of science principles to concrete examples in one's everyday life and the world of work.

Science is a field which is not exclusive of ethics. However, ethics are often not incorporated into the process of 'doing science.' Increasingly, because of the use of advanced technologies in scientific fields, individuals need to make complex decisions both in the work force and in everyday living. Students need to understand that ethics and science go hand in hand. A few discussion topics might be: "Is dissection necessary in the classroom or can computer simulations be used?" or "What are the ethics involved in an environmental issue - such as cutting down forests to meet our necessary need for paper?" Diminishing resources and increasing environmental problems world-wide mean teachers must be vigilant in providing students with a strong ethical base on which to make decisions.

"Constructivism does not claim to have made earth-shaking inventions in the area of education; it merely claims to provide a solid conceptual basis for some of the things that, until now, inspired teachers had to do without theoretical foundation."

Ernst von Glasersfeld, "A Constructivist Approach to Teaching," Constructivism in Education, Eds. L.P. Steffe, J. Gale, Hillsdale, NJ: Lawrence Erlbaum Associates, 1995, p. 15

One area where scientists currently have to make such decisions is in the field of genetic engineering. The recent discovery of a 'fat' gene raises an ethical dilemma. Is it appropriate for scientists to create a drug which can eliminate fat? Increasingly scientists are aware of the complexity of interactions which occur in ecosystems and between species. Future generations must learn that they are one piece of a vast global system and are dependent upon it for their health and well-being.

The latest knowledge of how children learn should be incorporated into the science education experiences and materials for K-12 students. K-12 instruction should introduce students to science concepts and theories with a gradual spiral of increasing levels of abstraction. One example of this approach is the Scope, Sequence and Coordination Project of the National Science Teachers Association (1992, 1993). Concepts, principles and theories should be carefully sequenced according to the cognitive level of the student's existing science knowledge. Instruction should also be designed so that students may construct and create a personal knowledge of science relative to themselves and their environment. This approach to learning is **constructivism.** The theory maintains that the central purpose of learning is to make a personal meaning of the reality which surrounds you (Tobin, 1993; Shapiro, 1994; Fensham, Gunstone and White, 1994; Steffe and Gale, 1995). This includes:

* linking new knowledge to existing knowledge

* reframing one's own understanding in light of new evidence

* testing one's ideas in new contexts to see whether they are valuable in investigating and explaining phenomena

Approaching science teaching in a Constructivist framework requires adoption of a "less is more" position regarding the science curriculum. It is better that students experience a few concepts, principles and their applications in depth than that they march through material to "finish" a textbook. Teachers and science supervisors must balance the need for a broad conceptual framework in science with the need for adequate time within the science curriculum for students to construct personal meaning of scientific ideas and to test their ideas in various ways (Black and Lucas, 1993).

A number of principles formulated by the National Committee on Science Education Standards and Assessment are adapted here as key assumptions for the Rhode Island Science Framework. They are:

* *All students, regardless of gender, cultural, linguistic or ethnic background, physical or learning disabilities, aspirations, or interest and motivation in science, should have the opportunity to attain higher levels of scientific literacy than they do currently. This is a principle of equity.*

* *All students will develop science knowledge as defined in the content standards and an understanding of science that enables them to use their knowledge as it relates to scientific, personal, social, and historical perspectives.*

* *Learning science is an active process.*

* *Resources, such as time, personnel, and materials must be devoted to science education.*

"Autonomy and initiative prompt students' pursuit of connections among ideas and concepts. Students who frame questions and issues and then go about answering and analyzing them take responsibility for their own learning and become problem solvers and, perhaps more important, problem finders."

Jacqueline G. Brooks, Martin G. Brooks, The Case for Constructivist Classrooms, Association for Supervision and Curriculum Development, Alexandria, VA, 1993, p. 103.

"The integration of curriculum may be accomplished along a continuum ranging from artificial subject matter divisions present in the current curriculum through multi- or trans-disciplinary curriculum in which the curriculum cuts across many areas and is more like what a student will encounter outside of school."

... Educating ALL Our Children. A Report of the 21st Century Education Commission, March 1992.

* *Greater emphasis must be given to critical concepts, rather than presenting a general overview of many topics.*

* *School science must reflect the intellectual tradition that characterizes the practice of contemporary science.*

* *Improving science education is part of systemic education reform.*

The science benchmarks presented in this document are adopted or adapted from Project 2061, a long-term educational reform initiative of the American Association for the Advancement of Science. Over the past decade, hundreds of scientists, mathematicians, engineers, social scientists, teachers, and administrators have collaborated to produce both a general guide to science education (Science for All Americans) and a provisional guide to science learning goals (Benchmarks for Science Literacy). Project 2061's vision for education reaches far beyond the "traditional" sciences to embrace mathematics, technology, the arts, and the social sciences. The RI science framework concentrates solely on selected benchmarks related to the sciences and the nature of technology. By no means should the reader infer that these are the only important benchmarks. Rather , school districts and teachers are encouraged to read and contemplate the other dimensions of the Project 2061 framework for its suitability in guiding reform efforts throughout the K-12 curriculum. *Benchmarks* as used in this document and in *Project 2061*, *"specifies how students should progress toward science literacy, recommending what they should know and be able to do by the time they reach certain grade levels." (AAAS, 1993: xi)*

The science benchmarks presented here delineate key concepts, principles, knowledge, and skills that all students should know and be able to do. We have purposely not completed our work with the benchmarks related to the sciences drawn from chapters 4 - 6 of the Benchmarks for Science Literacy. We invite you, our reader, to:

* join with colleagues and create additional pages drawing upon Project 2061 benchmarks

* amend our pages with alternative activities, assessment ideas, other process focus suggestions

* contribute short vignettes of one or two paragraphs linked to specific benchmarks which tell other Rhode Islanders how your school or classroom is addressing particular benchmarks, using assessment strategies, applying educational technology, modifying curriculum or practices to meet the needs of specific groups of students, and pioneering new instructional strategies.

The benchmarks presented here are not exhaustive, but are sufficient in the Development Team's view, to catalyze local curriculum development and instructional practices. No one curriculum is ideal for achieving these benchmarks nor is there one set of instructional practices which guarantees success for all students. Rather, school districts and teachers are expected to tailor their own curriculum and instructional practice to ensure that all students are afforded equitable opportunities to learn and experience science. For some students this will take a more applied, practical approach -- others will benefit from a more conceptually based approach. Some students will progress quickly through certain benchmarks, others at a slower pace.

All students should not just read about the sciences -- they must do science. The excitement that characterizes the enterprise of science should be experienced by every student as they seek in the company of their peers to make meaning of the natural world. Science experiences should also connect students to everyday life and the science- and technology-related social issues with which local communities, states, nations, and humanity struggle (Cheek, 1992; Aikenhead and Solomon, 1994).

Students also need exposure to the world of technology and the ways in which technology shapes human life. Technology is undoubtedly one of the most pervasive features of the twentieth century world (Marcus & Segal, 1989; Nye, 1994; Pursell, 1995). It is also one of the oldest of human endeavors, predating science, for example, by thousands of years. In recent decades, the connection between technology and the sciences has grown considerably closer -- to the point where sometimes scientific discoveries push technological innovations or technological inventions aid scientific discoveries or challenge existing theories about how the world works. A practitioner working today in a large scale Research & Development operation often finds the day a seamless conceptual web as they integrate their knowledge of science and technology to solve challenging problems.

Most of us use the word "technology" in the course of everyday conversation in a variety of ways. Sometimes we mean a particular way of doing things, sometimes we refer to a particular object as a technology. A particular contemporary and narrow use of the word is as a referent for computers and their related devices (modems, hard drives, etc.).

Stephen Kline, Professor of Mechanical Engineering at Stanford University and a faculty member in the university-wide Values in Technology, Science and Society Program, reminds us that we can talk about **technology** in one of four ways (Kline, 1985):

* as an artifact or hardware (e.g., an aspirin, chair, building, computer, or videotape)

It was a strange sight: a man, standing before a fountain, watching the falling water and tilting his head from side to side. Drawing closer, I saw he was rapidly moving the fingers of his right hand up and down in front of his face.

I was in the seventh grade, visiting Princeton University with my science class, and the man at the fountain was Albert Einstein.

For several minutes, he continued silently flicking his fingers. Then he turned and asked, "Can you do it? Can you see the individual drops?"

Copying him, I spread my fingers and moved them up and down before my eyes. Suddenly, the fountain's stream seemed to freeze into individual droplets. For some time, the two of us stood there perfecting our strobe technique. Then, as the professor turned to leave, he looked me in the eye and said, "Never forget that science is just that kind of exploring and fun."

Mary Budd Rowe, "Teach Your Child To Wonder," Reader's Digest, May 1995, p. 177

* as a methodology or technique (e.g., painting, using a microscope or pocket calculator)

* as a system of production (e.g., the automobile assembly line or an entire industry)

* as a sociotechnical system (an airplane, for example, suggests a plethora of interrelated devices, human resources, and artifacts such as airports, passengers, pilots, mechanics, fuel, regulations, and ticketing.)

"Since individual technologies and their networks enhance or undermine the people we want to be and the society in which we want to live, we as citizens must try to understand this mighty force and see it not only for what it is but also for what it might be."

C. Pursell, The Machine in America: A Social History of Technology, 1995, p. xii)

Technologies embody tradeoffs that are made between what is desired and real world constraints of cost, time, thought, energy, etc. (Wenk, 1986). This may mean that certain individuals, organizations, and social groups bear the costs and burdens while other individuals, organizations, and social groups derive benefits and profits. Even the same group will experience tradeoffs between conflicting objectives.

Another hallmark of technologies are unanticipated side effects (Westrum, 1991; Pursell, 1994). These are effects which cannot be accurately predicted in advance but emerge as the technology in question is implemented. Some of these side effects are positive in nature, some may be neutral, while others are decidedly negative.

Position papers endorsing the worth and importance of a science, technology and society (STS) approach to education have appeared from the National Science Teachers Association, National Council for the Social Studies, and the International Technology Education Association. The recently released curriculum standards for social studies (NCSS, 1994), the draft national science standards, and the Project 2061 Benchmarks all give attention to the importance of STS elements within school curriculum, especially in the sciences and the social studies. Technology has been the absent presence in the K-12 school curriculum. The technological world in which we live and in which our children will function demands greater attention to the role of technologies within society.

We look forward to your comments, suggestions, and revisions as we all engage in the process of setting new and higher standards for student achievement in the sciences. Members of the Development Team are available to meet with you and your colleagues to discuss this document, help you analyze your local curriculum, and to garner feedback for a second edition of this framework at some future point in time.

"Achieving the goal of scientific and technological literacy requires more than understanding major concepts and processes of science and technology. Indeed, there is a need for citizens to understand science and technology as an integral part of our society. Science and technology are enterprises that shape and are shaped by human thought and social actions."

Rodger W. Bybee and George E. DeBoer, "Research on Goals for the Science Curriculum," Handbook of Research on Science Teaching and Learning. Ed. Dorothy Gabel. Macmillan, NY 1994, p. 384).

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3

The Rhode Island Benchmarks

Scope and Sequence

Suggestions for a comprehensive scope and sequence are currently under development by Project 2061.

Science Process Skills

"The single most important factor influencing learning is what the learner already knows."

D. P. Ausubel, Educational Psychology: A Cognitive View. NY: Holt, Rinehart, and Winston. 1968, p. i)

Science process skills have been a routine part of nearly every curriculum document in science education for many decades. The science framework addresses these skills in a way that we hope will make them more meaningful to classroom teachers and curriculum developers. Instead of laundry lists of skills associated with each activity, we have keyed all activities to just a few skills that lie within particular arenas. As Figure 1 suggests, we believe that basically four arenas interact in determining the kinds of skills used in a science learning experience and the quality of the skills utilized. The core arena is foundational habits of mind and affect. These foundational habits are described in some detail in Chapter 12 of the Benchmarks for Science Literacy and in Science For All Americans of Project 2061. Briefly, one can think of them as general orientations toward knowledge, persons, and things that learners have resident with them before entering the science classroom. These are essentially attitudes and dispositions that are based on life experiences and philosophical beliefs. They are also habits which are relatively difficult to change or substantially alter. Yet they influence all subsequent learning experiences and human interactions - including what happens in science learning.

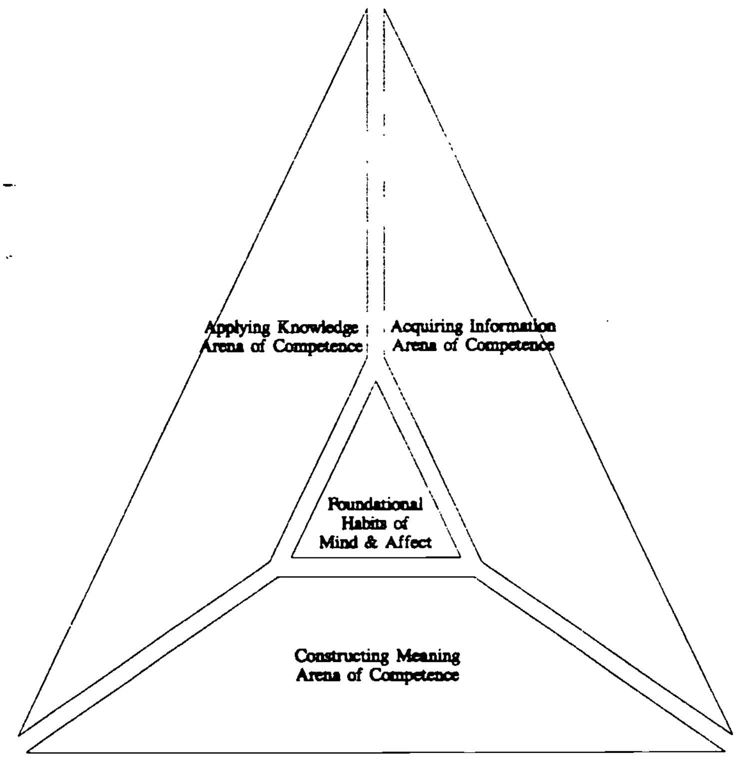

Figure 1.

Three other arenas interact with the foundational habits which the learner brings to the learning task: acquiring knowledge, constructing meaning, and applying knowledge. These arenas are all highly interactive with one another and decidely not linear in nature. Learning consists largely of making meaning out of a wide array of objects, phenomena, and processes in the world around us. In this sense, the construction of meaning is the central focus of the learning enterprise. This meaning is constructed personally by the learner and may or may not involve a substantial social process of knowledge construction with others (such as in varied forms of cooperative learning and informal social interaction). But even this construction of meaning is mediated by the knowledge/information that learners already possess, the new information that they acquire, and their experiences in applying their knowledge to new situations. In fact, the truest test of the worth of personal knowledge is application - does the learner find new uses for the knowledge so as to validate its meaning and functionality.

Within each arena of competency there are various proficiencies which might be identified. Figure 2 presents a few of the major proficiencies one might consider as lying under each arena. For example, in the Acquiring Information Arena, we can identify four major proficiency domains which learners must exercise if their search for new information is to achieve success: experimental, mathematical, language, and

If we expand upon these concepts to a more full-blown taxonomy of process skills, we end up with a diagram similar to Figure 3. The foundational habits undergird and strongly interact with all other dimensions of the process skills. Under each proficiency we may identify a variety of skills which one might use/demonstrate as one engages in acquiring information, constructing meaning, or applying knowledge. The taxonomy is not intended to be exhaustive but illustrative of the various kinds of skills that successful science learners will exhibit. Even young children exhibit many of these proficiencies at the start of their formal schooling. Part of the process of formal education is to increase the breadth and depth of these skills as part of the affective, cognitive, and psychomotor 'toolkits' that learners possess. High quality success at these skills equips learners not only for high achievement in school but success in life.

This taxonomy can be used by a teacher to begin to approach science process skills within a broader conceptual framework than the usual laundry lists. Every class has individuals who already exhibit excellence in one or more proficiency domains and deficiencies in other domains. Some learners are very good in individual tasks but very inept when it comes to collaborating with others to achieve common ends. As teachers, we can better identify where students are on these continuums, from poor to excellent, and consciously use this information to create a range of opportunities for all students to increase the breadth and depth of their science process skills. We are interested in hearing from teachers about how useful this taxonomy proves to be and how it might be improved as we move toward a second edition of the RI State Science Framework.

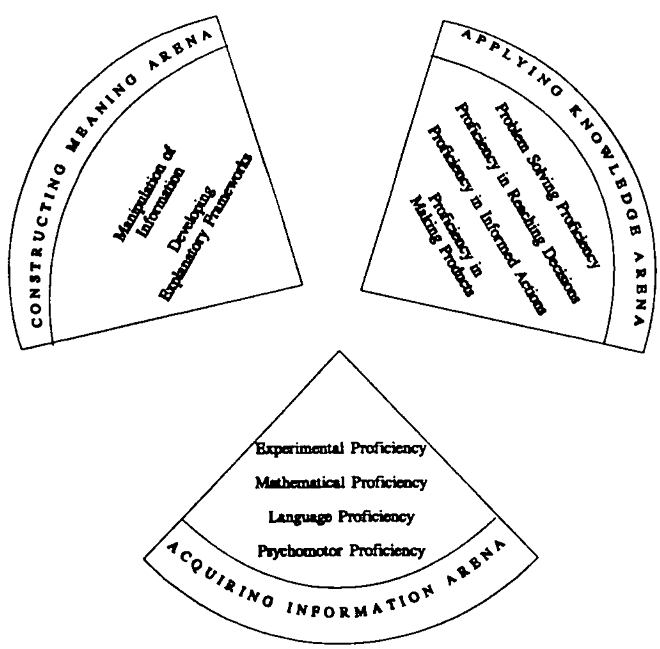

Figure 2

ARENAS OF COMPETENCE

ACQUIRING INFORMATION ARENA

Experimental Proficiency

Controlling variables
Defining in operational terms
Formulating/testing hypotheses
Identifying variables
Observing
Replicating
Verifying information
Framing experimental questions
Following a planned sequence of activities
Suggesting improvements to experimental techniques

Mathematical Proficiency

Performing calculations
Estimating
Graphing/Plotting
Measuring
Numeration

Language Proficiency

Locating/using written scientific information
Interviewing
Designing/using surveys
Active listening
Writing reports/position papers
Explaining procedures to others

Psychomotor Proficiency

Using instruments/tools
Utilizing computers and related materials
Manipulating materials
Recording data
Creating diagrams and drawings

CONSTRUCTING MEANING ARENA

Manipulating Information

Classifying/developing a key
Inferring
Interpreting/evaluating data
Questioning
Connecting new information with previous knowledge
Distinguishing correlation from cause and effect
Developing generalizations
Identifying patterns and relationships
Applying statistical procedures

Developing Explanatory Frameworks

Generating novel ideas
Creating/testing mental models
Creating/testing physical models
Linking concepts/principles
Making testable predictions/ attempting refutations

APPLYING KNOWLEDGE ARENA

Problem Solving Proficiency (conditions of low risk/ uncertainty)

Recognizing and labeling problems
Clarifying the nature of the problem
Setting a problem-solving goal
Implementing/verifying solutions

Proficiency in Reaching Decisions about Issues (conditions of high risk/uncertainty)

Defining and identifying alternatives
Developing criteria for comparing alternatives
Assessing probabilities
Assessing the worth of current information

Proficiency in Informed Action

Describing current practice/policy
Identifying intended consequences of action
Identifying unintended consequences of action
Describing costs and benefits
Recognizing areas of uncertainty
Involving key players affected by planned action
Implementing/fine-tuning action plan

Proficiency in Making Products

Identifying/gathering appropriate materials
Building/testing/refining prototype
Constructing desired product
Marketing/disseminating product
Developing safety features
Ensuring desired quality, quantity, and supply

PERSONAL HABITS

Monitoring
Reflecting
Evaluating
Identifying biases
Recognizing one's presuppositions
Knowing personal strengths/weaknesses

FOUNDATIONAL HABITS OF MIND AND AFFECT

GROUP HABITS

Communicating information/ideas
Negotiating
Sharing Responsibility
Compromising
Contributing toward group goals
Identifying group goals
Delegating tasks
Building rapport

Figure 3

BEST COPY AVAILABLE

The Nature of Technology

- ✓ Technology and Science
- ✓ Design and Systems
- ✓ Issues in Technology

THE NATURE OF TECHNOLOGY - Technology and Science
Grade K-2 (Benchmark 1 of 2)

By the end of 2nd grade all students will know that --

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

Suggested Activity:

Invite the custodian to demonstrate simple hand tools. Show students a nail that has been hammered into a board. Ask how the nail can be removed given different tools. Show students some table salt with a magnifying glass and ask how they can see the shape of each small piece. Ask students to measure other students who are not standing near each other to see who is the tallest. Have students make an alphabet book with pictures of tools.

Embedded Assessment:	Match tools with appropriate tasks.
Summative Assessment:	The same types of activities, using different examples.
Theme:	Constancy and Change
Process:	Language Proficiency, esp. identifying appropriate materials

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By the end of 2nd grade all students will know that --

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

Suggested Activity:

Give students paper and tape and ask them to build a block or a square. They may consult whenever and whomever they wish, either inside the classroom or outside of it. Try origami. Have students teach one another how to build different types of paper airplanes. Extend the activity to baking, building a model, etc. Use Legos, blocks, or paper airplanes for a hands-on example.

Embedded Assessment:	Why did one group finish first? How could we have made their job even faster and easier?
Summative Assessment:	List ways you can get help when a group wants to build something that is hard to build.
Theme:	Systems
Process:	Proficiency in Making Products, esp. building/testing/refining prototypes

By the end of 5th grade all students will know that --

- Throughout all of history, people everywhere have invented and used tools. Most tools of today are different from those of the past but many are modifications of very ancient tools.

Suggested Activity:

Have individual students select a modern tool and create a model of both it and an ancient precursor or what that particular technology might look like in the future. Good examples would be hammers, screwdrivers, levels, flat irons, egg beaters and bottle openers. Then have them explain to their peers the relationship between the two tools.

Embedded Assessment:	List similarities and differences in chart form.
Summative Assessment:	Have groups of students develop exhibits of the technological evolution of particular classes of tools, e.g. agricultural or manufacturing.
Theme:	Constancy and Change
Process:	Psychomotor Proficiency, esp. manipulating materials, creating diagrams and drawings

Arrange a visit to your local high school, New England Tech or Johnson & Wales University to observe the difference between traditional board design and CAD design. Contact Erin Kavanaugh at NEIT (467-7744) or Dean David Mello at Johnson & Wales (598-4601).

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THE NATURE OF TECHNOLOGY - Technology and Science
Grade 3-5 (Benchmark 2 of 4)

By the end of 5th grade all students will know that --

The products of technology enable scientists and others to observe things that are too small or too far away to be seen without them and to study the motion of objects that are moving very rapidly or are hardly moving at all.

Suggested Activity:

Students observe objects with magnifying glasses, binoculars, telescopes, and microscopes, depending on what is available. Students view time lapse photography and slow motion video. Use VCR tape of students in slow motion of frame by frame to analyze sports performance.

Embedded Assessment:	Compare what you see with and without the technology.
Summative Assessment:	Students select a particular need to see better or more fully in the present, envision a technological solution to this dilemma, and explain the positive benefits of such a technology. Write a story about the use of this technology.
Theme:	Scale
Process:	Experimental Proficiency, esp. observing

Contact the RI Medical Society (Jackie Bigelow at 331-3207) to see if you can arrange a visit by a sports medicine specialist. The Amateur Astronomical Society of RI (726-1328) is another excellent source for speakers, trips and materials that would link to this benchmark.

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By the end of 5th grade all students will know that --

Measuring instruments can be used to gather accurate information for making scientific comparisons of objects and events and for designing and constructing things that will work properly.

Suggested Activity:

Build a toy with moving parts. After practice in using measuring tools to compare objects and/or events, present students with an object, like a pyramid made from coffee stirrers. Have students build a smaller or larger identical object to scale.

Embedded Assessment:	Is the object built correctly?
Summative Assessment:	Students describe what would have gone wrong if they had not measured and/or multiplied or divided accurately.
Theme:	Scale
Process:	Mathematical Proficiency, esp. measuring

Have an *Invention Convention*! Using graph paper and sugar cubes pair students to design and build a three-dimensional figure. Name and describe. Other students or a panel of retired citizens evaluate for accuracy. Invite professionals to visit and share their experiences with models (e.g., doctors, architects, CAD designers, engineers, city planners). Contact associations of retired professionals (check the What's Out There? directory published by RIMSEC, RIOHE and RIDE for suggestions).

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By the end of 5th grade all students will know that --

Technology extends the ability of people to change the world: to cut, shape, or put together materials; to move things from one place to another; and to reach farther with their hands, voices, senses, and minds. The changes may be for survival needs such as food, shelter, and defense, for communication and transportation, or to gain knowledge and express ideas, or entertainment.

Suggested Activity:

Students make a chart on which they list technologies they use for obtaining food, shelter, defense, communication, and transportation. Have students bring in and report on a new technology that affects their life but did not exist during their parents' childhood.

Embedded Assessment:	Successful production of one sample portion of the chart, presentation to peers, selection of device.
Summative Assessment:	Compare technologies used by students in the class with those which might be used in different periods of time or from different cultures. Compare how new technology changed their lives, i.e., compact discs vs. 45 records.
Theme:	Constancy and Change
Process:	Language Proficiency, esp. comparing

From Ms. Frey's Class
Henry Barnard School
Providence, Rhode Island
Fifth Grade Activity

Building a Freshwater Pond

The fifth-graders in Ms. Frey's class built a freshwater pond with a waterfall in their classroom, and built a year-long curriculum around the study of this pond. Planning, design and measurement played a key role in the construction of this pond. Experts were consulted for their advice on design. The students measured and calculated the pond size and the quantity of water needed to fill the pond. Water displacement had to be predicted. And, of course, the pond had to be built and maintained! A truly interdisciplinary curriculum sprang up around the freshwater focus. Ms. Frey refers to this process as 'weaving a tapestry of learning.'

<u>*Science*</u>

- *Studied ecosystems, pond characteristics and littoral habitats.*
- *Classified and identified fresh water inhabitants through the construction of retrieval charts.*
- *Built and designed scale models of water driven devices such as clocks & water wheels.*

<u>*History*</u>

- *Traced the history fresh water played in the development of Rhode Island.*
- *Recreated locks, canals and towpaths in the sand table to gain an understanding of mills.*
- *Researched the role of fresh water in today's communities.*
- *Mapped the location of fresh water sources in Rhode Island.*

<u>*Language Arts*</u>

- *Dialogued with professionals, grandparents, retired citizens, and parents regarding fresh water ecosystems, local fresh water sources and environmental problems.*
- *Wrote poems and books for kindergarten children with fresh water themes.*
- *Read and discussed books with fresh water settings.*
- *Created fiction and non-fiction publications.*
- *Planned presentations including videos, photographs, and sketches.*
- *Designed and stitched a pond quilt with an accompanying book of sketches, stories, and autobiographies.*

<u>*Mathematics*</u>

- *Measured and calculated pond size and the quantity of water needed to fill the pond.*
- *Predicted water displacement, graphed water evaporation and temperature correlation of the pond, estimated plant and animal growth and compared the results.*
- *Routinely used problem solving strategies to maintain the pond.*
- *Created and programmed Lego/Logo fresh water creatures.*

A bibliography and list of resources are available from Ms. Frey at Henry Barnard. She also welcomes visitors to her pond, but asks that you call first to schedule a convenient time.

THE NATURE OF TECHNOLOGY - Technology and Science
Grade 6-8 (Benchmark 1 of 3)

By the end of 8th grade all students will know that --

In earlier times, the accumulated information and techniques of each generation of workers were taught on the job directly to the next generation of workers. Today, the knowledge base for technology can be found as well in libraries of print and electronic resources and is often taught in the classroom.

Suggested Activity:

Invite a local worker (e.g., carpenters, auto mechanics, electricians, plumbers) who is currently employed and a retired professional to compare and contrast their training and information access yesterday and today. Follow-up might include a class collage to display this workplace transformation to the school. Access data on CD ROM and on-line telecommunications to serve a particular purpose. For example, track Monarch Butterflies using internet resources, visit a vocational HS to view various technologies.

Embedded Assessment: Generate a report on the topic(s) from the class activity.

Summative Assessment: Have students take something they know how to do, e.g., a personal hobby or a particular skill, and encapsulate that knowledge/expertise in some form where it can be accessed by others.

Theme: Constancy and Change

Process: Manipulating Information

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By the end of 8th grade all students will know that --

Science and technology are essential to one another for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.

Suggested Activity:

Visit a local technology or science-intensive company or the URI Bay Campus. Document all the ways in which people within the company utilize science and technology in their everyday jobs.

Embedded Assessment: In conjunction with a visit to the URI Bay Campus, discuss how undersea exploration has changed since the invention of sonar, underwater photography, and deep sea exploration vessels, e.g., Alvin. What are the advantages and disadvantages of these changes?

Summative Assessment: The student will explain how space exploration has evolved, integrating many different technologies and career fields in their explanation.

Theme: Systems

Process: Manipulating Information

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By the end of 12th grade all students will know that --

Technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances.

Suggested Activity:

Have students compare the abacus, adding machine, slide ruler, calculator, and computer and how this evolution changed scientific research and technological progress. How will the use of internet change scientific research and technological progress?

Embedded Assessment: Given an actual or paper model slide rule and a hand-held calculator, the student will explain why slide rules are no longer commonly used by scientists.

Summative Assessment: Discuss the changes in music recording in the 20th century.

Theme: Constancy and Change

Process: Developing Explanatory Frameworks

Visit the Computer Museum in Boston (tel. 617-426-2800, ext. 334 to make reservations, or 1-800-370-2447 for general information) to learn about the history of computers and walk through the inside of a computer!

By the end of 12th grade all students will know that --

- Mathematics, creativity, logic, and originality are all needed to improve technology.

Suggested Activity:

Design and build a model bridge using pasta, tape and string (see the vignette on the next page). Or, given a protractor, string, and tape measure, determine the height of a tall street light.

Embedded Assessment: Submit a drawing and written report explaining why your design is an improvement.

Summative Assessment: Create a design and construction activity for other students to use that does not involve a bridge.

Theme: Constancy and Change

Process: Proficiency in Making Products

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From Mr. Rapose's Class
Pilgrim High School
Warwick, Rhode Island
High School Activity

The Pasta Bridge

In this activity students use information and equations they have been studying in a physical science or physics class to construct a bridge using spaghetti. The materials required for the activity are a half-pound of #3 spaghetti per student, string, glue, masking tape, an eye bolt and block, and a 20 kilogram mass set.

The students are given the task of constructing a spaghetti bridge that will hold 40 times its own mass. The maximum mass allowed for the bridge is 500 grams or half a pound.

The Rules:

1. The bridge can weigh no more than 500 grams.
2. Students may work alone or in pairs.
3. The bridge must have a span (length) of 25 cm.
4. The bridge width must be at least 5 cm.
5. The bridge must have a roadbed of 20 cm. width and a 4x4 cm. opening in the middle.
6. The bridge will have no height limits, but a 2x2x5 weighing block must be able to fit in the center span.
7. Glue, masking tape or string may be used in any combination to hold the bridge together, but the completed bridge cannot exceed the set weight limit.

First, a blueprint of the bridge that they are going to build must be produced. Next they must construct a working prototype that can hold at least ten times it's mass. Changes and readjustments can be made here as needed before the final bridge is produced. Finally the bridges are massed and the block and eye bolt are placed in the center of the road bed where masses are added until the bridge supports 40 times its mass (or collapses). Grades are determined on aesthetics and the mass the bridge is able to support.

This bridge project is a great deal of fun for students. It builds excitement and helps to spark interest in a subject that many students fear. The project also requires students to apply knowledge they have learned about force and gravity. Of course, a pasta lunch is recommended to culminate the activity.

THE NATURE OF TECHNOLOGY - Technology and Science
Grade 9-12 (Benchmark 3 of 3)

By the end of 12th grade all students will know that --

- Technology usually affects society in different ways than basic science because it solves practical problems and tries to serve human needs (and may create new problems and needs). In contrast, basic science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like.

Suggested Activity:

A gel electrophoresis test may be performed on a given DNA sample to ascertain its identity. Students describe the sequence of steps involved in the process, brainstorm range of applications for this technology, and identify applications presently in use.

Embedded Assessment:	Identify which two DNA samples (actual or photographs) are the same.
Summative Assessment:	Discuss the role of science and technology in a criminal investigation.
Theme:	Constancy and Change
Process:	Proficiency in Making Products

Dr. Robert Krasner at Providence College has run biotechnology workshops for science teachers during the summer months for the past several years. Teachers who complete these workshops may borrow the equipment to conduct gel electrophoresis testing in their classroom. Contact Dr. Krasner directly at 865-2239 for further information on the workshops. Unfortunately, due to the very high demand he cannot loan equipment to teachers who have not completed the course.

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THE NATURE OF TECHNOLOGY - Design and Systems
Grade K-2 (Benchmark 1 of 2)

By the end of 2nd grade all students will know that --

People can use objects and ways of doing things to solve problems.

Suggested Activity:

Divide students into groups and give each group an 8" square pan of water and same materials (e.g., sponge, Legos, tinkertoys, rubber bands, paper). Make a Lego person. How many different ways can your Lego person cross the water? Be prepared to demonstrate using the materials you have. This would be a fun activity for including senior citizens as participants, recorders and spectators.

Embedded Assessment:	Selected students discuss how use of a particular object helped in the achievement of their objective.
Summative Assessment:	Students present one problem of personal importance and describe a combination of various tools (objects as well as ideas) that they can use to solve the problem.
Theme:	Systems
Process:	Generating Novel Ideas

By the end of 5th grade all students will know that --

- There is no perfect design. Designs that are best in one respect (safety or ease of use, for example) may be inferior in other ways (cost or appearance). Usually some features must be sacrificed to get others. How such trade-offs are perceived depends upon which features are emphasized and which are down-played.

Suggested Activity:

Bring in a deck of cards and have the students build card houses, using many different designs. For each design have them create a diagram of its key features and analyze its strengths and weaknesses.

Embedded Assessment:	Discuss what is most important to look for when buying a particular toy or a particular game. What might you do if it is good in some ways and bad in others?
Summative Assessment:	Design a rating system to be used for evaluating childrens' toys and games.
Theme:	Systems
Process:	

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By the end of 5th grade all students will know that --

Even a good design may fail. Sometimes steps can be taken ahead of time to reduce the likelihood of failure, but it cannot be entirely eliminated.

Suggested Activities:

Have students bring in a broken toy and explain how it broke. Brainstorm ways the design might be improved and inherent limitations in design improvement. Build and test working models which exhibit some of these improvements and assess their viability and worth. Have students design and build a humane mouse trap using Legos.

Embedded Assessment:	Have each student prepare and present a design solution to at least one problem with the broken toy.
Summative Assessment:	Repeat embedded assessment with something other than a toy, such as a broken appliance.
Theme:	Systems
Process:	Ensuring Desired Quality

THE NATURE OF TECHNOLOGY - Design and Systems
Grade 3-5 (Benchmark 3 of 3)

By the end of 5th grade all students will know that --

- **The solution to one problem may create other problems.**

Suggested Activity:

Ask students to suggest solutions to a local problem such as heavy traffic on a road or too many passengers on the school bus. Environmental problems or issues would be good sources. Assign each group one of the solutions to further explore. What is good and bad about this particular solution? What new problems will likely arise?

Embedded Assessment:	Have each student identify and defend one proposed solution.
Summative Assessment:	Repeat the activity with a different problem and look for evidence of learning transfer.
Theme:	Systems
Process:	Identifying intended and unintended consequences of an action.

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By the end of 8th grade all students will know that --

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

Suggested Activity:

Students will design and build a bridge using 50 straws and 2 meters of tape. Have the bridge span two chairs and see whose bridge can span the greatest distance without touching the floor. Invite a city or town official to visit the class and describe a recent construction project.

Embedded Assessment:	Students will construct and 'test' (destroy) their bridge.
Summative Assessment:	Students will critique their design and suggest ways to improve it. They will also discuss limitations to their improvements.
Theme:	Models
Process:	Proficiency in Making Products

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THE NATURE OF TECHNOLOGY - Design and Systems
Grade 6-8 (Benchmark 4 of 4)

By the end of 8th grade all students will know that --

- Systems fail because they have faulty or poorly matched parts, are used in ways that exceed what was intended by the design, or were poorly designed to begin with. The most common ways to prevent failure are pretesting parts and procedures, overdesign, and redundancy.

Suggested Activities:

Have students redesign the bridge they built from straws (previous activity) to improve performance. Allow sufficient time and provide enough materials for students to adopt a 'systems approach' to bridge improvement. Have students design a container with strings, sticks, Styrofoam and an egg carton that can keep an egg intact when it is dropped from a high elevation.

Embedded Assessment:	Discuss why some systems approaches worked well and others did not.
Summative Assessment:	Select a relatively small system, such as a classroom or a home, and catalogue faulty or poorly matched components and examples of built-in redundancy.
Theme:	Systems
Process:	Proficiency in Reaching Decisions

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By the end of 12th grade all students will know that --

In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design.

Suggested Activity:

Have students contact their local Chamber of Commerce to locate a local company or independent producer. Invite a representative to address the class about the development and marketing of their product. Then examine the yearbook production process, identify relevant constraints, and see if the process could be made more efficient and/or effective.

Embedded Assessment:	Present empirical evidence for one aspect of the yearbook process that is a candidate for improvement and identify two or more possibilities for change.
Summative Assessment:	Analyze the school bus scheduling or course scheduling process, identifying constraints and possible improvements.
Theme:	Systems
Process:	Proficiency in Making Products

THE NATURE OF TECHNOLOGY - Design and Systems
Grade 9-12 (Benchmark 2 of 6)

By the end of 12th grade all students will know that --

The value of any given technology may be different for different groups of people and at different points in time.

Suggested Activity:

Undertake a cross-curricular study between science and social studies classes on the role of technology during the Industrial Revolution in New England and the demise of these factory sites. (Lowell, MA and its Tsongas Industrial History Museum is an ideal site for such an exploration or one of the many 'living' historical villages in New England.)

Embedded Assessment:	Students will list the immediate and broad impacts of the invention of the steam engine.
Summative Assessment:	Create a videotape describing key insights the class has gleaned from their investigation using real-life examples.
Theme:	Continuity and Change
Process:	Proficiency in Informed Action

Visit Slater Mill in Pawtucket (tel. 725-8638) and continue up the Blackstone River. Dr. Patrick Malone (Urban Studies) and Dr. Susan Smulyan (American Civilization) at Brown University have written about the river and its impact on society.

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THE NATURE OF TECHNOLOGY - Design and Systems
Grade 9-12 (Benchmark 3 of 6)

By the end of 12th grade all students will know that --

Complex systems have layers of controls. Some controls operate particular parts of the system and some control other controls. Even 'fully' automatic systems require human control at some point.

Suggested Activity:

Students will examine the central heating system or trash collection system of their school (with the approval and involvement of appropriate staff/administration).

Embedded Assessment:	Students will construct a flow chart of the heating system or trash collection system of their school.
Summative Assessment:	Students will design other possible alternative heating or trash collection systems for their school, based upon information obtained from a variety of human and non-human resources.
Theme:	Systems
Process:	Problem Solving Proficiency

Contact the RI Solid Waste Management Corp. (277-2797) or the OSCAR program (277-3434) for extended activities and curriculum resources dealing with solid waste management.

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By the end of 12th grade all students will know that --

Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. The public perception of risk may depend, however, on psychological factors as well as scientific ones.

Suggested Activity:

Identify a local controversial issue such as high voltage electricity transmission (EMF), solid waste disposal or land development. Conduct a risk/benefit analysis for this issue. Use Sim City computer simulation for this activity.

Embedded Assessment:	Submitted risk/benefit analysis.
Summative Assessment:	Give students a scenario of a large company moving into their community. The company produces a product of the teacher's choosing. Students will develop a risk/benefit analysis from the perspective of the company as well as from the perspective of their community.
Theme:	Systems
Process:	Proficiency in Informed Action

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By the end of 12th grade all students will know that --

The more parts and connections a system has, the more ways it can go wrong. Complex systems usually have components to detect, back up, bypass, or compensate for minor failures.

Suggested Activity:

A discussion of movies such as Apollo 13 and Jurassic Park, or real events such as the Challenger disaster, nuclear power plants (Chernobyl, Three Mile Island) could introduce the importance of back-ups, failure, and human error. Students will design and construct a working model of a machine designed to perform a simple task (i.e., picking up a pencil) through a complex system of mechanisms. Students will evaluate the energy efficiency and reliability of this device.

Embedded Assessment:	Plan and analysis of effectiveness and reliability of machines constructed.
Summative Assessment:	Modification of constructed machine to perform a given additional task (i.e., moving pencil to new location).
Theme:	Systems
Process:	Proficiency in Making Products

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By the end of 12th grade all students will know that --

- To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable.

Suggested Activity:

Have students use one or more computer simulations and compare their worth in simulating real-world situations.

Embedded Assessment:	A sufficiently detailed analysis of a real-world analysis as the basis for evaluating the reasonableness of the selected computer simulation.
Summative Assessment:	Study a simulation that has been widely used as a basis for a real-world discussion and document its effects over time (examples include Star Wars, Nuclear Winter, war games, global change models, sea flood spreading and plate tectonics, modeling of epidemics).
Theme:	Models

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From Ms. Ose's class
Andrews School
Bristol/Warren Regional Schools
Fourth Grade Activity

The Great Solar System Rescue:
A Cooperative Learning Videodisk Activity

What started as a special enrichment lesson for one class turned into a month long learning adventure for all 4th grade students at the Andrews School in Bristol. By watching a videodisk on the solar system, students found clues about various planets in order to locate a lost probe, while spending the least amount of money. Ultimately, approximately 200 children from every learning population experienced a simulated space exploration using this program.

Students were broken into teams of four (a geologist, an astronomer, a meteorologist and a historian). While watching the videodisk for 'lost probe transmission information', students took notes relating to their specialty. Ms. Ose would voice over the key facts at each step of the transmission and emphasize which specialists might want to make note of them.

Students compared notes and generated questions for a culminating scientific space forum, where they presented their findings in their specialty area.

During the month this program was presented, many 4th graders stopped Ms. Ose in the hall to see when the next 'installment' was coming. Several students brought special posters or other information to class to stimulate the discussion. The diversity of kids who participated contributed to making the experience more enriching for all. Limited English speaking students were encouraged by their English speaking peers to illustrate the shapes of the planet.

Learning gains were measured by teacher observation, and with the use of debriefing questions. Students gained insight into what various scientists do and what they look for when they are analyzing data. They experienced what it means to be part of a team, to count on someone else's information and to experience the consequences of making correct and incorrect choices. This cooperative learning activity allowed students to understand the solar system through a multimedia learning program where each child has a special role to play and can contribute to the solution of a common problem.

Information on *The Great Solar System Rescue* Videodisc is available from Tom Snyder Productions (tel. 1-800-342-0236).

THE NATURE OF TECHNOLOGY - Issues in Technology
Grade K-2 (Benchmark 1 of 2)

By the end of 2nd grade all students will know that --

- People, alone or in groups, are always inventing new ways to solve problems and get work done. The tools and ways of doing things that people have invented affect all aspects of life.

Suggested Activity:

Discuss how TV has affected the lives of people, especially children. Compare what life was like when student's parents were their age and what life is like today. List machines that have become common place in the 30 year span.

Embedded Assessment:	See how many aspects of life students recognize as being affected by TV. Construct a comparative chart of life thirty years ago and the present.
Summative Assessment:	Pick a tool in your house. Describe how it affects your life in the form of a visual wheel of effects. Pick a device that existed in their parent's generation and today. List how it has changed and how the change has affected life.
Theme:	Systems
Process:	Identifying Relationships

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By the end of 2nd grade all students will know that –

When a group of people wants to build something or try something new, they should try to figure out ahead of time how it might affect other people.

Suggested Activity:

Groups of students should be assigned the task of creating new recreation models for the school, including sandbox, swingset, pool, basketball court. Each group should construct a diorama of their proposed design. With the design there should be a list of how this new structure will affect other people. Who else should be consulted before the construction on the playground addition is started? Brainstorm. Project presentations should be delivered to a panel of 'experts' - principal, PTA, school committee members.

Embedded Assessment:	Students can describe the steps they used in their design process and their evolving thoughts about the possible impacts of their design on other people.
Summative Assessment:	Focus on a local community or school project and have students identify its possible impact on various constituencies.
Theme:	Systems
Process:	Recognizing and Labeling Problems

By the end of 5th grade all students will know that --

- Technology has been part of life on the earth since the advent of the human species. Like language, ritual, commerce, and the arts, technology is an intrinsic part of human culture, and it both shapes society and is shaped by it. The technology available to people greatly influences what their lives are like.

Suggested Activities:

Have students draw pictures showing different uses and types of technology from different time periods from prehistoric to modern times. Different groups can be assigned different periods. Have students interview a grandparent or other older person and discuss how household chores were different when they were young. Have students discuss the effect of the automobile or mass transit systems on how people live.

Embedded Assessment:	Students explain how technology influenced the lives of these people in various time periods.
Summative Assessment:	Students draw pictures or make models to speculate how technology will affect their future lives.
Theme:	Constancy and Change
Process:	Developing Generalizations

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By the end of 5th grade all students will know that --

Any invention is likely to lead to other inventions. Once an invention exists, people are likely to think up ways of using it that were never imagined at first.

Suggested Activities:

Given pictures of a series of inventions, students arrange them in probable historical order and explain their choices. Give students a common object and have them suggest other uses for the object. Explore inventions which paved the way for video games.

Embedded Assessment:	A list of uses for an object which goes well beyond its present uses.
Summative Assessment:	Given a multi-purpose tool (i.e. a Swiss Army knife) have students list possible uses.
Theme:	Constancy and Change
Process:	Identifying Patterns and Relationships

The book Material World: A Global Family Portrait is a compendium of photographs of families from around the world. In each photograph, the family is standing outside of their home with all their possessions. The book is available through the public library system in Rhode Island. Use some of its pages to have students discuss the wide range of existing inventions, their possible uses, and the differences and similarities of artifacts across cultures.

By the end of 5th grade all students will know that --

- Transportation, communications, nutrition, sanitation, health care, entertainment, and other technologies give large numbers of people today the goods and services that once were luxuries enjoyed only by the wealthy. These benefits are not equally available to everyone.

Suggested Activity:

Interview adults to find out what items in their homes were considered luxuries in the past. Interview recent immigrants to find out items which are available in average homes in their native countries. Ask what items are available in their native country, but not in the United States.

Embedded Assessment:	Make a chart to summarize results of the survey.
Summative Assessment:	Write a report about one item the student uses at home. The student should estimate and justify their view about how long ago this item was considered a luxury in the United States and speculate on where in the world it might still be a luxury.
Theme:	Constancy and Change
Process:	Interpreting and Evaluating Data, Interviewing

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By the end of 5th grade all students will know that --

Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. Other factors, such as cost, safety, appearance, environmental impact, and what will happen if the solution fails also must be considered.

Suggested Activity:

Tackle a real environmental problem in the school, such as capturing the water runoff from a leaky faucet or pipe in the building, a tree, or some other object in the school yard. Find a way to reuse the water.

Embedded Assessment:	Develop a concise statement of the problem and a proposed set of actions to address it.
Summative Assessment:	Identify some environmental impacts likely to be associated with a local community problem.
Theme:	Models
Process:	Building, Testing, Refining Prototypes

By the end of 5th grade all students will know that --

- **Because of their ability to invent tools and processes, people have an enormous effect on the lives of other living things.**

Suggested Activity:

Create a photo collection of various tools and processes (e.g., clearcutting, dredging, landfills, construction and demolition) in use in your local area. For each visual, brainstorm possible effects on other living things.

Embedded Assessment:	Do one sample item in class before assigning the task.
Summative Assessment:	Pretend you are a tree. Describe the good and bad things people have done to you and your family.
Theme:	Systems
Process:	Communicating Information/Ideas

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THE NATURE OF TECHNOLOGY - **Issues in Technology**
Grade 6-8 (Benchmark 2 of 7)

By the end of 8th grade all students will know that --

Technology cannot always provide successful solutions for problems or fulfill every human need.

Suggested Activities:

Students will view video footage concerning heart replacement with pumps and interview local medical personnel about the limitations of such technologies. Visit a hospital or nursing home to view how technology is used to fight disease and the effects of aging.

Embedded Assessment:	Class discussion will highlight the problems and continuing challenges with current heart pump technology.
Summative Assessment:	Students will define a scenario that describes a genuine breakthrough within a specific arena of technology.
Theme:	Constancy and Change
Process:	Proficiency in Reaching Decisions

By the end of 8th grade all students will know that --

- Throughout history, people have carried out impressive technological feats, some of which would be hard to duplicate today even with modern tools. The purposes served by these achievements have sometimes been practical, sometimes ceremonial.

Suggested Activity:

Have student teams design and complete plans to build a scale model pyramid using rolled newspapers and masking tape similar to the ancient pyramids of Egypt or Meso- America.

Embedded Assessment:	Discuss the problems the ancient Egyptians, Mayans or Aztecs encountered and compare their solutions to yours.
Summative Assessment:	Identify another impressive feat from prior centuries and describe its purpose(s) and what would be needed today to accomplish the same feat, e.g., medieval cathedrals, seaworthy vessels, distance communications devices.
Theme:	Constancy and Change
Process:	Proficiency in Informed Action

Check out the series of books by David Macauley available in the public library, including Cathedral. Also look for Thor Heyerdahl, Kon-Tiki and The Ra Expedition.

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By the end of 8th grade all students will know that --

Technology has strongly influenced the course of history and continues to do so. It is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications that have radically changed how people live.

Suggested Activity:

Create a visual history of the construction of Route 95 and its impact on Rhode Island's people, communities, environment and commerce.

Embedded Assessment:	Describe the benefits and problems that Route 95 has created for the citizens of Rhode Island.
Summative Assessment:	Describe in an essay how life would be different in the 1990's in RI without Route 95.
Theme:	Systems
Process:	Proficiency in Informed Action

THE NATURE OF TECHNOLOGY - Issues in Technology
Grade 9-12 (Benchmark 1 of 5)

By the end of 12th grade all students will know that --

Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.

Suggested Activity:

Have students research a product that is available in other countries but not in the U.S. Students will give a short presentation relating to how social, economic and/or political conditions affect the product's availability in the U.S.

Embedded Assessment:	An outline of their research before going to an oral/written presentation.
Summative Assessment:	Producing a paper, video, advertisement, or presentation about the product, why it is not available in the USA, and taking a position for or against its introduction.
Theme:	Constancy and Change
Process:	Proficiency in Reaching Decisions About Issues

Have a UN Day. Students will represent different countries with different assets. Let them barter and trade for what they need, and deal with environmental issues. Make them do some research on their country prior to this simulation. Michael Specht, a science teacher at Classical HS in Providence, has played the 'World Game' with his students and has offered to help others get started.

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THE NATURE OF TECHNOLOGY - Issues in Technology
Grade 9-12 (Benchmark 2 of 5)

By the end of 12th grade all students will know that –

Technological knowledge is not always as freely shared as scientific knowledge unrelated to technology. Some scientists and engineers are comfortable working in situations in which some secrecy is required, but others prefer not to do so. It is generally regarded as a matter of individual choice and values, not one of professional ethics.

Suggested Activity:

Classroom visit by a police/FBI forensic specialist, and a discussion of how secrecy plays a role in his/her occupation. OR Classroom visit by a patent attorney who deals with secrecy issues in technology. OR Students may give an oral presentation on some technology which is presently proprietary; and thus, there may be limits to the information they can research (e.g., Polaroid's instant photography). A local company competing in a world market would be a useful resource.

Embedded Assessment:	The student will explain the concept of proprietary secrecy and what the full implications of it are.
Summative Assessment:	Students will be exposed to a new fictitious technology which is proprietary and asked from a variety of perspectives to address the question, "Is secrecy necessary?". Multiple sides of the issue will be discussed by the students.
Theme:	Systems
Process:	Proficiency in Informed Action

By the end of 12th grade all students will know that --

In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits. What alternative ways are there to achieve the same ends, and how do the alternatives compare to the plan being put forward? Who benefits and who suffers? What are the financial and social costs, do they change over time, and who bears them? What are the risks associated with using (or not using) the new technology, how serious are they, and who is in jeopardy? What human, material, and energy resources will be needed to build, install, operate, maintain, and replace the new technology, and where will they come from? How will the new technology and its waste products be disposed of and at what costs?

Suggested Activity:

Classroom debate on the issue of some new technology (e.g., nuclear or hydroelectric power plant, waste treatment plant, etc.) entering the school's community. Who wins, who loses? As an alternative, find out how much paper the school uses and determine it's real cost and develop a range of well-reasoned options to reduce identified negative impacts of the existing system.

Embedded Assessment:	Students will present a plan for technology assessment for a given technology.
Summative Assessment:	A persuasive essay which takes a position on a current issue involving science and technology within society and uses facts, opinions of self and others, and identified assumptions to make its case.
Theme:	Systems
Process:	

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By the end of 12th grade all students will know that --

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

Suggested Activity:

Relate to students the story of the Suiki Crab during the 17th century. The Japanese emperor and his loyal troops were fleeing from enemy troops by sea, when a storm sank his ship. Soon after the sinking, Japanese fishermen caught crabs that appeared to have a human face on their back. The fishermen felt that the crabs with the human-like faces contained the souls of the Emperor's loyal troops. Therefore, the fishermen returned these crabs to the bay, thus selectively breeding this population of crabs with the face mutation.

Embedded Assessment:	Students will read the story and relate it to other local examples of humans' role in changing the ecosystem.
Summative Assessment:	Students should be able to apply this story to other situations such as changes in the oyster population in Narragansett Bay, changes in moth populations due to air pollution (e.g., peppered moth, *Biston betularia*) fish populations changing, and extinction of plants and animals.
Process:	Proficiency in Reaching Decisions
Theme:	Constancy and Change

A/V materials or readings on genetic engineering is also suggested, in preparation for a classroom visit by an horticulturist, animal breeder, or microbiologist who utilizes selective breeding in their occupation. SAVE THE BAY (272-3540) and other environmental organizations can be very helpful with resources in this area.

By the end of 12th grade all students will know that --

- Human inventiveness has brought new risks as well as improvements to human existence.

Suggested Activities:

Field trip to hospital to explore how risks associated with handling patients have fostered new improvements in hospital procedures (e.g., radiation, hematology, child birth, outpatient ambulatory care). Explore EMF, low level radioactive waste, airline safety. Visit an EPA lab while studying the effects of toxins on living organisms.

Embedded Assessment:	Identify the areas of risk in the hospital environment that have spurred development of new technologies and new risks that have emerged.
Summative Assessment:	Perform a simple risk benefit analysis for a selected technology.
Process:	Problem Solving Proficiency
Theme:	Constancy and Change

Call the EPA Environmental Research Lab in Narragansett at 782-3000 for help in this area.

3b

The Physical Setting

- ✓ The Universe
- ✓ The Earth
- ✓ Processes That Shape The Earth
- ✓ Structure of Matter
- ✓ Energy Transformations
- ✓ Motion
- ✓ Forces of Nature

By the end of the 2nd grade all students will know that --

There are more stars in the sky than anyone can easily count, but they are not scattered evenly.

Suggested Activity:

Show students a map of the sky. Ask students to try to count the stars. Tell them this picture is of only a part of the sky. Ask if they can see any pictures or patterns in the stars and how some stars are alike (size). Have the students make an actual observation of stars in the sky. Probe - how many stars are in the sky? What do your diagrams of the stars and their locations mean to you?

Embedded Assessment:	Given a picture of the Big Dipper, students can discuss what it looks like and locate the constellation on a simple map among other unlabeled constellations.
Summative Assessment:	Given pictures of constellations students will recognize that stars vary in size and are spaced closer together or farther apart.
Theme:	Models
Process:	Experimental Proficiency, esp. formulate hypothesis, observing

NASA Space Grant Program Center located at Brown University (863-2889) has celestial maps and other resources available for teachers.

By the end of the 2nd grade all students will know that --

The sun can be seen only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. The sun, moon, and stars all appear to move slowly across the sky.

Suggested Activity:

Build a model to show the rotation of the sun, moon and the earth. Use your shadow as a guide. Caution children NOT to look directly at the sun.

Embedded Assessment:	The students can describe the movement of the sun across the sky.
Summative Assessment:	Ask students to predict where the sun will be seen in the next two hours. Students can also be asked to repeat this activity with the moon or with a particular star.
Theme:	Models, Systems
Process:	Experimental Proficiency, esp. diagramming, observing, following a sequence of activities, psychomotor proficiency

By the end of the 2nd grade all students will know that --

The moon looks a little different every day, but looks the same again about every four weeks.

Suggested Activities:

Make a monthly calendar (30 or 31 days)on a bulletin board or large classroom chart. Each day have a student add the shape of the moon they have observed and sketched the previous night. Record the number of shapes for the moon and the days involved. Take students to local planetarium. Look at videos and books dealing with the moon. Ask students how they think the moon affects them.

Embedded Assessment:	Students record moon's appearance on Classroom Moon Calendar.
Summative Assessment:	Student predict phases of the moon for future/prior months.
Theme:	Models, Constancy & Change
Process:	Manipulating Information, esp. inferring, identifying patterns and relationships

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By the end of the 5th grade all students will know that --

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

Suggested Activity:

Students choose a constellation and research the type of stars found in their constellation. The constellations then are modeled and a mini-planetarium can be presented (paper towel or toilet tissue roll with constellation punched on construction paper over the end and flashlight).

Students who are able to observe stars at night can keep a constellation diary and observe their chosen constellation every night. They should look at the constellation at different times and plot where it is found. This activity, if repeated in another season, leads to many additional insights for the students.

Embedded Assessment:	Given a card with pictures they can identify five constellations.
Summative Assessment:	When asked if their constellation will be visible in another season, they will indicate that it may not be (depending on the movement of the constellation).
Theme:	Models
Process:	Language Proficiency, Psychomotor Proficiency

Visit a planetarium! Roger Williams Park Planetarium (785-9457), Middletown Planetarium at the Middle School, Worcester Museum of Science. Or use a portable planetarium, like Star Lab.

By the end of the 5th grade all students will know that --

Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.

Suggested Activity:

Take a field trip to an observatory. Work with students in advance to set up interview/questions. Allow students to use binoculars or borrow a telescope and see how they increase visibility. Compare pictures taken with various telescopes with different magnifications.

Embedded Assessment:	Students list things they can see better with a telescope.
Summative Assessment:	Students compare a view of the sky with the naked eye, binoculars, a small telescope, and a telescope in an observatory.
Theme:	Continuity and Change
Process:	Language Proficiency

Visit the observatory at Brown University; it is open to the public every Wednesday. Also try the Seagrave Observatory on Peeptoad Road in Scituate, the Ninigret Observatory in Charlestown, and the CCRI Warwick Campus.

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By the end of the 5th grade all students will know that --

Planets change their positions against the background of stars.

Suggested Activity:

Observe a planet (Mars or Venus are good candidates) outside at your home for a specific period of time. Draw a diagram of what you see, recording its position in relation to nearby stars. Compare your findings with those of your classmates. Discuss point of reference so changes can be plotted.

Embedded Assessment:	Chart of planetary locations at 6pm, 7pm, and 8pm.
Summative Assessment:	Predict the position of the planet at 9pm and 10 pm.
Theme:	Models
Process:	Psychomotor Proficiency, esp. recording data, creating diagrams

By the end of 5th grade, all students will know that --

- The earth is one of several planets that orbit the sun, and the moon orbits around the earth.

Suggested Activity:

Groups of students construct a scale model of the solar system inside or outside the school. Alternatively, use your geographic location as the basis (center) of your scale model and determine where the other planets would be. Each student researches a particular planet.

Embedded Assessment:	Students compare movement of different planets around the sun.
Summative Assessment:	Students make mobiles of the solar system.
Theme:	Models, Systems
Process:	Psychomotor Proficiency, esp. manipulating materials

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By the end of the 5th grade all students will know that --

Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. The sun is a star.

Suggested Activity:

Give three students identical flashlights or some spheres of the same size. Have them stand at different distances. Students observe the difference in apparent size compared to distance. Get light bulbs of different wattage and different colors to simulate how how stars vary.

Embedded Assessment:	Students explain how apparent size and actual distance are related.
Summative Assessment:	Have students in teams decide what the sun would look like from Pluto.
Theme:	Models
Process:	Psychomotor Proficiency

By the end of the 8th grade all students will know that --

The sun is a medium-sized star located near the edge of a disk-shaped galaxy (Milky Way) of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot.

Suggested Activity:

Visit planetarium, contact NASA for computer program, pictures, etc. Help students locate the Milky Way and prominent galaxies in the night sky.

Embedded Assessment	Look at photographs, identify the differences between a galaxy and a star.
Summative Assessment:	Using a diagram of our own galaxy and the approximate position of our solar system, explain the phenomenon known as the Milky Way.
Theme:	Systems
Process:	Developing Explanatory Frameworks

NASA Space Grant Program Center located at Brown University (863-2889) has celestial maps and other resources available for teachers.

By the end of the 8th grade all students will know that --

The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past.

Suggested Activity:

Use a visual and auditory device, such as banging cymbals or popping a balloon, so that the student can see the device go off before they hear it. This should be done in a large area - long corridor, field, etc. Use a stopwatch to time it. Make reference to thunder and lightning. Which comes first? Explain.

Pass out solar system chart with the astronomical distances from the sun. Have students calculate how far light travels in a year. With the use of a calculator, figure out how long it will take the light from the sun to reach the various planets.

Embedded Assessment	Have students explain why we see some activities before we hear them.
Summative Assessment:	Have students solve distance/time problems based upon the information given in charts you have earlier distributed.
Theme:	Scale
Process:	Mathematical Proficiency and Manipulating Information

Check out Odyssey, an astronomy magazine for kids, Cobblestone Publishing Inc., 7 School St., Peterborough, NH 03458, 603-924-7209, fax 603-924-7380.

By the end of the 8th grade all students will know that --

Large numbers of chunks of rock orbit the sun. Some of those that the earth meets in its yearly orbit around the sun glow and disintegrate from friction as they plunge through the atmosphere--and sometimes impact the ground. Other chunks of rocks mixed with ice have long, off-center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen material from their surfaces and pushes it into a long, illuminated tail.

Suggested Activity:

With appropriate resource materials, find information about objects from outer space that have reached the earth's surface. List the damage caused by these objects and what they have taught us about extraterrestrial geology. Place liquid plaster of Paris in a plate or tray coated with petroleum jelly, drop rocks of different sizes from different heights to observe craters formed. Visit museum and observe fragments of meteors.

Embedded Assessment:	Students will develop a time line presenting their findings.
Summative Assessment:	Have students research a speculative theory linking dinosaur extinction to asteroid impact (Alvarez thesis). Have the teacher prepare some models of impact craters and present them to the students for hypotheses about the height, size and direction of the meteorite impact.
Theme:	Models
Process:	Developing Explanatory Frameworks

By the end of the 12th grade all students will know that --

The stars differ from each other in size, temperature, and age, but they are made up of the same elements that are found on the earth and behave according to the same physical principles. Unlike the sun, most stars are in systems of two or more stars orbiting around one another (binary stars).

Suggested Activity:

Flame test and use of spectroscope to illustrate elements contained in stars and why star colors vary.

Embedded Assessment	Students will create a chart of the results of the flame test.
Summative Assessment:	Given a star's color and suitable reference materials, the student will be able to identify the likely predominant constituent elements.
Theme:	Systems
Process:	Manipulating Information

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By the end of the 12th grade all students will know that --

On the basis of scientific evidence, the universe is estimated to be over ten billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass (the 'Big Bang Theory'). Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. Eventually, some stars exploded, producing clouds of heavy elements from which other stars and planets could later condense. The process of star formation and destruction continues.

Suggested Activity:

View the movie "The Universe". Demo black balloon with painted stars or dots as balloon is blown up - the expanding balloon will demonstrate the expanding universe. Read and discuss a Brief History of Time by Stephen Hawkins.

Embedded Assessment	Students will be able to state the general outlines of the Big Bang Theory.
Summative Assessment:	Students will be able to summarize evidence for the Big Bang Theory and employ the history of astronomy to
explain	why it is likely not the final word on the subject.
Theme:	Models
Process:	Developing Explanatory Frameworks.

By the end of the 12th grade all students will know that --

Mathematical models and computer simulations are used in studying evidence from many sources in order to form a scientific account of the universe.

Suggested Activity:

Visit the Brown University NASA facility. Access computer simulations via the Internet. Brown University also has simulation programs available for loan.

Embedded Assessment:	Students will submit a report detailing their visit.
Summative Assessment:	Students will successfully use a computer program to predict the future motion and position of a celestial body.
Theme:	Constancy and Change
Process:	Psychomotor Proficiency

Contact the CIS Receptionist at the Graphics Lab of Brown University (863-7693) for information on borrowing computer simulation software.

By the end of the 2nd grade all students will know that --

- Some events in nature have a repeating pattern. The weather changes some from day to day, but things such as temperature and rain (or snow) tend to be high, low, or medium in the same months every year.

Suggested Activity:

Create season charts linking weather, clothing, recreation. Have students list the months, and in small groups apply the appropriate labels 'hot', 'warm', 'cool' or 'cold' next to each. Create a daily temperature chart. What types of seasonal changes do students see in hardware or other local store displays?

Embedded Assessment:	Using old catalogues match clothes to seasons. Ask if ALL the days in April are warm.
Summative Assessment:	Dress a tree by seasons (leaves, buds, blossoms, fruit, etc.)
Theme:	Constancy and Change
Process:	Manipulating Information, esp. developing generalizations

By the end of the 2nd grade all students will know that --

Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.

Suggested Activity:

Measure a specific quantity of water and transfer it to an unbreakable container. Mark the level before freezing, after freezing, and after melting.

Embedded Assessment:	Completion of a student designed chart and diagrams illustrating their predictions and the results obtained.
Summative Assessment:	Melt an ice cube and measure the water. Ask how much water there was before the ice cube was frozen.
Theme:	Constancy and Change
Process:	Experimental Proficiency, Mathematical Proficiency

By the end of the 2nd grade all students will know that --

- Water left in an open container disappears, but water in a closed container does not disappear.

Suggested Activity:

Place equal quantities of water in two clear containers. Mark level of water in each container. Cover one container tightly, place both containers in a warm sunny place for several days. Discuss the results.

Embedded Assessment:	Two wet sponges, two apples, etc.; one in plastic sandwich bag and one in the air. Students explain why there is a difference. Does water really disappear?
Summative Assessment:	Given a series of life situations students will relate them to the benchmark. Where does a mud puddle go? Why do clothes dry on a clothesline? Having no towel, how do yo dry off after swimming?
Theme:	Constancy & Change
Process:	Manipulating Information

Children are usually fascinated by the evaporation of liquids from fruits and vegetables. Pursue this principle with dried fruits: raisins, dried apricots or apples, etc. One or more parents may regularly dry fruit and share their experiences and expertise.

By the end of the 5th grade all students will know that --

Things on or near the earth are pulled toward it by the earth's gravity.

Suggested Activity:

Drop objects which differ greatly from one another. Discuss how objects vary in size, weight, color, shape. Focus on the fact that although the rates may vary, all objects come down.

Embedded Assessment:	Discuss what all the objects have in common. What could be pulling them down?
Summative Assessment:	What would happen if you dropped a ball in Australia? Dropped it while flying in an airplane?
Theme:	Continuity and Change
Process:	Manipulating Information, esp. developing generalizations

By the end of the 5th grade all students will know that --

Like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day.

Suggested Activities:

Put a pin in a ball to represent a person. Using a flashlight and the ball, have a child rotate the ball in front of a stationary light. Have the children experience what it feels like to view their surroundings when sitting on a slowly spinning stool.

Embedded Assessment:	What does the flashlight represent? When does the person see light? When is the person in darkness? Discuss the concept of a sun dial.
Summative Assessment:	What would a day be like if the earth did not rotate?
Theme:	Models
Process:	Psychomotor Proficiency, esp. manipulating materials

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By the end of the 5th grade all students will know that --

Air is a substance that surrounds us, takes up space, and whose movement we feel as wind.

Suggested Activities:

Blow up balloons and have students release the air on their skin. Take a paper or plastic bag and collect a bag of air. Pop it with a smack. Put a crumpled paper towel in the bottom of a glass, turn the glass upside down and place it in a bowl of water. Students can spin on a stool and use 'fins' (hold out pieces of paper) to illustrate air resistance. Weigh a sports ball inflated and uninflated.

Embedded Assessment	Students will write a story about how the air entered the bag or why the paper towel didn't get wet. Have students explain how a fan works.
Summative Assessment:	Have students relate their experiences from the balloons, the bags and the glass/paper towel to explain what they have inferred about air.
Theme:	Constancy and Change
Process:	Manipulating Information and Developing Explanatory Frameworks

Invite a meteorologist (or radio/television weather reporter) to visit the school. Have students collect local and national weather maps to observe the importance of air masses, their movement, and weather prediction. Have students predict weather daily and weekly and assess their accuracy.

By the end of the 8th grade all students will know that --

We live on a relatively small planet, the third from the sun in the only system of planets definitely known to exist (although other, similar systems may be discovered in the universe).

Suggested Activity:

Charge students to locate information on the relative sizes and positions of the planets. Have students make a scale drawing using a set size for the earth as the standard. Discuss the probability of other planetary systems. Discuss what it might be like to live on another planet.

Embedded Assessment	Evaluate scaled drawing according to the chart.
Summative Assessment:	Ask students to express in words the size of the earth in relationship to other planets.
Theme:	Scale
Process:	Manipulating Information, esp. identifying patterns and relationships

An astronomer at Penn State has recently reported observational evidence of another star with orbiting planets. Students can investigate this discovery and its acceptance/rejection by the astronomical community.

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By the end of the 8th grade all students will know that --

The earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from earth.

Suggested Activity:

Design a scale model to represent the relative size of the earth and the layers of water and air surrounding it. Have small groups create scale models representing selected planets and explain the difference between their particular planet and earth.

Embedded Assessment:	Have students list factors unique to the earth which support life.
Summative Assessment:	Place students in the year 2035 as professional astronomers who have just discovered an earth-like planet and related bodies in a nearby star system. Have them describe the system and its associated planets.
Theme:	Scale
Process:	Language Proficiency and Psychomotor Proficiency

By the end of the 8th grade all students will know that --

- Everything on or anywhere near the earth is pulled toward the earth's center by gravitational force.

Suggested Activity:

Have students answer the question -- if gravity were gradually decreasing on earth, what accommodations would need to be made at home, at school, in industry, in planning for the future? Collect findings, predictions and design a mural for the school to encourage ideas from peers and faculty.

Embedded Assessment:	Discuss the difference in a person's weight between the earth and the moon.
Summative Assessment:	How did NASA compensate for the decreased gravity on the moon?
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking concepts and principles

By the end of the 8th grade all students will know that --

Because the earth turns daily on an axis that is tilted relative to the plane of the earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the earth during the year. The difference in heating of the earth's surface produces the planet's seasons and weather patterns.

Suggested Activity:

Draw a small grid on the blackboard. Shine a flashlight on the grid while holding it perpendicular; and at 30, 45, and 90 degree angles. At each angle have a student draw the circle of light, using a different color for each angle. Using a diagram of the earth or a globe, show how the tilt of the earth affects the amount of light on a given area, contributing to seasons. Areas could be calculated. Access international weather information from the Internet.

Embedded Assessment	Have each student explain the activity and how it relates to the seasons.
Summative Assessment:	Given the statement that during summer we are farther from the sun, have students explain the warmth of the summer.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. creating and testing physical models

By the end of the 8th grade all students will know that --

The moon's orbit around the earth once in about 28 days changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth--the phases of the moon, but the same side of the moon always faces the earth.

Suggested Activity:

Have students make a 28 day diary (have students do this the month before). They are to look at the moon the same time every day and then record where it is located in the sky (a straw on a protractor stand can be used to measure the angle of inclination) and the shape it has. Design an activity to model that part of the moon facing the sun that would be illuminated - e.g., using ping pong ball 1/2 black and 1/2 unpainted and pass it around in circular motion around a lighted bulb.

Embedded Assessment	Check daily diary
Summative Assessment:	By using diagrams, have students show how the phases of the moon are created.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. creating and testing physical models

THE PHYSICAL SETTING - The Earth
Grade 9-12 (Benchmark 1 of 2)

By the end of the 12th grade all students will know that --

Life is adapted to conditions on the earth, including the force of gravity that enables the planet to retain an adequate atmosphere, and an intensity of radiation from the sun that allows water to cycle between liquid and vapor.

Suggested Activity:

Discuss the possibility of a water cycle existing on Mars.

Embedded Assessment	Recognize the components of the water cycle; evaporation, condensation, precipitation, etc.
Summative Assessment:	Students will describe the water cycle and its role in life on earth.
Theme:	Systems
Process:	Manipulating Information

NASA Space Grant Program Center located at Brown University (863-2889) has maps and other resources available for teachers

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By the end of the 12th grade all students will know that --

Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans, and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall—and such circulation, influenced by the rotation of the earth, produces winds and ocean currents.

Suggested Activity:

Investigate how El Niño affects weather - does it affect ocean currents or do ocean currents affect it? The Rossby Wave is a wave which originates in Southern Asia and travels across the Pacific. It seems to cycle with El Niño.

Embedded Assessment	Students collect and analyze recent weather data.
Summative Assessment:	Students present findings and conclusions as to whether the Rossby Wave and El Nino are connected.
Theme:	Systems
Process:	Manipulating Information

Check with the local cable company (Cable TV of East Providence 438-7953; Cox Cable 946-3830; Dimension Cable 828-2288; Full Channel TV 247-1253) for offerings on the Weather Channel, Discovery Channel, or other weather resources.

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade K-2 (Benchmark 1 of 3)

By the end of the 2nd grade all students will know that --

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

Suggested Activity:

Students start a collection of rocks. In observing the settling of sand and rocks in a bottle of water, students discern different sizes of particles and layers of rock and sediment. A trip to a gravel pit or rocky shore of RI would be a great collection spot.

Embedded Assessment	Students will draw what they see and identify the various sized particles.
Summative Assessment:	Given assorted rocks, students can sort them by size and shape.
Theme:	Models
Process:	Manipulating Information, esp. classifying

Try these local resources on Rhode Island geology:

Cain, J.A. 1986. Geology of Rhode Island. *Rocks and Minerals* 61(5): 257-263.
Quinn, A.W. 1976. *Rhode Island Geology for the Non-Geologist.* Providence, RI: Rhode Island Department of Natural Resources.

By the end of the 8th grade all students will know that --

Sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by precipitation of dissolved minerals to form solid rock again.

Suggested Activity:

In a plastic bottle, dissolve one stick of chalk in 8 oz. of water. Add 1-2 cm of sand (2-3 different kinds) in layers until the bottle is filled. Use sand collected from the shores of RI. A small shell can be added between layers to represent fossils. Set aside to dry for several months without the cap.

Embedded Assessment:	Students will draw and label the components of their 'rock'.
Summative Assessment:	Ask students to find a rock similar to their created rock.
Process:	Developing Explanatory Frameworks, esp. creating physical models
Theme:	Models

By the end of the 8th grade all students will know that –

Sedimentary rock buried deep enough may be reformed by pressure and heat, perhaps melting and recrystallizing into different kinds of rock (metamorphism). These re-formed rock layers may be forced up again to become land surface and even mountains. Subsequently, this new rock too will erode. Rock bears evidence of the minerals, temperatures, and forces that created it.

Suggested Activity:

Students will go into the field and find metamorphic rock which is all over Rhode Island.

Embedded Assessment:	Students will discuss the processes of the rock cycle.
Summative Assessment:	Using an appropriate laboratory activity, students will identify the major rock classifications.
Process:	Manipulating Information
Theme:	Constancy and Change

Professor Bruno Giletti at Brown University is available to help you find sites for this activity (863-2242). He suggests two very good sites -

1. Where the old visitor center was at the junction of Rtes. 295 and 95 on westbound side (parking may be difficult here); and
2. Jamestown Island off of old Rte. 138, next to the old Jamestown Bridge. Standing on the shoreline you can see a series of outcrops - high grade metamorphic.

By the end of the 8th grade all students will know that --

Thousands of layers of sedimentary rock confirm the long history of the changing surface of the earth and the changing life forms whose remains are found in successive layers. The youngest layers are not always found on top, because of folding, breaking, and uplift of layers.

Suggested Activity:

Make layers of bread, peanut butter and jelly, and cut and push the layers together to observe lifting and folding. Complete activity available in AIMS "Peanut Butter and Jelly Geology " lesson.

Embedded Assessment:	Students understand that youngest layers may not always be on top.
Summative Assessment:	Show students a picture (or take them to) a roadcut and ask them to suggest various hypotheses that could account for its appearance.
Process:	Manipulating Information, esp. identifying patterns and relationships
Theme:	Models

More local resources for help in this areas –

Milkowski, G. 1981. *Beach processes in Southern Rhode Island.* Narranganset, R.I.: Rhode Island Sea Grant, University of Rhode Island.
Murray, D.P. 1988. *Rhode Island: The Last Billion Years.* Kingston, R.I.: University of Rhode Island

By the end of the 8th grade all students will know that --

Although weathered rock is the basic component of soil, the composition and texture of soil and its fertility and resistance to erosion are greatly influenced by plant roots and debris, bacteria, fungi, worms, insects, rodents, and other organisms.

Suggested Activities:

Sample soils in different places in the school yard (core sample, dig a pit, etc., using the same size sample in each area) and compare with other sites in state by partnering with one or more distant schools. Have students relate surface appearance to soil structure, texture, moisture, and color. Take two pans of soil (large rectangular size), one with grass, planted or turf, one just with soil. Place at an incline and sprinkle water on the top of each pan. Watch for erosion.

Alternatively, use the module 'River Cutters' available as part of the GEMS series from the Lawrence Hall of Science (see resources section).

Embedded Assessment:	Students indicate an understanding of the relationship between soil constituents and fertility, erosion, etc. They can describe how the organisms they find affect the soil.
Summative Assessment:	Show students a picture of a particular environment and have them predict what the soil below would look like.
Process:	Manipulating Information, esp. identifying patterns and relationships.
Theme:	Systems

By the end of the 8th grade all students will know that --

Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms.

Suggested Activity:

Have students predict the environmental consequences of a proposed development in their community. If possible, include public hearings, site visits and interviews. Alternatively, obtain and use the module available from the New York Science, Technology and Science Education Project.

Embedded Assessment:	Students research the effects of the proposed development.
Summative Assessment:	Write an editorial for the newspaper describing your position on the class issue.
Process:	Proficiency in Informed Action, esp. identifying intended and unintended consequences of action.
Theme:	Systems

For local resources look for:

Carpenter, V. 1993. *The Piping Plover: A History*. The Nature Conservancy. Providence, R.I.: The Nature Conservancy.
Dickson, D.R. and C. L. McAfee. 1988. *Forest Statistics for Rhode Island - 1972 and 1985*. Resource Bulletin E-104. Broomall, Pa: United States Department of Agriculture, Forest Service.

From Mr. Tappero's Class
West Warwick High School
West Warwick, Rhode Island
High School Activity

Using Simulations to Make Land Use Decisions

"Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it."

We use a simulation game to show the mechanism of making land use decisions. The students have all had some time studying values and uses of urban, suburban and rural lands. They are given a map of 'Centerpiece City' showing the metropolis, suburban fringe and surrounding countryside, including a one mile square piece of abandoned farmland that has just been willed to the city. They also receive a list of characteristics of the city and a few notions strongly held by the people in the city.

Role cards are passed out at random. There must be three town council cards. The remaining cards are equal to the students in the class and are of three general categories - (1) environmentalist; (2) private business owner; and (3) city department (board of education, department of public works, recreation commission, etc.). Each student must then prepare an oral presentation with a visual of their idea of how the newly acquired land should be used. We use a five minute presentation with three minutes of questions from the 'audience'. The Town Council then evaluates each presentation on an objective grid they have developed by playing their role. The teacher should give just enough help to the Council to ensure an objective and numerical system of evaluation.

What happens is ALWAYS predictable. The business groups always win and the environmental groups always lose. This information can be used by the teacher in many different ways, depending on the age level and maturity of the students. The reason for the predictable outcome is the fact that the Council will invariably construct an evaluation instrument that is based on the financial stability of the city. This fact can lead to much discussion and even the construction (classroom, homework or collaborative project) of an evaluation instrument that more equally considers both human needs and environmental conservation.

By the end of the 12th grade all students will know that --

- Plants alter the earth's atmosphere by removing carbon dioxide from it, using carbon and light energy to make sugars, releasing oxygen. This process, commonly known as photosynthesis, is largely responsible for the oxygen content of the air.

Suggested Activity:

A sample of elodea can be used to produce oxygen. Various tests (e.g., the chemistry of the light and dark reactions) can be used to verify this.

Embedded Assessment:	Given the chemical equation representing photosynthesis, student will recognize the components of this process.
Summative Assessment:	How might clear cutting a significant number of forests alter the earth's atmosphere?
Theme:	Systems
Process:	Manipulating Information

By the end of the 12th grade all students will know that --

The formation, weathering, sedimentation, and reformation of rock constitute a continuing "rock cycle" in which the total amount of material stays the same as its forms change.

Suggested Activity:

Use appropriate AV materials, rock identification, manuals or kits and visit appropriate sites to observe evidence of any of the above processes.

Embedded Assessment:	Identify and list characteristics of above processes
Summative Assessment:	Given a slide or photograph of a RI geological formation, the student will be able to discuss and identify which processes are applicable.
Theme:	Constancy & Change
Process:	Manipulating Information

The Graduate School of Oceanography at URI will provide information and presentations on geology and related topics. Contact H. Sigurdsson, Professor at 792-6596.

By the end of the 12th grade all students will know that --

The slow movement of material within the earth results from heat flowing out from the deep interior and the action of gravitational forces on regions of different density.

Suggested Activity:

Bring a beaker of water to a boil and then add push pins. Pins will begin to rise and fall, demonstrating a convection cell. Make connection to convection in air and the effect of this natural phenomenon on weather.

Embedded Assessment	Describe the dynamics of movement in a convection cell.
Summative Assessment:	**Students will be able to relate this movement to the convection currents in the earth.**
Theme:	Models
Process:	Manipulating Information

By the end of the 12th grade all students will know that --

The solid crust of the earth--including both the continents and the ocean basins--consists of separate plates that ride on a denser, hot, gradually deformable layer of the earth. The crust sections move very slowly, pressing against one another in some places, pulling apart in other places. Ocean-floor plates may slide under continental plates, sinking deep into the earth. The surface layers of these plates may fold, forming mountain ranges. This is known as 'plate tectonics'.

Suggested Activity:

Demo - Use plate tectonics model blocks as well as overhead transparencies of earthquake zones and faults.

Embedded Assessment	Recognize the relationship between earthquakes and fault zones.
Summative Assessment:	Given a plate tectonics map and a list of cities students will be able to predict which ones might have earthquakes.
Theme:	Systems
Process:	Manipulating Information, esp. interpreting data

By the end of the 12th grade all students will know that --

Earthquakes often occur along the boundaries between colliding plates, and molten rock from below creates pressure that is released by volcanic eruptions, helping to build up mountains. Under the ocean basins, molten rock may well up between separating plates to create new ocean floor. Volcanic activity along the ocean floor may form undersea mountains, which can grow above the ocean's surface to become islands.

Suggested Activity:

Using appropriate AV materials, locate epicenters on a map using sample data.

Embedded Assessment:	Identify geological features and internal forces that are associated with plate activity.
Summative Assessment:	Identify problems associated with building in an earthquake prone area.
Theme:	Systems
Process:	Manipulating Information

Have you ever been in an area that had an earthquake? Why do earthquakes occur more in some locations than others? To try and answer this question, geologists map the number and intensity of earthquakes. *Locating Active Plate Boundaries* is a curriculum guide that helps you perform this same activity in the classroom. For copies of the entire lesson plan, contact Marge Bucheit at the University of Rhode Island (792-6596). The National Science Teachers Association also sells a complete earthquake curriculum module.

By the end of the 5th grade all students will know that --

No matter how parts of an object are assembled, the weight of the whole object made is always the same as the sum of the parts; and when a thing is broken into parts, the parts have the same total weight as the original thing.

Suggested Activity:

Each pair of students has the same number and size of Lego blocks. Build any object with all blocks. Weigh the blocks loose and in object form.

Embedded Assessment:	Observe measurement of objects. Record results in journal and write about the activity.
Summative Assessment:	Issue other materials and pose same problem.
Process:	Experimental Proficiency and Psychomotor Proficiency
Theme:	Models

By the end of the 5th grade all students will know that --

Materials may be composed of parts that are too small to be seen without magnification.

Suggested Activity:

Mystery Powders (5) - Students use a hand lens to observe and compare the composition of white sand, baking soda, talc, sugar and salt.

Embedded Assessment	Students will list 4 properties that make the 5 powders alike and different.
Summative Assessment:	Given a glass of water, a hand lens and 2 of the powders, students will identify the powders.
Theme:	Models
Process:	Experimental Proficiency

By the end of the 8th grade all students will know that --

All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.

Suggested Activities:

A series of activities that make the point that we can observe the effects of atoms without being able to see (sense) them directly. Student activity - make solutions of various materials (sugar, salt, colored solutes) - what happened? How do you know the substance is still there? Where did it go? Add a soluble solid to a beaker of water of known mass and observe change in mass as the solid dissolves. Fill a balloon with air-observe-how do you know there is something in there? A 'black box' activity. Students examine various samples of elements - aluminum, sulfur, iron, copper, lead, carbon, etc. to compare their properties. Examine water (H2O) and Hydrogen Peroxide (H2O2) and have students add Manganese Dioxide (Mn2O2) to each and observe reactions and pose possible reasons for observed differences. Divide class into groups of 3 or 4 students. Each group uses a bag containing pieces of tinker toys. Each group's bag has the same pieces. Students are blindfolded and given 5/10 minutes to use all pieces to construct some item. At the end of the time limit each group displays their work. Discussion should be centered around why we have different products when all used the same materials.

Embedded Assessment:	Scavenger hunt to locate elements outside the school setting. Observe whether students can develop a rationale to explain the differences between items produced.
Summative Assessment:	Defend the statement "All matter is made up of atoms." Include examples showing that atoms can be combined in different ways.
Theme:	Models
Process:	Developing Explanatory Frameworks

'Periodic Table' videodisc and other software from Journal of Chem Education, published by the American Chemical Society, tel. 202-872-4388. For more complete information check Chapter 9 - References.

By the end of the 8th grade all students will know that --

Equal volumes of different substances usually have different masses.

Suggested Activity:

Have students determine the mass of two identical size cubes made of different materials of the same state. Use two balloons, fill one with air and one with water. Determine that the volumes are equal by measuring the circumference and calculating. Repeat the experiment with 2 gases like CO2 (heavier than air) and He (lighter than air). Use different liquids.

Embedded Assessment:	Have students determine the density of their samples.
Summative Assessment:	Explain how equal volumes of different substances can have different masses.
Theme:	Patterns
Process:	Manipulating Information, esp. developing generalizations

From Mr. Palano's class, Northern Cumberland Middle School, Cumberland ...

Mr. Palano's second class of the day is his smallest, only eight students with a classroom aide. While teaching the concepts of density, mass and volume he is using a Computer Assisted Science Labs package. Students are instructed to select a variety of wooden blocks, measure the mass and volume using rulers and a triple-beam balance, and finally calculate the density. They work in pairs. As each pair completes a set of calculations, they move to a special computer workstation attached to a scale. They place their wooden block on the scale and enter their calculated values in the computer. In seconds the accurate results (mass, density and volume) are displayed on the screen, along with an accuracy rating from 0 to 5. Students know immediately if their measurements were very exact (rating of 4.7 or more), if they were close but not terribly accurate (between 4.2 and 4.7) or if they have made an error somewhere along the line. When they score below a 4.7 they go back to their stations and try to identify the problem. Mr. Palano circulates around the room, offering helpful advice at each station. Students let out a little cheer when the computer verifies their measurements as accurate. This activity will be repeated throughout the day with Mr. Palano's other classes. What makes this class unique is that the students are in a self-contained classroom for the rest of the day. Keeping the class size small and having a familiar classroom aide allows these students to fully participate in the eighth grade science laboratory experiences.

By the end of the 8th grade all students will know that --

Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.

Suggested Activity:

Place BB's (or any other small, round objects) into a plastic petri dish to about 1/3 full. Place petri dish on overhead projector to demonstrate each state of matter by increasing the speed of the BB's by moving the Petri dish on the overhead projector.

Embedded Assessment:	Have students identify which state of matter is represented by the teacher at differing stages of the demonstration.
Summative Assessment:	Students will design their own model to demonstrate molecular motion in the different states of matter.
Theme:	Models
Process:	Experimental Proficiency

By the end of the 8th grade all students will know that --

The temperature and acidity of a solution influences reaction rates. Many substances dissolve in water, which may greatly facilitate reactions between them.

Suggested Activity:

Use 2 lightsticks in this demonstration. Put one in ice water and the other in warm water. Students should observe differences in intensity of light. Place equal amounts of cream of tartar and baking soda in a petri dish. Students should notice that they do not react. Then make saturated solutions of each substance. Then pour solutions together. Notice reaction.

Embedded Assessment:	Students draw conclusions as to why there were differences in rates of reaction.
Summative Assessment:	Tell students that food spoilage is caused by chemical changes formulated by microorganisms. Have students explain why refrigeration is an effective way to prevent food spoilage. Research food preparation and handling codes and discuss why they are important.
Theme:	Change, Systems
Process:	Manipulating Information, esp. connecting new information with previous knowledge

By the end of the 8th grade all students will know that --

Scientific ideas about elements were borrowed from some Greek philosophers of 2,000 years earlier, who believed that everything was made from four basic substances: air, earth, fire, and water. It was the combination of these 'elements' in different proportions that gave other substances their observable properties. The Greeks were wrong about those four, but now over 100 different elements have been identified -some rare and some plentiful, out of which everything is made. Because most elements tend to combine with others, few elements are found in their pure form.

Suggested Activities:

Have students compare the Greek conception with present day theory. Make a chart of similarities and differences. A second activity would be to view the video listed in resources and have students list as many substances as are mentioned. Students can then identify which items in the list are elements.

Embedded Assessment:	Make a chart of similarities and differences from actual testing of element samples.
Summative Assessment:	Choose a substance or substances and have students explain its composition using both systems.
Theme:	Continuity and Change
Process:	Manipulating Information, esp. classifying

The PBS Series 'Dimensions in Chemistry' would make an excellent resource here. Contact Channel 36, WSBE, at 277-3636.

By the end of the 8th grade all students will know that --

No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same.

Suggested Activity:

Place small amount of baking soda in the corner of a 1 quart Plastic sandwich bag bag (minimum size). Also put in a tiny paper cup with vinegar in the same bag. Place entire bag on a scale and calculate weight. Turn bag upside down so that vinegar and baking soda mix. Allow gas to fill bag and reweigh. (Note: Be sure to test correct ratio of vinegar to baking soda before demonstrating.)

Embedded Assessment:	Students should predict and justify what will happen when the bag is turned upside down.
Summative Assessment:	Have teacher do a precipitate demonstration in an open system (beaker in a beaker). Students should predict what will happen to mass and justify their reactions.
Theme:	Systems
Process:	Experimental Proficiency

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By the end of the 12th grade all students will know that --

Atoms are made of a positive nucleus surrounded by negative electrons. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms form bonds to other atoms by transferring or sharing electrons.

Suggested Activity:

Classroom demonstration of the reactivity of various elements, e.g., sodium's volatility vs. helium's inertness. Relate these demonstrations to the electron configuration and/or valence electrons of each respective element.

Embedded Assessment:	Student writes atomic configuration of elements and identifies and/or defines possibilities of ionic, covalent, and metallic bonds.
Summative Assessment:	Students will be given various elements and a periodic table. Student determines the configuration. For a given compound student will draw appropriate Lewis (electron dot) type diagram to indicate bonds.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

By the end of the 12th grade all students will know that --

Protons and neutrons, having a mass nearly two thousand times greater than the electron, compose the nucleus of the atom. The number of protons in an atom, called the atomic number, equals the number of electrons in the electrically neutral atom. The nucleus is a small fraction of the total volume of the atom. Atoms change their charge by adding or losing electrons. These atoms are then called ions.

Suggested Activity:

Build scale model of atom to illustrate the empty space and size involved. Relay to students the analogy of a flea on the pitcher's mound in a baseball stadium (the flea being the nucleus and the remainder of the stadium being the domain of the electrons). Demonstrate the presence of ions in an electrolytic aqueous solution using an electrical conductivity tester.

Embedded Assessment:	Student writes the electron configuration of a given atom and its resultant ion and compares sizes using reference charts.
Summative Assessment:	**Students will identify atoms from given electron configurations. Student will respond to the question: Why is the atom considered to have a volume that contains mostly empty space. Why are properties of atoms and ions of some elements different?**
Theme:	Models
Process:	Manipulating Information, esp. developing generalizations

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By the end of the 12th grade all students will know that --

Neutrons have a mass that is nearly identical to that of protons, but neutrons have no electric charge. Although neutrons have little effect on how an atom interacts with others, they do affect the mass and stability of the nucleus. Isotopes of the same element have the same number of protons (and therefore of electrons) but differ in the number of neutrons.

Suggested Activity:

Introduce what an isotope is to students, perhaps using hydrogen, deuterium, and tritium as examples. Their importance in the production of 'heavy water' or the fusion process should also be discussed.

Embedded Assessment:	Student, given appropriate data, should be able to determine the nuclear structure of a given isotope of an element.
Summative Assessment:	Student will describe the structure of a given atomic isotopes' nucleus and compare properties.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

By the end of the 12th grade all students will know that --

The nucleus of radioactive isotopes is unstable and spontaneously decays, emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate. This predictability of decay rate allows radioactivity to be used for estimating the age of materials that contain radioactive substances.

Suggested Activity:

Either as a lab or a demonstration show that a capacitor can be charged and slowly discharged. Use its slow discharge as an analogue to a decay rate. Data may be graphed and should resemble a decay curve. Introduce (through reading and/or discussion) the utility of radioactive decays. (Carbon-14 dating and radiation treatment of tumors are based upon such decay.)

Embedded Assessment:	From given data students graphically can determine the decay curve for a radioactive element, and thus the half-life.
Summative Assessment:	Students using a radioactive analogue apparatus, such as a large number of multi-sided dice, can experimentally reproduce the probability curves of simulated radioactive decay, and thus determine the half-life, modeling this behavior.
Theme:	Models
Process:	Manipulating Information, esp. applying statistical procedures

THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 5 of 9)

By the end of the 12th grade all students will know that –

Scientists continue to investigate atoms and have discovered even smaller constituents of which electrons, neutrons, and protons are made.

Suggested Activity:

The film "Powers of Ten" could give students a nice insight into how small subatomic particles actually are.

Embedded Assessment:	Stop the film at one or two preselected points and have students jot down their own thoughts and share them with at least one other student.
Summative Assessment:	Students evaluate the government decision to stop the construction of the 'super-collider' accelerator in Waxahachie, Texas.
Theme:	Continuity and Change
Process:	Proficiency in Reaching Decisions About Issues

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By the end of the 12th grade all students will know that --

The placement of elements on the periodic table of elements is determined by common chemical properties. The same sequence of properties appears over and over again in the list.

Suggested Activity:

Classroom demonstration of the reactivity of elements within the same family (e.g., sodium and potassium in water or magnesium and calcium in hydrochloric acid).

Embedded Assessment:	**Students predict from a periodic chart what elements have properties similar to a given element.**
Summative Assessment:	Given a periodic table, student identifies properties of a given element like acidity, reactivity, etc.
Theme:	Models
Process:	Developing Explanatory Frameworks.

By the end of the 12th grade all students will know that --

Atoms often join with one another in various combinations in distinct molecules or in repeating three-dimensional crystal patterns. An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.

Suggested Activity:

Growth of a crystal structure. Using given salts, students may develop a seed crystal by cooling a supersaturated aqueous solution of that given salt. That seed crystal may be suspended in the same supersaturated solution and grow slowly in near perfect three-dimensional patterns. Various PC software programs on crystal patterns and atomic motion are available.

Embedded Assessment:	Students will recognize various basic crystal patterns, e.g., cubic or hexagonal close packed.
Summative Assessment:	Given reference to crystalline forms, (e.g., Chem-Physics Handbook of CRC or Lange's Handbook of Chemistry) student can list or observe most frequent shapes.
Theme:	Models
Process:	Manipulating Information, esp. developing generalizations

By the end of the 12th grade all students will know that --

The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others.

Suggested Activity:

Using a student molecular kit (ball and spring set or comparable set), students may build three-dimensional models of various molecules. If the molecules are covalent in nature, the shapes may be correlated to the Valence Shell Electron Pair Repulsion (VSEPR) Theory, which predicts the shapes, bond angles, and consequent forces between atoms in a given molecule.

Embedded Assessment:	Students will become adept at using the VSEPR theory to predict molecular shapes.
Summative Assessment:	Students, presented with the configuration of several atoms in a molecule, shall identify the molecule's properties.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

By the end of the 12th grade all students will know that --

The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others.

Suggested Activity:

A laboratory activity known as the 'The Clock Reaction' or the 'Starch-Iodine Clock Reaction'. Students mix two clear solutions and in several seconds observe a dynamic color change. Upon heating, cooling, or diluting one of the original two solutions, the rate of reaction will vary.

Embedded Assessment:	Students will understand the concept of a reaction mechanism and how it actually plays a role in the rate of reaction by constructing a data table and analyzing the data.
Summative Assessment:	Student should be able to describe the factors affecting the rate of reaction between chemical substances.
Theme:	Models
Process:	Manipulating Information, esp. identifying patterns and relationships

From Mr. Maruszczak's Class
Ponaganset High School
Foster-Glocester, Rhode Island
Tenth Grade Activity

A Constructivist Approach to Science

"Given the realities of our current world, the concept of Science Literacy can best be achieved at Ponaganset High School by using multiple resources rather than relying on a single textbook; by involving students directly with hands-on experiences in responding to the issues of science; by working cooperatively in groups; by utilizing all forms of instructional technology; by students developing their own relevant database (notebooks); and by immersion into relevant issues as the focus of study ... The spirit of inquiry, which characterizes all human curiosity, becomes the primary concept in discovering the sciences. The question 'Why?" becomes paramount and invites a response which functions within an orderly pattern and one which suggests useful applications for our world. This, then, rather than some specific 'scientific' dogma is the heart of this program."

from Science for All Students, Ponaganset High School's two year integrated science curriculum based on the concepts of Project 2061.

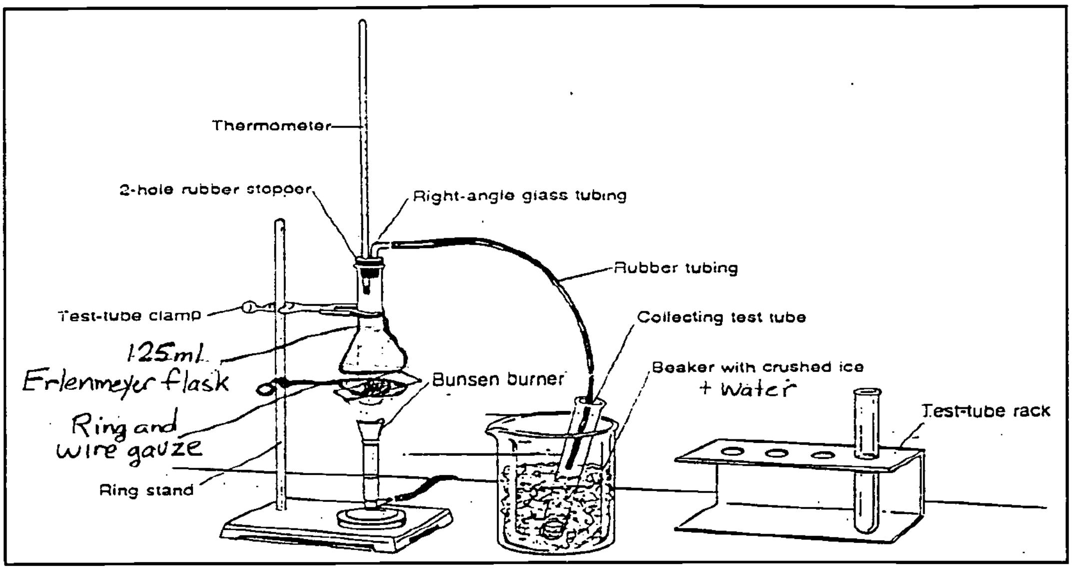
This particular lab is an example of an activity re-written for a more inquiry-based or constructivist approach. With the release of Ponaganset's new science curriculum, many lab activities were re-written, making them less 'cookbook' in nature. Activities are now designed to be purposeful, research-based, and aligned with student behavioral goals. (Making an activity 'hands-on' does not necessarily make it worthwhile and educational!)

The following information is copied and distributed to the students:

Fractional Distillation ... What Good Is It Anyway?

1. *Using a graduated cylinder, obtain 25 ml of the liquid mixture that I mixed in front of the class. Remove the 2-hole rubber stopper from the Erlenmeyer flask and pour in the mixture.*

2. *Be sure that the thermometer is near the top of the neck of the Erlenmeyer flask, NOT in the liquid. Place a few boiling chips in the Erlenmeyer flask. Now put the 2-hole stopper back on the flask, making sure that the flask is firmly clamped in place, and everything is stable.*



YOUR SET-UP SHOULD LOOK LIKE THE PICTURE ABOVE

3. *Light the Bunsen Burner. WORK WITH A LOW TO MODERATE SIZE FLAME!!! Very slowly heat the mixture. Do not allow the liquid to boil rapidly. If it does, remove it from the flame.*

4. *At what temperature do you notice that the mixture starts to boil?? You should notice that a liquid is beginning to collect in the test tube in the beaker of ice water. (CAUTION: Do not allow the rubber tubing to touch the liquid being collected.) Describe the physical characteristics (color, smell, appearance, etc.) of the liquid which is being collected. What liquid do you believe this to be? Why? Explain.*

5. *When the temperature begins rising again, remove the collecting test tube from the ice water and replace it with an empty test tube. Place the test tube with the collected liquid in the test tube rack.*

6. *The temperature will stop rising again. At what temperature do you notice this happens?? You should begin to notice a liquid again collecting in the second test tube. (Again, do not allow the rubber tubing to touch the liquid being collected.) Describe the physical characteristics of the liquid which is being collected. What liquid do you believe this to be? Why? Explain.*

7. *When the temperature begins rising again, turn off the Bunsen burner and allow the heated Erlenmeyer flask to cool. Describe fully the physical characteristics of the liquid left behind in the Erlenmeyer flask. What can you say about its boiling point?*

8. *All liquids may be discarded down the drain. Clean the Erlenmeyer flask once it is cool enough.*

9. Did the complete separation of all three liquids that make up the mixture take place? If not, what could you do to make each liquid more pure? Explain.

10. The process you just performed in the lab is known as FRACTIONAL DISTILLATION. How do you know that fractional distillation is a physical separation, not a chemical one?

11. Describe a mixture that would be really DIFFICULT to separate different liquids by fractional distillation. Explain completely.

12. Where is the process of fractional distillation used in the real world? Describe how it is useful.

Student involvement and enthusiasm are very high. Students MAY exhibit more confusion/trepidation because less specific information is given them. However, they are challenged to a higher level, and their work becomes more meaningful as they have to identify problems, make decision, convey an understanding of what they are working with, be curious, and apply THEIR RESEARCH to the existing body of knowledge. Essentially we are asking kids to take a step beyond their prior experiences.

A helpful supplemental reading on this is "Cooking and Constructivism," The Science Teacher, February 1994, pp. 34-37.

By the end of the 8th grade all students will know that --

Energy cannot be created or destroyed, but only changed from one form into another. Most of what goes on in the universe--from exploding stars and biological growth to the operation of machines and the motion of people--involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation. Energy appears in different forms. Heat energy is in the disorderly motion of molecules; chemical energy is in the arrangement of atoms; mechanical energy is in moving bodies or in elastically distorted shapes; gravitational energy is in the separation of mutually attracting masses.

Suggested Activity:

Have each student take a paper clip and bend it back and forth 15-20 times and then feel the heat generated by motion. Demonstration of palm glasses, radiometer, doorbells arealso pertinent.

Embedded Assessment:	Students tabulate their findings listing the energies involved in each of the activities.
Summative Assessment:	Students to make list of all energy transformations they can identify in their homes.
Theme:	Continuity and Change
Process:	Manipulating Information, esp. inferring

By the end of the 8th grade all students will know that --

Heat can be transferred through materials by the collisions of atoms (conduction) or across space through radiation. If the material is fluid, currents will be set up in it that aid the transfer of heat (convection).

Suggested Activity:

Use dabs of butter or drops of wax along a length of coat hanger (knitting needle) and hold end in candle to show heat traveling down the solid. Take two equal size bottles; fill one with hot water and one with cold water. Put food coloring in the hot water. Place the bottle of cold water on the top of the bottle with hot water so that the hot and cold water will mix. Students can see the current of dye. A flat iron can be used to show that a hand that is placed 12" from an iron is heated but the air in between still remains cool.

Embedded Assessment:	Redo the hot and cold water demonstration and reverse the order of the bottles. Ask students to predict the results and justify their reasoning.
Summative Assessment:	Have students explain "a day at the beach." Students should explain why even though the air temperature may by 90 degrees the water feels cold and the sand feels hot. They should use all three methods of heat transfer in their explanations.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

By the end of the 12th grade all students will know that --

Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount. (The Law of Conservation of Energy)

Suggested Activity:

Set up a pendulum (large or small) and show that it returns to almost the same height at which it starts. Ask students why it doesn't return to exactly the same position and where the rest of the energy goes.

Embedded Assessment:	Using the pendulum demonstration define potential and kinetic energy and indicate which type exists at various points of the arc.
Summative Assessment:	Transferring hot water to cold water allows students to calculate and measure heat transference.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. creating/testing physical models

By the end of the 12th grade all students will know that --

- Heat energy in a material consists of the disordered motions of its atoms or molecules. In any interactions of atoms or molecules, the statistical odds are that they will end up with less order than they began—that is, with the heat energy spread out more evenly. With huge numbers of atoms and molecules, the greater disorder is almost certain. This disorder is called entropy.

Suggested Activities:

Teacher can demonstrate randomness of systems by using an air-based popcorn popper. The popcorn popper is filled with kernels, a 400 ml. beaker is placed underneath the popper, the popper is turned on. As the popcorn pops, kernels in an ordered system (inside machine) spread out and become disordered as some reach the beaker while others fly about and reach the tabletop. Students can demonstrate randomness of systems by using ping pong balls, racks, and pool cues or yardsticks and the floor. The racks can be made by the teacher or students from cardboard in a triangular shape. Students somehow mark the starting point, rack the ping pong balls on the floor, remove rack, hit the group of balls with cue or yardstick gently. Position of the balls is measured from the starting point and later graphed. Students can demonstrate randomness of systems by using a beaker (400 ml), ice cubes, tap water at room temperature and Celsius thermometer. Students fill a 400 ml beaker to 300 ml. line. Students measure temperature of the water using a Celsius thermometer. Students mark the beaker on the sides at N. S, E, W with a grease pencil. Each student obtains an ice cube (known to be at 0 Celsius). The ice cube is placed in the water. Temperature of the beaker is taken every five minutes at each compass position. Students should record the temperatures throughout the class period. Students create a graph with temperature vs. time, graphing each position (N, S, E, or W) in different color markers or pencil.

Embedded Assessment:	Student successfully takes required temperature readings, records these and constructs a graph of temperatures for all of the four positions.
Summative Assessment:	Students are given a few tables of temperature readings for various solutions. Students examine each table to decide if system is becoming more or less disordered. After deciding, students must explain in written form how they arrived at their decision.
Theme:	Continuity and Change
Process:	Manipulating Information

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By the end of the 12th grade all students will know that --

Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation, conduction or convection into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with it.

Suggested Activity:

Student has a battery, small bare copper wire or aluminum foil, small light bulb or brass fastener. Students should feel the wire or foil to determine its relative hotness or coldness. Students set up circuit between battery, leads, and light (or fastener). Circuit is completed for a few minutes. Students should feel the wire (or foil) to determine its relative hotness or coldness. Discussion should also mention heat loss in engines, such as car engines and mufflers. Discuss heat loss due to friction.

Embedded Assessment:	Students successfully assemble circuit, note before and after temperatures, recognize that electrical energy produces heat (which serves no useful purpose in this situation).
Summative Assessment:	Student finds three other examples of heat energy produced by transformations of energy (electrical to light, electrical to heat such as an iron cord) from his/her experience and describes the energy transformation in written form including how the 'useless' heat is produced and how this heat affects the environment.
Theme:	Systems
Process:	Experimental Proficiency

By the end of the 12th grade all students will know that --

Different energy levels are associated with different configurations of atoms and molecules. Some changes of configuration require an input of energy whereas others release energy.

Suggested Activity:

Perform heat of solution of sulfuric acid experiment, or other simple demonstrations of exothermic and endothermic reactions in class.

Embedded Assessment:	Determine the numerical heat of solution for sulfuric acid.
Summative Assessment:	Students will understand the thermodynamics of both exothermic and endothermic reactions.
Theme:	Systems
Process:	Manipulating Information, esp. interpreting/evaluating data

By the end of the 12th grade all students will know that --

When energy of an isolated atom or molecule changes, it does so in a definite jump from one value to another, with no possible values in between. The change in energy occurs when radiation is absorbed or emitted, so the radiation also has distinct energy values. As a result, the light (radiation) emitted or absorbed by separate atoms or molecules (as in a gas) can be used to identify what the substance is.

Suggested Activity:

Students will be given appropriate information regarding energy levels of electrons, energized electrons, release of electron energy as light, ground state electron spectroscopy. Students observe various gas discharge tubes using diffraction gratings. Students make notes and create spectral patterns on pieces of white paper. Spectral lines are spaced and colored to approximate what was observed. Students explain, in written form, what individual lines represent and why spectral patterns are different.

Embedded Assessment:	Student successfully draws spectral patterns, explains patterns of individual gases and what each spectral line represents, relating the configuration patterns to spectral changes.
Summative Assessment:	Student explains the impossibility of two or more elements or compounds leaving the same spectral patterns by describing electrons in ground and excited states.
Theme:	Models
Process:	Manipulating Information, esp. identifying patterns and relationships

By the end of the 12th grade all students will know that --

Energy is released whenever the nuclei of very heavy atoms, such as uranium or plutonium, split into middleweight ones (a process known as 'fission'), or when very light nuclei, such as those of hydrogen and helium, combine into heavier ones (a process known as 'fusion'). The energy released in each nuclear reaction is very much greater than the energy given off in each chemical reaction.

Suggested Activity:

Research the mass involved in nuclear and conventional fuels to produce the same quantity of energy. Introduce conservation of mass and energy, E=mc2 and the impact such a discovery has made on human society in the twentieth century.

Embedded Assessment:	Students will be able to read and interpret a nuclear reaction equation.
Summative Assessment:	Students will realize that both fusion and fission reactions obey the law of conservation of matter and energy even though they give off great amounts of energy.
Theme:	Constancy & Change
Process:	Developing Explanatory Frameworks, Creating Mental Models

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By the end of the 2nd grade all students will know that --

Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.

Suggested Activity:

Go outside and categorize everything you see moving. Use the categories given in the benchmark.

Embedded Assessment:	Students use movement terms appropriately. Do the 'hokey-pokey'.
Summative Assessment:	Ask students to give instructions to other students or to complete a maze using only words to guide them.
Theme:	Constancy and Change
Process:	Psychomotor Proficiency, Language Proficiency

By the end of the 2nd grade all students will know that --

The way to change how something is moving is to give it a push or a pull.

Suggested Activities:

Assemble tinker toys -- construct and use cars. Use carts, elastic, balloons, playground equipment, medicine ball/tug of war to illustrate the benchmark.

Embedded Assessment:	Teacher will use toys that demonstrate push or pull. Student will identify which toys utilize push or pull.
Summative Assessment:	Give a series of pictures of machines and ask students to determine which are pulled or pushed.
Theme:	Continuity and Change
Process:	Experimental Proficiency, esp. comparing, observing

By the end of the 2nd grade all students will know that --

Sound is caused by vibration.

Suggested Activity:

Children will use a variety of items such as cymbals, hair combs and rulers, to produce sounds and record the physical evidence of how things that make sound vibrate. Have students place their hand on their neck and begin speaking. Discuss what happens when they speak louder.

Embedded Assessment:	Children will record on a chart physical evidence of vibration using three senses, visual, auditory, tactile.
Summative Assessment:	Construct a Styrofoam cup phone. Have students describe what happens when they talk and listen. In addition list other items that vibrate.
Theme:	Constancy and Change
Process:	Psychomotor Proficiency, Experimental Proficiency

Contact someone in your school or district who works with the hearing impaired and have them visit your class.

By the end of the 8th grade all students will know that --

Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors.

Suggested Activity:

Demonstrate spectrum by placing a prism in front of a white light source (e.g., slide projector). Later place differing colored cellophane or gel strips in front of lens to show how spectrum changes. By using diffraction gratings students can observe indirect sunlight to observe differences between sunlight and white light.

Embedded Assessment:	Compare the changes in each observation.
Summative Assessment:	**Have students draw and label a spectrum and then have them explain how it would change if the light source color changed.**
Theme:	Constancy and Change
Process:	Experimental Proficiency, esp. observing, comparing

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By the end of the 8th grade all students will know that --

Something can be "seen" when light waves emitted or reflected by it enter the eye--just as something can be "heard" when sound waves from it enter the ear.

Suggested Activity:

Demonstrate projection of an image (pinhole device or lens); Make shoebox with a picture at one end and two holes at the other. Have students view the picture through one hole with the second hole closed. Do the same activity with both holes open.

Embedded Assessment:	By drawing a diagram, students trace the path of light from the object to the image.
Summative Assessment:	Compare how a camera works to how the eye works or compare the way you see to the way you hear.
Theme:	Models
Process:	Developing experimental proficiency, esp. creating/testing mental models

From Ms. Leonard's Class
Blessed Sacrament School
Providence, Rhode Island
Eighth Grade Activity

Using Research to Inform Instruction

The majority of elementary students and some middle school students who have not received any systematic instruction about light tend to identify light with its source (i.e., a light bulb) or its effect (i.e, a patch of light). They do not have a notion of light as something that travels from one place to another. Hands-on exploration activities that engage students will help increase the understanding of scientific concepts and make the science classroom a more positive place.

Ms. Leonard has been using some exciting and fun activities to explore and reinforce the concepts of how light waves travel.

The Color Wheel - You'll need some colored paper (yellow, orange, green, purple, and red), a glue stick, a pencil, cardboard, and scissors. Draw a circle on the cardboard and cut it out. With the pencil, draw six equal parts out of the circle. Cut one piece of each one of the colors and glue them onto the cardboard. Punch a hole through the center of the circle to produce a 'top' like figure. Put the pencil through the hole, and holding the pencil, spin the wheel fast and watch what happens! What colors can you see? Do you always see the same color? Why?

Shadows - You'll need construction paper, thin sticks, scissors, flashlight, and tape. Have students cut out a few crazy characters from the construction paper. Emphasize that the shape should have some holes in it. Carefully tape them onto the thin stick (a yardstick works well). Holding the flashlight, ask a volunteer to work the puppet. Turn off all the lights and shine the flashlight on the puppet up against the wall. Can you make this image bigger or smaller? What does this prove to you about how light waves travel?

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By the end of the 8th grade all students will know that --

An unbalanced force acting on an object changes its speed or path of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center.

Suggested Activity:

Any of several demonstrations of inertia could be done by students, such as the card and coin. Demonstrate centripetal force using two weights connected by a string threaded through a spool or rubber stopper.

Embedded Assessment:	Have students explain the behavior of the coin in the demo.
Summative Assessment:	Have students simulate their motion in a car as the car changes speed and direction (as a group activity). Individually, have students explain why they move as they do.
Theme:	Constancy & Change
Process:	Developing Explanatory Frameworks

By the end of the 8th grade all students will know that --

Vibrations in materials set up wavelike disturbances that spread away from the source. Sound and earthquake waves are examples. These and other waves move at different speeds in different materials.

Suggested Activity:

Have students observe the effect of a tuning fork on a pan of water. Compare this to what happens when an object is dropped into water. Have students listen to the transmission of sound through various solids (hold base of tuning fork against the solids).

Demonstrate the difference in the speed of light in different mediums by placing a straw in an empty glass, in a glass of water, in a glass of glycerol, and in a glass of alcohol. Because light travels at different speeds in each of these liquids, students will perceive the straw to be bending at various angles.

Embedded Assessment:	Describe what happens when a pebble is dropped in still water.
Summative Assessment:	Have students design a demonstration to show the patterns formed as waves move away from a source.
Theme:	Models
Process:	Developing Explanatory Frameworks

By the end of the 8th grade all students will know that --

Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation--visible light. Differences of wavelength within that range are perceived as differences in color.

Suggested Activity:

Discuss examples of the electromagnetic spectrum that students are familiar with (UV, IR, microwave, X-,radio, and visible light). Discuss infrared photography, "black light", etc. Relate differences to wavelength. Demonstrate infrared goggles.

Embedded Assessment:	Create a large classroom spectrum. Have students bring in various examples of radiant energy and match them to regions of the spectrum.
Summative Assessment:	As a cooperative learning exercise have students assemble a spectrum from a series of pieces (examples and wavelengths in scientific notation)
Theme:	Scale
Process:	Manipulating Information, esp. identifying patterns and relationships

Invite an opthamologist or school nurse to visit the class and bring a model of the eye. Ask the doctor or nurse to explain how the eye works, vision testing especially with the use of pinhole testers, some common vision problems, current research, and details of his or her own training. Extend inquiry at this point to incorporate color blindness: tests for, causes, compensatory techniques, role of heredity. This is an opportunity to integrate a project with the art department - have students design a poster to screen for color blindness.

The discovery/invention of each of the familiar examples of the electromagnetic spectrum (UV, IR, micro-, X-, radio-, etc.) should be investigated in conjunction with the history department. As a class, design a questionnaire to be used as the basis of interviews to be conducted on-site at a photography studio. The on-site visits should include opportunities to see the equipment, and conduct the interviews regarding functioning of the site, uses of the product, problems solved and training of all employees.

By the end of the 12th grade all students will know that --

The change in motion of an object (the acceleration) is proportional to the applied force and inversely proportional to the mass.

Suggested Activity:

Using an air puck (or air track) and elastic band launcher, show that as the number of elastic bands (force) increases, the acceleration increases. Using the same apparatus with only 1 elastic band, show that as the mass of the puck increases, the acceleration decreases.

Embedded Assessment:	Predict the outcome of changing the forces or masses involved in this activity.
Summative Assessment:	Compare the resulting acceleration when switching engines with a motorcycle and a dump truck.
Theme:	Models
Process:	Manipulating Information, esp. developing generalizations

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THE PHYSICAL SETTING - Motion
Grade 9-12 (Benchmark 2 of 6)

By the end of the 12th grade all students will know that --

All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion.

Suggested Activity:

Discuss the motion of 2 cars traveling in the same direction. One travels at 50 mph, the other at 55 mph. Discuss what happens if you drop something in a moving vehicle. In which direction does it fall? Have students construct their own experiment at home whole traveling in a car.

Embedded Assessment:	The student should be able to discuss the speed of the cars relative to each other and relative to the earth.
Summative Assessment:	Perform the same discussion and assessment when the cars are traveling in opposite directions.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. making testable predictions

By the end of the 12th grade all students will know that --

Accelerating electric charges produce electromagnetic waves around them. A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. In empty space, all electromagnetic waves move at the same speed--the "speed of light."

Suggested Activity:

Using a diffraction grating or prism, break white light into component parts and compare it to a spectrum chart with wavelengths.

Embedded Assessment:	Given two colors, determine which has a longer wavelength.
Summative Assessment:	Write a paragraph describing similarities and differences between several wavelengths of the electromagnetic radiation.
Theme:	Models
Process:	Manipulating Information, esp. interpreting/evaluating data

By the end of the 12th grade all students will know that --

Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.

Suggested Activity:

Have two students lock together two force scales of the 10 newton type. Have one student pull on their scale while the other keeps the other scale still. Both scales should register the same force on the dials.

Embedded Assessment	Students should be able to reason that the scales are dividing the same force, one pull and the other resistance.
Summative Assessment:	Students should be able to describe the forces meeting on a box that is being moved, and what happens when they push on a wall.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

By the end of the 12th grade all students will know that --

The observed wavelength of a wave depends upon the relative motion of the source and the observer. If either is moving toward the other, the observed wavelength is shorter; if either is moving away, the wavelength is longer. This is known as the Doppler Effect. Because the light seen from almost all distant galaxies has longer wavelengths than comparable light here on earth, astronomers believe that the whole universe is expanding.

Suggested Activity:

Using a ribbed hose, students will swing the hose over their head and listen to the sounds being produced. Sound should be one pitch or frequency near the source and another pitch or frequency away from the source. Ask students to relate this phenomenon to applications of a radar gun in sports and traffic speed control.

Embedded Assessment	Students should recognize when the source is near and when it is more distant by the frequency of the sound.
Summative Assessment:	Students should be able to transfer their knowledge about sound behavior to light behavior, recognizing that sound and light both travel in waves.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

By the end of the 12th grade all students will know that --

Waves can superpose on one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. The energy of waves (like any form of energy) can be changed into other forms of energy.

Suggested Activity:

Have students observe a laser beam passing through the air to a target on the wall. Spraying water mist on the beam can show the beam in the air. The beam can then be passed through different materials to show the effect. Students may also work with a wave tank and generate water waves with various wavelengths and demonstrate various wave properties, such as reflection, refraction, diffraction, and interference.

Embedded Assessment	Students can predict the effect of the beam as it strikes different materials.
Summative Assessment:	Given a list of materials students can identify which materials will absorb, reflect, or transmit the laser beam.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. making testable predictions/attempting refutations

By the end of the 2nd grade all students will know that --

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

Suggested Activity:

Demonstrate and/or have students experience the dancing paper clip, mazes with magnetic marbles, hidden magnet under desk.

Embedded Assessment:	What makes these things move?
Summative Assessment:	Given a pan of sand and iron filings, students will determine how to separate iron filings from the sand without the magnet touching the sand.
Theme:	Models
Process:	Experimental Proficiency

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By the end of the 8th grade all students will know that –

Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at least one of the objects has a lot of mass.

Suggested Activity:

Discuss ways we know that both the earth and moon have gravity. Reinforce with videos, NASA, etc. Compare earth's and moon's gravity - discuss why they are different. Extend the description to other planets.

Embedded Assessment:	Have students explain why they would have a greater weight on Jupiter.
Summative Assessment:	Distribute a chart of several planets - their relative positions and relative masses. Have students predict their relative weights on these planets. Graph mass and gravitational pull of the planets. Discuss relationship.
Theme:	Systems
Process:	Manipulating Information, esp. interpreting/evaluating data

By the end of the 8th grade all students will know that --

- The sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.

Suggested Activity:

Use a light and heavy object threaded through a spool. The spinning objects represent two planets in their orbits, and the spool represents the sun (demonstration).

Embedded Assessment:	Have students relate how this compares to a moon revolving around a planet and a planet around the sun.
Summative Assessment:	You are in the year 2061. Your work is on a newly launched space station. Explain why it will not fall to earth.
Theme:	Models
Process:	Manipulating Information, esp. developing generalizations

By the end of the 8th grade all students will know that --

Electric currents and magnets can exert a force on each other.

Suggested Activity:

Give students pairs of unmarked magnets and ask them to experiment with attraction and repulsion. Make a coil about 3" in diameter of #20 bellwire (about 50 turns). Attach both ends of the coil to a galvanometer. Have students pass magnets in and out of the coil rapidly.

Embedded Assessment:	Make a table summarizing your findings.
Summative Assessment:	Using a doorbell, explain how magnetism and electricity make a bell operate.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking concepts and principles

By the end of the 12th grade all students will know that --

Gravitational force is an attraction between masses. The strength of the force is proportional to the masses and weakens rapidly with increasing distance between them.

Suggested Activity:

Perform the Cavendish experiment. The force of gravitation between two movable or stationary spheres can be measured by observing, with the help of a mirror and light beam, the amount of bend in the fiber suspending the two spheres.

Embedded Assessment	Students will be able to correctly solve the problem
Summative Assessment:	Students will be able to predict in general terms how an increase or decrease in one mass will affect the gravitational force between the two.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. making testable predictions/attempting refutation

By the end of the 12th grade all students will know that --

There are two kinds of charges--positive and negative. Like charges repel one another, opposite charges attract. In materials, there are almost exactly equal proportions of positive and negative charges, making the materials as a whole electrically neutral. Negative charges, being associated with electrons, are far more mobile in materials than positive charges are. A very small excess or deficit of negative charges in a material produces noticeable electric forces.

Suggested Activity:

Have students construct a simple electronic motor or take a motor apart. Let students feel the effects of touching a Van de Graaf generator. Teacher may demonstrate attractive and repulsive forces using wool, a pith ball, and plastic rod.

Embedded Assessment	Given directions students will be able to construct a working electric motor.
Summative Assessment:	Students will be able to describe how the electrical and magnetic forces interact in an electric motor.
Theme:	Models
Process:	Developing explanatory frameworks, esp. linking concepts/principles

THE PHYSICAL SETTING - Forces of Nature
Grade 9-12 (Benchmark 4 of 6)

By the end of the 12th grade all students will know that --

Different kinds of materials respond differently to electric forces. In conducting materials such as metals, electric charges flow easily, whereas in insulating materials such as glass, they can move hardly at all. At very low temperatures, some materials become superconductors and offer no resistance to the flow of current. In between these extremes, semiconducting materials differ greatly in how well they conduct, depending on their exact composition.

Suggested Activity:

Have students test the electrical conductivity of various materials using a battery and bulb set up. Introduce students to superconductivity through a demonstration.

Embedded Assessment	Student will make generalizations about conductors and non-conductors.
Summative Assessment:	Given a list of 20 materials students will be able to distinguish the conductors and non-conductors.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. classifying

By the end of the 12th grade all students will know that --

The forces that hold the nucleus of an atom together are much stronger than the electromagnetic force. That is why such great amounts of energy are released from the nuclear reactions in the sun and other stars.

Suggested Activity:

View films about nuclear reaction, like "The Universe" which is available through the Curriculum Center at RIC.

Embedded Assessment	Recognize the importance of nuclear fusion and its effect on living things.
Summative Assessment:	Be able to describe the effects of radiation on humans as well as the benefits of power generation from the sun.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. developing generalizations

The Living Environment

- ✓ Diversity of Life
- ✓ Heredity
- ✓ Cells
- ✓ Interdependence of Life
- ✓ Flow of Matter and Energy
- ✓ Evolution of Life
- ✓ Forces of Nature

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THE LIVING ENVIRONMENT - Diversity of Life
Grade K-2 (Benchmark 1 of 3)

By the end of 2nd grade all students will know that --

Some animals and plants are alike in the way they look and in the things they do, and others are very different from one another.

Suggested Activity:

Comparing leaves collected from the school playground.

Embedded Assessment:	Sorting different kinds of leaves.
Summative Assessment:	Sorting other things, i.e. nuts, shells, flowers pets, animals.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. classifying

From Ms. McGuirl's First Grade Class, Oak Haven School, Coventry ...

Science should begin in kindergarten with students learning to work in small teams, rather than as isolated individuals. Students should ask and answer questions about their surroundings and share their findings with classmates. Praise should be given for curiosity and creativity even when the investigations they lead to do not turn out as planned. Ms. McGuirl's first graders use the 'mystery object' format. Students need access to a hand lens, forks, toothpicks and napkins for this activity, and the 'mystery object' along with a more familiar (but related) object. Last year, Ms. McGuirl used a chestnut burr with the class, and provided acorns for comparison. This activity is usually done over two days. The first day involves a discussion of what the 'mystery object' is, where it comes from, and what you do with it. Students are permitted to observe, dissect, and explore the object in small groups. Discussion and guessing are encouraged among the small groups. To bring closure on the first day, Ms. McGuirl and her class read The Tree, A First Discovery Book together. The second day, students go out and find maple seeds in the playground. The seeds are collected and compared. Again working in small groups the students discuss how the seeds are similar or different. Ms. McGuirl recommends Lois Ehlert's Red Leaf, Yellow Leaf to complement this second day. During this activity, the teacher encourages students to notice how parts of plants are similar in many ways, and different in others. Children are encouraged to compare the 'mystery object' to similar items they know about, and to share this knowledge with the class.

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By the end of 2nd grade all students will know that --

Plants and animals have features [adaptations] that help them live [survive] in different environments.

Suggested Activity:

Observing animal adaptations, using pictures, live animals (pets, trip to zoo or farm). Provide students with replicas of animal feet. Students observe features of feet and relate them to the animals' survival in the environment (food-gathering, defense, etc.) Another activity might be to design a real or imaginary aquarium or terrarium.

Embedded Assessment:	During discussion, students are able to match features with environments (e.g., webbed feet with water).
Summative Assessment:	Design a creature given a particular environment. Relate features of a creature to the creature's survival in that environment.
Theme:	Systems
Process:	Manipulating Information, esp. developing generalizations

"Feet" are available from NASCO or Museum Products. Roger Williams Park Zoomobile "What's In My Lunchbox" program is useful. Farms: Dame Farm on Brown Ave. in Johnston, Watson Farm in Jamestown, and Coggeshall Farm in Bristol.

By the end of 2nd grade all students will know that --

Stories sometimes give plants and animals attributes they really do not have.

Suggested Activity:

Use a story and separate fact from fiction. Can animals really talk? Fairy tales, Disney stories, or Magic School Bus stories may all work well.

Embedded Assessment:	Children discuss how the story is different from reality.
Summative Assessment:	Compare a fantasy animal or plant (like Peter Rabbit or Roger Rabbit) to the real thing, or to actual photos.
Theme:	Models
Process:	Manipulating Information, esp. interpreting/evaluating data

From Ms. Andrews First Grade Class, Clayville Elementary School, Scituate ...

Ms. Andrews takes advantage of her first-graders interest in 'spooky' things during the week preceding Halloween. One afternoon following recess she and her class sat down to talk about bats. First students were asked what they knew about bats. As each child spoke in turn they had the chance to share with the class their knowledge and experience of bats. This evolved naturally into a discussion about the reputation of bats, and the diversity of bats (and 'bat-stories'!) around the world. Ms. Andrews was prepared with a variety of cardboard Halloween decorations depicting bats. She would hold them up as the discussion progressed, asking "does a bat really look like this?" or "why do you suppose haunted houses are always shown with bats?". Eventually the class agreed that many stories about bats, and many pictures of bats, have very little to do with real bats.
To focus and review the real-life attributes of bats, Ms. Andrews reads the non-fiction book Bats to the class. Students have the opportunity to comment on the facts presented in the book, and the general body of knowledge about bats continues to grow. As a culminating activity the class works together to label the anatomical features of a model brown bat.

THE LIVING ENVIRONMENT - Diversity of Life
Grade 3-5 (Benchmark 1 of 2)

By the end of 5th grade all students will know that --
A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group.

Suggested Activity:
Play "Guess My Rule". Using a collection of invertebrates (insects, crustaceans, mollusks, etc.) students group and regroup them according to 'rules' that make sense to them. Students use evidence, based on physical properties, to defend and explain their rules. This game could also be played using leaves, nuts, bark, shells, flowers, and so on. Explore how a supermarket is organized, and what the supermarket's 'rules' for grouping are.

Embedded Assessment:	Observe students to see if the 'rules' are based on physical properties and observable characteristics. Have students explain and justify their rules (classification) to other students. Have students develop a conceptual map of how items in a collection are related to one another.
Summative Assessment:	Given a collection of 10-15 animals (invertebrates) the students will group them in at least three different ways and explain the rules for their groupings.
Theme:	Constancy and Change, Systems
Process:	Manipulating Information, esp. classifying

If you are collecting marine organisms from the shore, remember that a Scientific Collectors Permit may be required if you collect out of season, illegal sizes or from restricted areas. If you have any doubts, please check with Dick Sisson of DEM at 277-3075.

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By the end of 5th grade all students will know that --

Features used for grouping depend on the purpose of the grouping.

Suggested Activity:

Students classify (group) a collection of plant foods obtained from the garden or the grocery store and explain how their groupings are personally useful.

Embedded Assessment:	Students explain the utility of their grouping.
Summative Assessment:	On a walk around the school building, the student(s) will group ten different plants identified by the teacher and explain their groupings based upon their degree of usefulness.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. classifying

By the end of 8th grade all students will know that --

One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods. Some kinds of organisms, many of them microscopic, cannot be neatly classified as either plants or animals.

Suggested Activity:

Students work in cooperative groups to design an imaginary microscopic organism. Drawings and explanations are presented to the class. Teams decide whether the organism is a plant or an animal based on the presentations. The teacher and students continually point out fine distinctions and may compare their creation to real organisms such as Euglena.

Embedded Assessment:	Observing whether students can defend their decision of plant or animal.
Summative Assessment:	Using the data gathered in the activity, students will identify the characteristics of plants and of animals and use them to characterize a mystery specimen* provided by the teacher.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. generating novel ideas

*Buying cultures of Euglena and paramecium is suggested for microscopic exam, you may not always get good results from pond water.

By the end of 8th grade all students will know that --

Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.

Suggested Activities:

Discuss food tube segmentation. Compare an earthworm's digestive system to the human system. Dissect earthworms and examine. As an alternative, computer simulation may be substituted for actual dissection.

Have students work in groups of four. Each group is given a different 'beak' (clothes pin, chopsticks, tweezers, spoon) and candies or other objects in a variety of shapes. The students are asked to fill their 'stomachs' (a paper cup) with as much food as possible. Discussion should be expanded to include environmental change and food shortages.

Place a cactus and ivy plant in two pots of the same size. Water plants equally. Observe the plants over a period of several weeks and discuss the results.

Embedded Assessment:	Students can relate the beak activity to different beaks possessed by real birds.
Summative Assessment:	Graphs are made to analyze the beak data, and an analysis of which beak is most efficient for each type of food is made. Given an example of an animal's jaw, the student will be able to infer the type of food the animal eats and something about how it moves.
Theme:	Systems
Process:	Manipulating Information, esp. developing generalizations

Use the 'WHAT'S IN MY LUNCH BOX' activity from Roger Williams Park Zoo. Along with curriculum materials a kit is provided which contains teeth, claws, feet and beaks from various animals.

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By the end of 8th grade all students will know that --

Similarities among organisms are found in internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.

Suggested Activity:

Working from similar size photographs or diagrams, make jigsaw puzzles of the wing bones from a bird; the arm bones from a man; the wing bones of a bat; and the flipper bones of a whale. Have students work cooperatively, one puzzle per group. The students need to guess what animal their puzzle depicts. A group discussion of homologous and analogous structures follows.

Embedded Assessment:	Given photos of bones the students can identify the type of animal they represent.
Summative Assessment:	The children note the similarities and differences among the four puzzles.
Theme:	Models
Process:	Manipulating Information, esp. identifying patterns and relationships

By the end of 8th grade all students will know that --

For sexually reproducing organisms, a species comprises all organisms that can mate with one another to produce fertile offspring.

Suggested Activity:

Do fruitfly mating of different genetic mutants (available from numerous biological supply houses). The teacher explains genetic mating and a Punnett Square.

Embedded Assessment:	Children can identify the different types of fruit flies resulting from mating and do a simple Punnett Square.
Summative Assessment:	The student's ability to interpret Punnett Squares.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. making testable predictions

By the end of 8th grade all students will know that --

All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment.

Suggested Activities:

Set up a pond water system - plankton, fish, snails. Make observations over a period of time.

Set up a mini ecosystem using glass jars, metal lids, soil and 2 or 3 plants (no animals) tightly sealed. Date and set in sunlight (or window sill). Students record observations over entire school year. Demonstrate photosynthesis and explore its role in ecosystems.

Embedded Assessment:	Discuss the making of an ecosystem, what is necessary and what is needed to sustain it.
Summative Assessment:	Relate the mini-ecosystem to the real world.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

Illustrate a food web by making a large mural and making connections with string.

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By the end of 12th grade all students will know that --

The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions, and a great diversity of species increases the chance that at least some living things will survive in the face of large changes in the environment.

Suggested Activities:

Group study of -- a) geologic time column; b) map diagrams of earth surface changes; c) paleontological map diagrams of fossil forms; d) peppered moth (Biston betularia) diversity response; e) dinosaur-bird relationship.

Video studies of earth history, species diversification, cell diversification, Charles Darwin, "Life on Earth" by David Attenborough.

Embedded Assessment:	Students should discover that diversification and adaptation are constant features throughout time uniformentarianism). Students should be aware of subtraits within groups of species and that both temporary and permanent environmental change lead to divergent selective traits for survival.
Summative Assessment:	Research (written paper, journal writing) on trait diversity in life forms due to changes in climate, plate tectonics, human activity (e.g., accelerating extinctional rates in recent centuries).
Theme:	Continuity and Change
Process:	Manipulating Information

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By the end of 12th grade all students will know that --

The degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification based on anatomical similarities.

Suggested Activity:

Suggested prediscussion of terms and techniques to include DNA, gel electrophoresis, DNA typing. Teacher produces simulated DNA sequences for 5 organisms (incl. man) from various phyla. Groups of students (or individuals) are presented with DNA sequences and attempt to recognize similarities between organisms by correlations in DNA patterns.

Embedded Assessment:	Students recognize organisms which are closely and distantly related.
Summative Assessment:	**New DNA simulations can be created by the student after they have been given a description of a 'new' organism. Such simulations indicate student understanding of 'closeness' or 'distance' from already examined DNA sequences.**
Theme:	Constancy & Change
Process:	Manipulating Information, esp. identifying patterns and relationships

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By the end of 2nd grade all students will know that --

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

Suggested Activities:

Allow students to experience or examine similar or different games, clothing, colors, heights, etc. Play twenty questions with graphic representation. Take a walk near the school. Look at similar plants (such as trees, flowers or shrubs) and note the similarities and differences within populations.

Embedded Assessment:	Sort seeds, sort buttons
Summative Assessment:	Sort seeds for subtle differences. Bring in a picture of the person you most resemble and write a story about how you look alike.
Theme:	Constancy and Change
Process:	**Experimental Proficiency, Language Proficieny, Mathematical Proficiency**

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By the end of 2nd grade all students will know that --

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

Suggested Activity:

Given pictures of humans, other animals or plants, students will recognize similarities and differences.

Embedded Assessment:	Students should recognize the similarities and the differences among related beings.
Summative Assessment:	A discussion of how siblings are both similar to and different from their parents and each other.
Theme:	Constancy & Change
Process:	Manipulating Information, esp. interpreting/evaluating data

By the end of 8th grade all students will know that --

In some kinds of organisms, all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent.

Suggested Activities:

Tongue curling, ear lobe pedigrees. Have students observe root plant cuttings.

Embedded Assessment:	Children are able to correctly test themselves in class and note differences between themselves and classmates.
Summative Assessment:	Children are able to test and chart relations at home and share pedigree information later in class. (Teachers need to be sensitive to non-traditional families with this activity).
Theme:	Constancy and Change
Process:	Experimental Proficiency

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By the end of 8th grade all students will know that --

In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male. As the fertilized egg, carrying genetic information from each parent, multiplies to form the complete organism with about a trillion cells, the same genetic information is copied in each cell.

Suggested Activities:

Using either picture graphics or models (preferable) present information about sexual reproduction and cell development (eucaryotic) from blastula to gastrula to complete organism. Discuss necessity for differentiation and advantages of specialization for multicellular organism. Use the appropriate segment of the PBS video, "The Universe Within."Optional: discuss differentiation in clonal development and dedifferentiation in cancer development, as well as new reproductive technologies.

Embedded Assessment:	Students interest in and contribution to the discussion.
Summative Assessment:	Students are able to demonstrate either verbally or in writing a basic understanding of sexual reproduction and multicellular organismal development and specialization. They are also able to relate these concepts to their own life and development.
Theme:	Constancy and Change
Process:	Language Proficiency

Collect newspaper and journal articles on the new technologies. Divide the class in half for a debate on the costs/benefits of pursuing these technologies, of making them accessible to the public. All points should be supported with documentation.

By the end of 8th grade all students will know that --

New varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits.

Suggested Activity:

Challenge children to list some pets, garden plants, vegetable and flowers, fruit trees, etc. that they are aware of in their own lives. For example, seedless grapes, new tulip varieties, Himalayan cats, racehorses that result from selective breeding. Discuss the results of this breeding, both advantages and disadvantages. Different types of maize (corn) can also be obtained from a biological supply company - students can plant seeds to see the results of some selective breeding.

Embedded Assessment:	Students ability to name some examples of selective breeding that they are aware of in their own lives; students ability to grow and recognize maize (corn) selective breeds.
Summative Assessment:	Students can discuss in detail pros and cons of selective breeding and relate this practice to everyday life.
Theme:	Constancy & Change
Process:	Experimental Proficiency

For a discussion on Dutch Elm disease, contact Paul Dolan at DEM. Information about animal and plant breeds from Colonial days can be obtained from Roger Williams Park Zoo or Plimoth Plantation (1-508-746-1622, ext. 356) in Massachusetts.

By the end of 12th grade all students will know that --

Some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious.

Suggested Activity:

Suggested prediscussion of various types of mutation such as deletion and transposition. Students are presented with a human DNA fragment representing a normal gene and are asked to determine the amino acid sequence. New DNA fragments are transcribed and then translated to determine the order of amino acids. Students note any differences when comparing the new fragments to the original. Students describe what effects they think will result from the changes. (Contact Pam Fontaine at LaSalle Academy in Providence for more details on this activity.)

Embedded Assessment:	Students are able to recognize changes between the original and new fragments and are able to transcribe and translate the DNA to an amino acid.
Summative Assessment:	New DNA fragments are given to students to take home, examine and compare to normal DNA fragments. Students must identify the mutated fragment, mark the region of mutation and explain why they believe the fragment to be mutated.
Theme:	Constancy & Change
Process:	Manipulating Information

Use DNA/RNA model kits and codon charts to illustrate these areas.

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By the end of 12th grade all students will know that --

The sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents.

Suggested Activity:

Students will work in pairs. They will be given a list of at least 12 different physical characteristics. A chart will describe the phenotype of homozygous dominant, recessive and heterozygous conditions. Students assume they are parents who are heterozygous for each trait listed. Both students flip coins to determine the genotype of their child - 2 heads homozygous dominants, 1 head 1 tail a hybrid, etc. When finished obtaining data, each pair of parents will draw their offspring. Class will compile a list of gene frequencies for each trait listed.

Embedded Assessment: Students are able to flip the coins and determine whether the offspring are homozygous dominant, homozygous recessive, etc. and predict offspring phenotype. Drawing of 'child' accurately reflects coin data.

Summative Assessment: Students can examine display offspring, counting frequency of the 12 traits. Students decide the frequency (4/12, 6/12,etc.) of traits and determine which trait is dominant, etc. and compare with expected phenotypic ratios.

Theme: Constancy and Change

Process: Manipulating Information, esp. interpreting/evaluating

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By the end of 12th grade all students will know that --

The information passed from parents to offspring is coded in DNA molecules.

Suggested Activities:

Students are given a specific segment of DNA and they duplicate it to produce identical sequences. Students then create their own 3-D models of both the original fragment and the replicated pair.

A second activity is to show students how to construct a Punnett square for height in pea plants (Tt), ABO blood groups (dominant, recessive and co-dominant), cystic fibrosis, etc.

Embedded Assessment:	Students recognize that in this case the original DNA fragment was copied exactly into 2 new strands.
Summative Assessment:	Teacher presents the background of a specific disease such as PKU to the students. The gene fragment with the mutation is compared to the normal sequence by the students. Students discuss the difference(s) between the 'normal' and 'PKU' fragment in writing. Students describe the amino acid change(s) in the PKU fragment as compared to the normal and correctly surmise that gene changes must have been present in the parental DNA.
Theme:	Constancy and Change
Process:	Manipulating Information

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By the end of 12th grade all students will know that --

Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.

Suggested Activity:

Teacher pre-discusses STOP codons and their relationship to mutations. Students are given two very similar gene fragments. One fragment differs from the other only in one base (A for T, for example). Students determine the codon sequence for each fragment, noting that both gene fragments code for the same amino acids. Two new gene fragments are given to students with one fragment differing from the other in only one amino acid again (different location). Students determine the codon sequence for each fragment, noting that this time there is a change in the coding of amino acids.

Embedded Assessment:	Students recognize that small alterations in DNA sequences may have no or some effect on the resulting amino acid sequence.
Summative Assessment:	**Students are presented with four new DNA fragments, one coded as 'original', and sequence the amino acids. Students are asked to predict whether the changes from the original will have no, little, or deleterious effect based on prior knowledge and experience.**
Theme:	Constancy and Change
Process:	Manipulating Information

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By the end of 12th grade all students will know that --

Gene mutations can be caused by such things as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring; if they occur in other cells, they can be passed on to descendant cells only. The experiences an organism has during its lifetime can affect its offspring only if the genes in its own sex cells are changed by the experience.

Suggested Activity:

Students research one particular somatic and one particular germ cell mutation.

Embedded Assessment:	Student understands the concept of mutation and can distinguish between germ and somatic cell changes.
Summative Assessment:	Four examples of mutations provided by student research are presented to other students. Students must determine which are germ and which are somatic mutations and must defend their choices.
Theme:	Constancy and Change
Process:	Manipulating Information

Contact a Genetic Counselor (Dr. Dianne Abuelo at Rhode Island Hospital, 444-8361) to use as a resource. Have the class read and discuss Rachel Carson's Silent Spring in terms of gene mutations due to toxic chemicals.

By the end of 12th grade all students will know that --

The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different genes are turned on and other genes are repressed as cells develop and specialize.

Suggested Activity:

Carrot callus and differentiation media can be ordered from biological supply houses and students can see that a mature specialized cell can give rise to a new carrot embryo clone just as a carrot seed can. The teacher can show liver, skin, lung, etc. and then raise questions about how these specialized cells all developed from the same fertilized egg. A visit to a histology and/or cytology laboratory could also be scheduled.

Embedded Assessment:	Students actively participate in discussion and raise pertinent questions about how genes are turned on and how they are repressed.
Summative Assessment:	Students are able to generalize this concept to fetal development, plant cloning and such pathological processes as cancer.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. developing generalizations

By the end of 8th grade all students will know that --

All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.

Suggested Activity:

Examine plant, animal and bacterial cells using microscope and prepared slides (or alternatively microviewers). Students should draw and label these different cells or label prepared diagrams about how these cells differ from each other and how they are similar. Have students prepare their own slides of cells.

Embedded Assessment:	Students are able to recognize similarities and differences between procaryotes (bacteria) and eucaryotes (plants and animals).
Summative Assessment:	Presented with several slides of plant, animal and bacterial cells which are unfamiliar, students can correctly identify the appropriate kingdoms.
Theme:	Systems
Process:	Experimental Proficiency

By the end of 8th grade all students will know that --

Cells continually divide to make more cells for growth and repair. Various organs and tissues function to serve the needs of cells for food, air, and waste removal.

Suggested Activity:

Examine yeast cultures (such as used in micro-breweries) to show cell growth (budding) and division; Planaria culture - part of planaria can be cut off and the planaria will regenerate.

Embedded Assessment:	Students observe and describe how the yeast culture grows and divides. Students observe and describe how planaria regenerates.
Summative Assessment:	Students are able to write a small report complete with diagrams about the similarities and differences between single cell growth (yeast) and multicellular (planaria) growth and replacement. Other questions - such as how long the yeast culture took to divide vs. regeneration of planaria can be asked.
Theme:	Scale
Process:	Experimental Proficiency

Teams of students, in cooperation with the culinary arts/cafeteria staff, should make their own bread. Select different recipes where rising time for yeast varies. Students should observe, time and record time cycles for the rising process and the conditions that affect them. Students should chart the relationship between the variables. A visit to a local bakery/restaurant should be included so students understand the impact of this timing process in the workplace and for employees who rise before dawn.

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THE LIVING ENVIRONMENT - Cells
Grade 6-8 (Benchmark 3 of 4)

By the end of 8th grade all students will know that --

Within cells, many of the basic functions of organisms--such as extracting energy from food and getting rid of waste--are carried out. The way in which cells function is similar in all living organisms.

Suggested Activity:

Set up 3-4 yeast cultures using the same amount of water (e.g., 100 ml, 200 ml, or 500 ml) in each of the 3-4 beakers. Then vary the amount of sucrose (table sugar), 1 gram in 1 beaker, etc. Students describe growth density of yeast over 2-3 day period. Students then draw conclusions concerning food availability and waste build-up on the yeast culture growth. Collect data and graph results.

Embedded Assessment:	Students are able to read and follow directions on how to set up cultures.
Summative Assessment:	Students are able to describe the growth differences between the cultures. Students are also able to relate the culture's growth to environmental problems of food availability, population growth and waste removal.
Theme:	Models
Process:	Experimental Proficiency

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By the end of 8th grade all students will know that --

About two thirds of the weight of cells is accounted for by water, which gives cells many of their properties.

Suggested Activity:

Using onion cells (peel thin layer from onion) have students treat the onion cells on microscope slides with water; isotonic saline; hypertonic saline solution. Students observe the effect each solution has on their onion cells (using the microscope). Using potato slices in 3 solutions, demonstrate turgor pressure and compare to what may happen in animal cells.

Embedded Assessment:	Students are able to follow directions, make three different onion cell slides, treat them with respective solutions and note the results from the water, isotonic and hypertonic solutions.
Summative Assessment:	The students are able to correctly describe and discuss their results. They can generalize about cell structures (cell wall) that are needed to protect cells from the environment.
Theme:	Systems
Process:	Experimental Proficiency

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By the end of 12th grade all students will know that --

Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape and, for animal cells, movement.

Suggested Activity:

Students cut a certain length of dialysis tubing closed at one end with string and filled about half full of starch solution (known quantity). A beaker of water (known quantity) is prepared. Dialysis tubing is closed with string and placed in beaker. After 24 hours, the dialysis tubing is examined for change in volume (by eye), tube is cut open and contents measured. The contents of the beaker are also measured. The water solution may be colored to show the movement. Various solutions may be tried to show that some molecules (due to size) cannot move in and out of dialysis membrane. The starch solution may be placed in the beaker and the water in the dialysis tubing to reinforce this concept.

Embedded Assessment:	The student successfully observes changes in volume in beaker and tubing and identifies movement of solution either in or out.
Summative Assessment:	Students repeat experiment using unknown protein or other solution. The students can make hypotheses about the cause of solution movement or lack of movement.
Theme:	Models
Process:	Manipulating Information, esp. inferring

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By the end of 12th grade all students will know that --

Within the cell are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, information feedback, and even movement. In addition to these basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not.

Suggested Activities:

Students observe and draw a variety of single-celled organisms or single cells in tissue (paramecium, Euglena, onion, etc.). Students observe various organelles and the similarities and differences between specimens. Use relevant portions of the PBS video, "The Universe Within."

Embedded Assessment:	Students successfully identify common and different characteristics in the biological samples.
Summative Assessment:	**Students are asked to develop an organism suited to a particular environment (selected by the teacher). Organelles should be listed and then a description given which explains the survival benefit of each organelle.**
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. creating/ testing mental models

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By the end of 12th grade all students will know that --

The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino-acid molecules. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes is a consequence of attractions between the amino acids in the chain.

Suggested Activity:

Use transparencies (overhead) to show students the structure of different proteins (egg albumin, insulin, hemoglobin) in their active shape. Take fresh egg albumin (egg white) and heat it up. Students should record observed changes in albumin. Using fresh egg albumin, place the albumin in dilute HCl (0.1M). Students should record observed changes in albumin. Teacher then discusses how heat, acid, etc. can break H-bonds in proteins, resulting in denaturation which causes a change in protein shape and consistency.

Embedded Assessment:	Students are involved in the activity and the discussion. They can make correct assessments about the experimental results.
Summative Assessment:	**The students are able to generalize about other environmental effects on proteins (i.e., how UV light and sunburn affect their skin) in writing.**
Theme:	Models
Process:	Developing Explanatory Frameworks

By the end of 12th grade all students will know that --

The genetic information in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms.

Suggested Activity:

Using DNA/RNA/Protein model kits (from a biological supply house) the students are given a particular DNA sequence (nonsense strand). The students, working in pairs or small groups, must build the DNA model, the m-RNA and finally must construct the protein (students are also given a codon sheet).

Embedded Assessment:	Students are able to take a DNA sequence from given information and build it, along with its complementary strand - make the correct m-RNA and then determine the sequence of amino acids coded for by the m-RNA.
Summative Assessment:	**The students are able to describe and discuss DNA synthesis, transcription and translation. If they make a mistake in their model building they can generalize about the consequences (mutations) if the mistake was made in a real cell.**
Theme:	Models
Process:	Developing Explanatory Frameworks

By the end of 12th grade all students will know that --

Gene mutation in a cell can result in uncontrolled cell division, called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.

Suggested Activity:

Using DNA/RNA model kits and codon charts, students will be given a DNA sequence to construct (30-45 DNA nucleotides). Then they will construct the m-RNA and the final protein. Students will then be asked to make a transversion, substitution and deletion somewhere in the original DNA and then show the changes which occur in the RNA and final protein. Since class members can choose the locations of their mutations, final class results will vary. A class summary can be prepared.

Embedded Assessment:	Students observe a relationship between DNA mutations and the structure of the final protein.
Summative Assessment:	Using class data students will be asked to explain which mutations in DNA have the most profound effect on the final protein structure and must defend their position.
Theme:	Models
Process:	Experimental Proficiency, esp. identifying variables

Purchase irradiated and non-irradiated seeds from a biological supply house. Investigate the implications of ingestion of various chemicals, pesticides, etc. Class groups should do research using computer resources, interviews (with dietitians, oncologists, nutritionists) on various types of cancer. This should culminate in a jigsaw sharing which would not only detail various possible cancer causes/effects, but also emphasize some already discovered cancer prevention strategies.

By the end of 12th grade all students will know that --

Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules. Even small changes in acidity can alter the molecules and how they interact. Both single cells and multicellular organisms have molecules that help to keep the cell's acidity within a narrow range.

Suggested Activity:

Have students conduct an experiment involving BOD (biological oxygen demand) using methylene blue or similar indicator (bromthymol blue) with yeast in milk. Use 3 temperatures: 20°C, 37°C, 55°C. Have student note differences in oxidation as function of temperature - and at higher temperature, denaturation effects should be noted. For another activity use similar yeast cultures (3) and vary pH using levels of 7.0, 5.0, and 2.0.

Embedded Assessment:	**Students are able to observe that changes in pH and temperature directly affect the ability of the yeast cells to effectively oxidize methylene or bromthymol blue.**
Summative Assessment:	When students are presented with a new hypothetical situation such as yeast culture kept at a narrower temperature (or pH) range, students are able to predict what will happen to the yeast cultures and can defend their predictions.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. identifying patterns and relationships

By the end of 12th grade all students will know that --

A living cell is composed of a small number of chemical elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules.

Suggested Activity:

Students can create a variety of organic molecules using model kits, gumdrops and toothpicks, etc.

Embedded Assessment:	Students understand the basis of organic molecules and can construct molecules with appropriate numbers of atoms and bonds.
Summative Assessment:	Students construct an organic ring molecule at home and explain its structure.
Theme:	Models
Process:	Psychomotor Proficiency

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THE LIVING ENVIRONMENT - Interdependence of Life
Grade K-2 (Benchmark 1 of 2)

By the end of 2nd grade all students will know that --

Animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting.

Suggested Activity:

Construct a food chain. Construct a habitat which includes the animals' food, shelter and water. Take a walk and collect materials an animal might use to build a nest. Examine ant farms.

Embedded Assessment:	Explain the choice of materials for the nest.
Summative Assessment:	**Given an animal's habitat, students will explain the relationship between plants and animals.**
Theme:	Systems
Process:	Experimental Proficiency, esp. observing

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THE LIVING ENVIRONMENT - Interdependence of Life
Grade K-2 (Benchmark 2 of 2)

By the end of 2nd grade all students will know that --

Living things are found in a variety of places everywhere in the world. There are different kinds of living things in different places.

Suggested Activity:

Take students to a woodland area (or a field, the beach, a backyard, etc.). Students will observe living things under a rock, in a tree, and on the edge of a pond or stream.

Embedded Assessment:	Make a terrarium in the classroom with the help of the students and ask students to describe features and changes they observe.
Summative Assessment:	Provide a picture of habitat and ask students to explain who lives on land, water, and air. Explain how they survive.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. developing generalizations

THE LIVING ENVIRONMENT - **Interdependence of Life**
Grade 3-5 (Benchmark 3 of 5)

By the end of 5th grade all students will know that --
Organisms interact with one another in various ways besides providing food. Many plants depend on animals for carrying their pollen to other plants or for dispersing their seeds.

From Ms. Arruda's Fifth Grade Class, Babcock Middle School, Westerly ...

By the end of 5th grade, students should know something about the life cycle of plants and how they interact with one another in various ways besides providing food. To help students explore how some organisms satisfy their environmental needs, Ms. Arruda uses the "Exploring with Wisconsin Fast Plants" kit, produced by the Department of Plant Pathology at the University of Wisconsin-Madison and distributed by Carolina Biological Supply Company. The kit comes complete with all the necessary materials to grow 'fast' plants.

This nickname is appropriate, seeing that it only takes 28 days for these Brassica plants to complete their entire life cycle. This kit enables students to experience a plant's complete life style, beginning with a seed and ending with the development of a new seed, which encouraging students to actively participate in the plant's life cycle. For example, students actually use a bee body (attached to a toothpick) to cross pollinate the plants. They rub the thorax of the bee into the flower gathering pollen, then rub the pollen onto the flower parts of another flower, thus cross pollinating the plants. The students absolutely love learning about plants in this manner, and the activity orientation of the lessons helps to make them positive and meaningful.

Embedded Assessment:	Students can explain the process of pollination using their actions in the lab as an analogue.
Summative Assessment:	Students can identify three examples within their environment which illustrate the elements of this benchmark and explain their selections.
Theme:	Models
Process:	Experimental Proficiency, Psychomotor Proficiency

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THE LIVING ENVIRONMENT - Interdependence of Life
Grade 6-8 (Benchmark 1 of 2)

By the end of 8th grade all students will know that --

In all environments--freshwater, marine, forest, desert, grassland, mountain, and others--organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions.

Suggested Activity:

Give each team of students 2 petri dishes. Place wet paper towels on the bottom of the petri dishes. Place 6 to 8 seeds in one dish, place 30-40 seeds in the other. Make sure watering is equal and minimal.

Embedded Assessment:	Predict development in each petri dish and justify your reason.
Summative Assessment:	Explain why a farmer plants 4/5 seeds per hill and later returns to thin seedlings. Why didn't he just plant 1 seed per hill? Why did he not let all the seedlings remain?
Theme:	Systems
Process:	Manipulating Information, esp. connecting new information with previous knowledge

Take a trip to the zoo. Observe animals that share the same environment and those that are housed alone. Discuss observations. Use the activity "Quick Frozen Critters" from Project Wild (contact Chris Dudley at 783-7490). Contact URI's Learning Landscape at 792-2900 for relevant environmental education programs.

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THE LIVING ENVIRONMENT - Interdependence of Life
Grade 6-8 (Benchmark 2 of 2)

By the end of 8th grade all students will know that --

Two types of organisms may interact with one another in several ways: they may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

Suggested Activity:

Videos (e.g. National Geographic series), pictures, photographs, nature walks. Utilize any or all of the above to identify relationships.

Embedded Assessment:	Identify and label relationships in each activity.
Summative Assessment:	Given a list of randomly organized names or organisms, have students match organisms and describe or label their relationship.
Theme:	Systems
Process:	Manipulating Information, esp. identifying patterns and relationships

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By the end of 12th grade all students will know that --

Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one.

Suggested Activity:

Students research a well-known ecological disaster (such as Mt. St. Helen's eruption, DDT and bird populations, mid-Western floods of '93, Yellowstone Fire, or other current events). Research should discuss damage to ecosystem and recovery progress to date.

Embedded Assessment:	Students demonstrate understanding of ecosystems and effects of change on such systems and system recovery.
Summative Assessment:	Teacher provides ecosystem and change which affects it. Students are asked to predict recovery or decline of ecosystem over a defined period.
Theme:	Constancy & Change
Process:	Problem Solving Proficiency

By the end of 12th grade all students will know that --

Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution.

Suggested Activity:

Students are presented with a summary of the gypsy moth infestation of the early 1980's. Students are asked to interview older family members, friends, community members about the infestation. Students will record such information as gypsy moth numbers, moth physical appearance, damage to bushes and trees, refoliation of trees, home remedies to kill moths, town remedies. Conduct related discussions of deer tick and 'killer' bee populations.

Embedded Assessment:	Students understand the nature of the infestation by using primary and secondary sources and successfully record information.
Summative Assessment:	Students are to respond to the questions, "Do you believe another infestation is possible?" and defend their response. If there was another infestation, what would they do to control the infestation?
Theme:	Constancy & Change
Process:	Proficiency in Reaching Decisions About Issues

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From Mr. Rapose
Pilgrim High School
Warwick, Rhode Island
High School Activity

The Two Liter Ecosystem

In this activity students observe, record and create hypotheses while experimenting with a self-contained ecosystem in a two liter bottle. To begin the activity the teacher must collect bean, tomato, squash and pea seeds, potting soil, and clear two liter bottles. The seeds should be germinated by laying them on a wet paper towel cut to fit inside a petri dish. Two of each type of seed should be germinated in each petri dish, which should be placed in a sunny area for about a week. Once the plants begin to sprout the students plant one of teach type of seed in an open two liter bottle (cut the top half off). Students should be given a fixed amount of soil and water to be used in their ecosystem. The seeds should be planted in the bottle about one inch deep in the soil. The bottles are then sealed by re-joining the top half to the bottom with clear tape.

Over the course of about four weeks students make daily observations of any action occurring in their ecosystem. They record changes such as the movement of water inside the bottle (water cycle) and the rate of plant growth. They may observe that some plants will flourish, while others will die out. As they work together in groups they may discuss things such as evaporation, cloud formation, plants bending toward the sunlight, and the effect of gases on the ecosystem. I use the ecosystem activity to introduce many ecological ideas, such as limited resources, competition, and the hydrological cycle.

By the end of the fifth week the ecosystem begins to break down, and students can observe the growth of molds and the browning of the plant leaves. At this point students are asked to speculate why their once healthy ecosystems are beginning to decay. In some of the ecosystems small bugs begin to appear. This always amazes the students.

As the ecosystem continues to break down, students work in teams to create a report explaining what they learned from the activity. I supply them with some leading questions and help them get started.

By the end of 12th grade all students will know that --

Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

Suggested Activity:

Have students choose a local issue of interest. Divide the group into different roles. Have them take on identities as foresters, developers, store owners, and environmentalists. See if they can work out use of the land so that it is environmentally balanced. The results of this activity will be class adoption of a problem that needs to be addressed. Student teams will devise a plan of action based on scientific knowledge, survey of existing research, and action steps. This will be a jigsaw cooperative learning opportunity. Major responsibility areas should include research, interview, follow-up, document preparation, and presentation to community groups.

Embedded Assessment:	Students are able to recognize the effect of human activity on ecosystems and can contemplate repairing any damage to the ecosystem.
Summative Assessment:	Students interview a person in their school or community regarding potential ecological hazards existing in the individuals school, business, town. Student reports findings orally to class. Students also report on human activity within a community which has had a positive effect on a local ecological community.
Theme:	Systems
Process:	Proficiency in Informed Action

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By the end of 8th grade all students will know that --

Food provides the fuel and the building material for all organisms. Plants use the energy from light to make sugars from carbon dioxide and water. This food can be used immediately or stored for later use. Organisms that eat plants break down the plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.

Suggested Activities:

Energy and Biomass Pyramids: assign each group of students an ecosystem and have them develop pyramids for their system.

Grow 2 sets of bean seeds, one on the classroom windowsill and one in a dark closet. Keeping all other variables equal, observe differences and similarities.

Embedded Assessment:	Construct and compare energy and biomass pyramids for their given ecosystem.
Summative Assessment:	Have students imagine they are eating a fast food hamburger. Have them trace the materials and the energy back through the food chains.
Theme:	Systems
Process:	Manipulating Information, esp. identifying patterns and relationships

By the end of 8th grade all students will know that --

Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change.

Suggested Activity:

Biomass Pyramid: trace matter - take the biomass pyramid developed in Benchmark 1 of 3 in this section and trace what happens to matter as it moves through the pyramid.

Embedded Assessment:	How does this principle apply to the biosphere?
Summative Assessment:	Have students imagine they are eating a fast food hamburger. Have them trace the materials and the energy back through the food chains.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking concepts and principles

By the end of 8th grade all students will know that --

Energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight.

Suggested Activity:

Biomass Pyramid: trace matter - take the biomass pyramid developed in Benchmark 1 of 3 in this section and trace what energy transfer and loss happens.

Embedded Assessment:	Check to see that students can explain that energy can be changed to heat/movement or transferred to another organism in the chain.
Summative Assessment:	Have students imagine they are eating a fast food hamburger. Have them trace the materials and the energy back through the food chains.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking concepts and principles

By the end of 12th grade all students will know that --

At times, environmental conditions are such that plants and marine organisms grow faster than decomposers can recycle them back to the environment. Layers of energy-rich organic material have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. By burning these fossil fuels, people are passing most of the stored energy back into the environment as heat and releasing large amounts of carbon dioxide.

Suggested Activity:

A speaker from Narragansett Electric speaks to the class about coal-generated electricity, renewable and non-renewable resources, use of electricity in the home. Included will also be a discussion of the waste generated by burning coal. Video should be shown to class regarding fossil fuel electricity generation. The issues of fuel consumption, waste generation, electricity consumption should be included in a class discussion.

Embedded Assessment:	Students understand how electricity is produced from fossil fuels and the implications to the environment from consumption of fossil fuels.
Summative Assessment:	Student writes a short paper which relates fossil fuel consumption to the average temperature of the earth and the overall 'greenhouse' effect.
Theme:	Systems
Process:	Proficiency in Informed Action, esp. describing current practice/policy

By the end of 12th grade all students will know that --

The amount of life any environment can support is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow and reduce the fertility of the land.

Suggested Activities:

Each pair of students prepares a 2L soda bottle 'growing system' to contain potting soil, radish plants, or other 'fast' plants. The teacher prepares various dilutions of standard houseplant fertilizer. Each pair of students receives a different dilution of fertilizer. All the bottles receive the same amount of sunlight, heat, water, and fertilizer. Students observe open bottles over a designated period recording germination time, height, leaf size, leaf color, and the death of the plant (if applicable). At the end of the experiment, students pool and graph class data for concentration of fertilizer versus other characteristics.

As an additional activity have each pair of students prepare a 2L soda bottle with potting soil, water, grass clippings, and leaves (preferably dry) on top of the soil. Bottles are left open and observed over a designated period to document changes in the clippings and leaves.

Embedded Assessment:	Students properly tend 'gardens' and understand the relationship between fertilizer concentration and growth and health of plants.
Summative Assessment:	Students construct and explain graphs and decide optimum (best) concentration of fertilizer for each characteristic. Students explain how overfertilization can be injurious to plants and how dependence on artificial fertilizers eventually depletes the land.
Theme:	Systems
Process:	Developing Explanatory Frameworks

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By the end of 12th grade all students will know that --

The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.

Suggested Activity:

Teacher generates carbon cycle by proposing to students that a single C atom can be recycled time and time again. By question and answer, students generate movement of carbon from one organic molecule to another until the carbon moves through the entire cycle. Teacher must stress that the cycle is driven by the sun.

Embedded Assessment:	Students understand the C cycle and how the cycle is driven by the sun.
Summative Assessment:	Students attempt to determine the water cycle using prior knowledge and the description of the C cycle. Students write a summary of the path of a single molecule of water through a cycle.
Theme:	Systems
Process:	Manipulating Information, esp. identifying patterns and relationships

A good reference for this benchmark is the Education in Global Change project, Joseph P. Stoltman, Department of Geography, Western Michigan University, Kalamazoo, MI 49008-5053; (616) 387-3429. Curriculum materials on global change developed under the auspices of the International Council of Scientific Unions.

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By the end of 2nd grade all students will know that --

Different plants and animals have external features that help them thrive in different kinds of places.

Suggested Activity:

Match animals and plants with environments such as cactus with desert; fish or seaweed with water; polar bear with snow; banana tree or monkey with tropics; elephant or grass with plains. Given a habitat and basic body, students can be asked to choose features and 'build the bird' or 'build the tree'.

Embedded Assessment:	Students note characteristics and/or features that help them live in that environment.
Summative Assessment:	Construct a home for a bird and write a story about how the home protects the bird. Compare the home of a bird with the home of a cat.
Theme:	Systems
Process:	Language Proficiency

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THE LIVING ENVIRONMENT - Evolution of Life
Grade 6-8 (Benchmark 1 of 3)

By the end of 8th grade all students will know that --

Small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors.

Suggested Activity:

Discuss examples of the selective breeding of plants and animals for a particular use (e.g., sheep - meat vs. wool, horses - speed vs. power). Disease resistant food crops. Have a horticulturist visit your school with different plants.

Embedded Assessment:	See if students have examples from their experiences.
Summative Assessment:	There is a $100,000 reward for the first person to develop a black tulip. Explain the biological processes you would use to attempt to win this prize. These tulips must be able to produce further generations of black tulips.
Theme:	Constancy and Change
Process:	Developing Explanatory Frameworks, esp. linking concepts and principles

By the end of 8th grade all students will know that --

Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.

Suggested Activity:

Take a variety of seeds (e.g., corn, beans, etc.) and upon germination transplant into 2 containers. Put 1/2 in a different environment from the original and observe the changes.

Embedded Assessment:	Have students keep a daily record of changes in seedlings. Write up a lab report after a specified time.
Summative Assessment:	Your community has experienced many years of Gypsy moth infestation. Describe this forest's composition of trees 5 years later.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. interpreting and evaluating data

By the end of 8th grade all students will know that --

Many thousands of layers of sedimentary rock provide evidence for the long history of the earth and for the long history of changing life forms whose remains are found in the rocks. More recently deposited rock layers are more likely to contain fossils resembling existing species.

Suggested Activity:

Search for sandstone, shale and slate rocks in your area. Examine them for fossils. Prepare a baby food jar with a screw top lid. Inside place equal amounts of clay, sand, gravel, and pebbles. Add water, and shake vigorously. Students should allow it to settle.

Embedded Assessment:	Have students draw a cross section (labeled) to show which layer settled first, second, etc.
Summative Assessment:	You are helping dig a hole in your yard for a basketball hoop - while digging you uncover assorted animal remains. Describe the system that you would use to determine which was the oldest and which was the youngest.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. inferring

By the end of 12th grade all students will know that --

The basic idea of biological evolution is that the earth's present-day species developed from earlier, distinctly different species.

Suggested Activity:

Lecture/discussion on evolution (e.g., from single cells to porifera to coelenterates to worms to echinoderms to chordates). Stress one particular system, such as the evolution of the circulatory system from contractile vessel (worms) to 2 chambered heart (fish) to 3 chambered heart (amphibians) to 4 chambered heart (birds, mammals).

Embedded Assessment:	Students will be able to discuss current understanding the evolutionary relationship of major groupings of the animal world.
Summative Assessment:	Students will be able to create an evolutionary tree diagram, which depicts six different organisms and their assumed evolutionary relationship to each other.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. developing generalizations

By the end of 12th grade all students will know that --

Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another.

Suggested Activities:

Students are presented with paper strips containing amino acid sequences of closely related species such as man, chimpanzee, gorilla, orangutan, etc. Students 'correlate' strips, noting similarities and differences between the DNA strips and determine the degree of correlation between them. Explore with students in a general way the limitations of this technique.

An additional activity would be to use an overhead and/or handouts to show an evolutionary tree constructed from the number of amino acid differences between cytochrome C (a highly conserved protein) molecules of different species -- going from plants to fungi to mammals.

Embedded Assessment:	Students recognize that some of the species are more genetically related than others because of the degree of correlation.
Summative Assessment:	**Students are presented with another paper strip of an organism related to man. Students are to determine the degree of correlation to man and the other organisms studied previously. Students must decide which organism studied is closest, in an evolutionary sense, to the 'unknown' and defend their choice.**
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. making testable predictions/attempting refutations

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By the end of 12th grade all students will know that --

Natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.

Suggested Activity:

In a local field situation, students observe as many examples of coloration in a particular species as possible in one habitat. Students should postulate as to the various advantages, disadvantages of certain colors in a particular species.

Embedded Assessment:	Students will organize observations and derive meaningful conclusions concerning them.
Summative Assessment:	Students are to consider the fact that over time, Rhode Island is affected by global warming. Students are to discuss in writing the possible adaptations which might be manifested in plant and/or animal species in Rhode Island. An optional activity might be a laboratory exploration of bacterial resistance to antibiotics.
Theme:	Systems
Process:	Proficiency in Reaching Decisions about Issues

By the end of 12th grade all students will know that --

Heritable characteristics can be observed at molecular and whole-organism levels--in structure, chemistry, or behavior. These characteristics strongly influence what capabilities an organism will have and how it will react, and therefore influence how likely it is to survive and reproduce.

Suggested Activity:

Get albino and regular seeds of the same species (lettuce, radish, etc.) Grow 1/2 of each type in the light and 1/2 of each type in the dark. Compare results.

Embedded Assessment:	Discuss the relationship of genotype, phenotype and environmental conditions.
Summative Assessment:	Relate this work to a discussion of sickle cell distribution in populations.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. inferring

Your school nurse should have a great deal of information on sickle cell and other genetic disorders of children. Another excellent resource for information on sickle cell in Betty Leef at Rhode Island Hospital (444-5241). RIH also has a sickle cell social worker and various group meetings on this subject.

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By the end of 12th grade all students will know that --

New heritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells. Changes in other cells of an organism cannot be passed on to the next generation.

Suggested Activity:

Student will perform standard mitosis and meiosis laboratories.

Embedded Assessment:	Students understand the similarities and differences in each process, emphasizing nuclear material in their laboratory discussion.
Summative Assessment:	Students explain, in writing, the differences between meiosis and mitosis. Students are presented with a prepared scenario by the teacher in which a hypothetical individual receives whole-body irradiation by X-rays. Students will then predict mutations in various cells, deciding if such mutations will be passed to any potential offspring. Students will defend their predictions.
Theme:	Constancy and Change
Process:	Experimental Proficiency

By the end of 12th grade all students will know that --

Natural selection leads to organisms that are well-suited for survival in particular environments. Chance alone can result in the persistence of some heritable characteristics having no survival or reproductive advantage or disadvantage for the organism. When an environment changes, the survival value of some inherited characteristics may change.

Suggested Activity:

Review appropriate audio visual material about adaptation, such as "Life on Earth" by David Attenborough. Teacher-led discussion can follow about various adaptations that have increased or decreased survival value.

Embedded Assessment:	Students understand that not all changes in heritable characteristics create enhanced survival value, while some changes do increase survival value.
Summative Assessment:	Discuss the change in survival value that global warming would have on the white snowshoe hare.
Theme:	Constancy and Change
Process:	Developing Explanatory Frameworks

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The Human Organism

- ✓ Human Identity
- ✓ Human Development
- ✓ Basic Functions
- ✓ Learning
- ✓ Physical Health
- ✓ Mental Health

THE HUMAN ORGANISM - Human Identity
Grade K-2 (Benchmark 1 of 3)

By the end of the 2nd grade all students will know that --

People have different external features, such as the size, shape, and color of hair, skin, and eyes, but they are more like one another than like other animals.

Suggested Activity:

The teacher should cut pictures showing heads, torsos, feet, hands, etc. from magazines. Pictures should be affixed to cards. Children will be given a pile of cards and will sort the cards into various piles - humans, birds, dogs, etc. Children should be asked why they arranged the piles as they did. From this information a list of human, bird, dog characteristics can be listed on the board. Expand this activity to show how people are different in various parts of the world.

Embedded Assessment:	Each child should be able to demonstrate knowledge of characteristics of each category of organism.
Summative Assessment:	Given a new group of cards, the child can easily classify the organism as human or not.
Theme:	Models
Process:	Manipulating Information, esp. developing generalizations

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THE HUMAN ORGANISM - Human Identity
Grade K-2 (Benchmark 2 of 3)

By the end of the 2nd grade all students will know that --

People need water, food, air, waste removal, and a particular range of temperatures in their environment, just as other animals do.

Suggested Activity:

Divide class into groups. Each group will be responsible for the care of a classroom animal. Students will care for the animal until spring. In the spring, students will be given a variety of materials that they will use to build an environment in which they could survive. Toy people, animals and plants could be included in the materials.

Embedded Assessment:	**Teacher conferences with group and observes environment to make sure that they have provided for water, food, air, waste removal, and temperature.**
Summative Assessment:	Students construct a suitable environment using concepts gained from animal care.
Theme:	Models
Process:	Proficiency in Making Products

Connect this activity to a study of the school and neighborhood. Ask the class to consider how the school provides for their needs. Assign different aspects (water, food, temperature, exercise) to small groups and investigate within the school. Then visit local establishments to identify how those needs are accommodated in other settings. Returning to the classroom, construct a chart and list the data collected.

By the end of the 2nd grade all students will know that --

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

Suggested Activity:

Teacher generates a discussion of family roles/who does food shopping, laundry, etc. and progresses to discussion of relative's work roles (jobs). Students could explain these roles to others. A list of jobs can be compiled by the teacher. A walking trip to local police, fire and/or water department could be scheduled. Police, fire, postal workers can discuss jobs in the classroom if a field trip is not possible. A community map containing major work sites can be created.

Embedded Assessment:	Interview a community worker and report to the class about the duties of the worker.
Summative Assessment:	**Students can create a model community assigning individuals in the class to various self-designed roles.**
Theme:	Systems
Process:	Manipulating Information, esp. developing generalizations

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THE HUMAN ORGANISM - Human Identity
Grade 3-5 (Benchmark 2 of 3)

By the end of the 5th grade all students will know that --

Human beings have made tools and machines to sense and do things that they could not otherwise sense or do at all, or as quickly, or as well.

Suggested Activity:

Students will be asked to make a list of machines, tools that they have at home and use frequently. Students then ask parents and grandparents if those tools were available in their youth and if so how these tools have changed over time. Students should report their findings to the class. Design a tool or a machine from a wooden splint that will make your life easier.

Embedded Assessment:	Children recognize tools and machines that make their lives easier.
Summative Assessment:	**Students explain the statement "necessity is the mother of invention."**
Theme:	Continuity and Change
Process:	Manipulating Information, esp. connecting new information with previous knowledge

By the end of the 5th grade all students will know that --

Artifacts and preserved remains provide some evidence of the physical characteristics and possible behavior of human beings who lived a very long time ago.

Suggested Activity:

Teacher should discuss the nature of archaeology and what an archaeologist does. A field trip to a museum should be scheduled so that students see artifacts. Teacher prepares a mock archaeological dig on school grounds. Students investigate specific area(s) of the site, collect artifacts and classify them (tools, clothing, food, waste, etc.). Students develop scenarios to explain artifacts and their relationship to lifestyle and characteristics of former inhabitants.

Embedded Assessment:	Students can explain what a particular artifact reveals about an ancient culture.
Summative Assessment:	Show tools or instruments from the past (like old kitchen tools) and have children theorize how they were used.
Theme:	Continuity and Change
Process:	Manipulating Information, esp. identifying patterns and relationships

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From Marge Bucheit
Graduate School of Oceanograhy
University of Rhode Island
Kingston, Rhode Island

Maya Dig Activity

Through systematic and thorough research, archaeologists have been able to learn about the Maya and their history. This lesson helps students recognize the grid as a useful tool in site reconstruction.

The objectives of the lesson are:

1. *Students will identify and use coordinates on a grid to describe the location of artifacts.*
2. *Students will transfer this knowledge to another class grid to obtain a complete picture of the site.*
3. *Students will engage in data recovery methods specific to archaeology.*
4. *Students will interpret collected data and draw conclusions about the excavated site.*

The materials required for this activity are common and inexpensive. By modifying the lesson, the activity can be adapted to almost any age group.

Students are asked to compare an archaeologist to a detective who must accurately note the smallest details in order to reconstruct a scene. Archaeologists must study a site both vertically and horizontally. One device used to study a site is a grid. The students are told they will be role playing archaeologists and that they will be using a grid to help them reconstruct and label a site. The site chosen is created beforehand to resemble the heart of a home of the ancient Maya.

Students are broken into groups, receive their 'tools' and begin work on their section of the excavation. At the conclusion, the class compares and discusses their findings.

This lesson plan is available from Marge Bucheit at URI. Included are several related activities that deal with dating artifacts.

By the end of the 8th grade all students will know that --

Like other animals, human beings have body systems for obtaining and providing energy, defense, reproduction, and the coordination of body functions.

Suggested Activity:

Each student picks an animal to study (from a teacher list). The student compares one or more body systems of the organism to those same systems in humans, listing similarities and differences. Students must be able to explain similarities and differences in systems for obtaining food, reproducing, etc.

Embedded Assessment:	Student recognizes and explains similarities and differences among systems.
Summative Assessment:	Students are asked to compare and contrast the systems of humans and another organism not previously discussed in class.
Theme:	Systems
Process:	Language Proficiency

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THE HUMAN ORGANISM - Human Identity
Grade 6-8 (Benchmark 2 of 6)

By the end of the 8th grade all students will know that --

Human beings have many similarities and differences. The similarities make it possible for human beings to reproduce and to donate blood and organs to one another throughout the world. Their differences provide the ability for adaptive change.

Suggested Activity:

Have students list as many characteristics of humans as possible. Have them discuss how each characteristic may vary within the human population. Have all students stand. Ask every left-handed student to sit. Ask every student under 5 feet to sit. Ask every student with blue eyes to sit. Ask every student who cannot roll their tongue to sit. Class should record data as the activity progresses and discuss its implications.

Embedded Assessment:	Students recognize that humans with common characteristics exhibit variety within the population.
Summative Assessment:	Students are presented with scenarios of cataclysmic events such as global warming, ozone depletion, etc. Students must decide which members of the class will have survival advantages and must explain why these students are better adapted to such a changed environment.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking concepts and principles

RESOURCE: Have an individual from the RI Blood Bank come and discuss human blood groups and the implications of this differentiation within the human species.

THE HUMAN ORGANISM - Human Identity
Grade 9-12 (Benchmark 1 of 2)

By the end of the 12th grade all students will know that --

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

Suggested Activity:

Students are presented with the DNA sequences of a human and four other organisms. The students will determine the percent similarity of the 4 organisms with the human DNA. The identity of the four organisms will be revealed and the students will explore their relationship to humans.

Embedded Assessment:	Students will be able to explain the interrelatedness of human beings.
Summative Assessment:	Students compare the DNA sequences of human, chimpanzee, and other selected organisms and interpret the results for correlation and separation between organisms.
Theme:	Constancy & Change
Process:	Manipulating Information

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THE HUMAN ORGANISM - Human Identity
Grade 9-12 (Benchmark 2 of 2)

By the end of the 12th grade all students will know that --

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

Suggested Activity:

Students examine communication and tool use in other species (apes, cetacea, sea otters, bees) and compare with humans.

Embedded Assessment:	Students are able to distinguish unique features of human communication.
Summative Assessment:	Students can relate how human communication systems have evolved over time.
Theme:	Continuity & Change
Process:	Manipulating Information

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THE HUMAN ORGANISM - Human Development
Grade 3-5 (Benchmark 2 of 4)

By the end of the 5th grade all students will know that --

Human beings live longer than most other animals, but all living things die.

Suggested Activity:

Students should pick an animal/plant species from a 'can' and should research the life expectancy of the plant/animal using the library or other resources. Students return to class with information. Students can create charts and graphs showing various life expectancies. This activity is an opportune time to introduce a discussion on death with the aid of a mental health professional.

Embedded Assessment:	Students properly construct graphs/charts which reflect data collected.
Summative Assessment:	Students are asked to predict the general life span of a plant/animal related to (but not) one already mentioned in class.
Theme:	Continuity and Change
Process:	Manipulating Information, esp. interpreting/evaluating data

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By the end of the 5th grade all students will know that --

There is a usual sequence of physical and mental development among human beings, although individuals differ in exactly when they learn things.

Suggested Activity:

Students are asked to develop timelines for human events such as walking, talking, or riding a bicycle. Have the children teach younger children a simple skill, such as jumping rope, and then discuss the differences they found in skills and development of the younger children. This might also be a time to discuss mental handicaps like Down's Syndrome, where physical and mental development occur in the same order, but at a different rate.

Students could volunteer service in a K-2 classroom to assist the younger children with various activities.

Students can also determine development by raising the left arm so that the left hand covers the right ear. Students can see that children over seven can do this, while younger students generally cannot.

The PBS series 'Childhood' would be an excellent resource for this activity. The series can be purchased on videotape from PBS Video (1-800-328-7271) for educational insitutions.

Embedded Assessment:	Students take adequate notes of their observations and transfer the information to their respective timeline.
Summative Assessment:	Students are able to describe key elements of their own development through early adolescence.
Theme:	Scale
Process:	Manipulating Information, esp. developing generalizations

THE HUMAN ORGANISM - Basic Functions
Grade K-2 (Benchmark 1 of 3)

By the end of 2nd grade all students will know that --

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

Suggested Activity:

Students are divided into teams. One team is blindfolded or asked to close their eyes (confined in a clear area), and one team has their hands covered by mittens. Students will be presented with food and non-food items such as orange slices, apple slices, wrapped candy, and tennis balls. Students will be asked to identify the items presented using the senses, including taste.

Embedded Assessment:	Children are asked to describe how they used the sense of smell to find food, used the hands to guide it to the mouth and hands, nose and mouth to determine what the food was.
Summative Assessment:	Students can connect what they learned about humans to a provided example of another species which is not too dissimilar.
Theme:	Systems
Process:	Manipulating Information

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By the end of 2nd grade all students will know that --

The brain enables human beings to think and sends messages to other body parts to help them work properly.

Suggested Activity:

Students are divided into teams. Teams are assigned a task to describe such as combing hair, covering a yawn. Students must make an ordered list of activities in combing hair which will be given to the teacher (representing the brain). The teacher follows student directions. Discussion can follow which illustrates 'automatic' activities which do not have to be thought of.

Embedded Assessment:	Students can identify a number of key functions that the brain performs based upon the simulation they have experienced.
Summative Assessment:	Students can describe in simple fashion what has to occur in order for a person to raise their arm, move their leg, or other movement.
Theme:	Systems
Process:	Language Proficiency

By the end of 5th grade all students will know that --

Skin protects the body from harmful substances and other organisms and from drying out.

Suggested Activity:

Start with two tomatoes, remove the skin from one. Have children investigate and compare what happens to both over time.

Small groups of students work with 4 apples. The apples are labeled as A, B, C, and D. Using straight pins, make 4 or 5 holes in apples B and C. Have a group member with unwashed hands rub his or her hands on apples A, B, and C. Apply rubbing alcohol to the punctured areas of apple C. Apple D serves as the control. Leave the apples where they can be observed for 7 days. Each day, observe (but don't touch) and keep track of your observations in a journal. At the end of the seven days, discuss the similarities between apple skin and our skin. Notice the effect of the antiseptic (alcohol) on germ growth.

Invite a dermatologist to visit the classroom. Student groups should be prepared to ask the doctor to discuss different effects of sunlight, topical applications, wound protections and the like, which they have researched prior to the visit.

Embedded Assessment:	Students can correctly record their observations and make simple inferences based on the data.
Summative Assessment:	Students are asked to explain precautions severely burned individuals have to take and what steps might be taken to help them.
Theme:	Systems
Process:	Manipulating Information, esp. inferring

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By the end of 12th grade all students will know that --

Reproduction is necessary for the survival of any species. Sexual behavior depends strongly on cultural, personal, and biological factors.

Suggested Activity:

Students will research and write a report on the cultural, personal, and biological factors which affect courtship rituals and mate selection in at least 3 societies (one Eastern, one Western, and one animal species).

Embedded Assessment:	Students will list at least 3 different cultural, personal, biological factors which may affect sexual behavior.
Summative Assessment:	**Students will orally report on the results of their research to the class. Class results will be summarized under the headings of cultural, personal and biological factors. Students will determine which category (if any) has the greatest effect on sexual behavior.**
Theme:	Constancy and Change
Process:	Manipulating Information, esp. developing generalizations

Sociobiological and anthropological resources could be used with this activity, including the work of E.O. Wilson.

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THE HUMAN ORGANISM - Learning
Grade K-2 (Benchmark 1 of 3)

By the end of 2nd grade all students will know that --

People use their senses to find out about their surroundings and themselves. Different senses give different information. Sometimes a person can get different information about the same thing by moving closer to it or further away from it.

Suggested Activity:

Any study of the five senses should include recognition of the handicapped. Teacher will generate a variety of activities which cause students to make judgments using their senses. Activities could include listening to tapes of a variety of sounds for student identification. Students place hands in 'feelie' boxes (shoeboxes containing a variety of objects) and try to identify the objects. Focus on an object in the environment (a tree, telephone pole, building) and make observations from increasingly close distances, finally using a magnifying glass.

Embedded Assessment:	Students can verbalize their experiences using a variety of descriptors.
Summative Assessment:	Using a common insect or pet, ask students to explain the manner in which it employs its varied senses.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking conceptual principles

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By the end of 2nd grade all students will know that --

Some of the things people do, like playing soccer, reading, and writing, must be deliberately learned. Practicing helps people to improve. How well one learns sometimes depends on how one does it and how often and how hard one tries to learn.

Suggested Activity:

Teacher creates a paper or physical maze. Students are asked to find their way through the maze several times. They are then asked to relate how difficult/easy it was after several trials.

Embedded Assessment: Each student can successfully 'navigate' the maze.

Summative Assessment: Have students teach each other or younger children some simple skill or activity.

Theme:

Process: Foundational Habits, esp. reflecting

Take a field trip to the 'Green Animals' maze in Portsmouth, RI. Invite the music teacher to the class to talk about the value of practice in learning.

By the end of 2nd grade all students will know that --

People can learn from each other by telling and listening, showing and watching, and imitating what others do.

Suggested Activity:

Demonstrate a card trick or a simple magic trick. Students are asked what they think happened. Teacher can explain the trick and have the students try to repeat it. Teacher demonstrates/explains again and students repeat once more.

Embedded Assessment:	Students develop some proficiency with the given trick and can make a generalizable statement of their experience.
Summative Assessment:	Each student can present an activity to another student and tutor them until they achieve some measure of success.
Theme:	
Process:	Manipulating Information, esp. developing generalizations

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By the end of 5th grade all students will know that --

Human beings have different interests, motivations, skills, and talents.

Suggested Activity:

Make a personal 'coat-of-arms; showing personal interests, skills, talents, aspirations with an accompanying explanation describing areas and color use. Coats of arms can be exchanged and interpreted by others. Discussion should follow about the importance and value of the goals and aspirations of students.

Higgins Armory Museum in Worcester, MA is an excellent resource for the use and making of coats of arms.

Embedded Assessment:	Students can describe for their peers the significance of the emblems they have placed on their personal coat-of-arms.
Summative Assessment:	**Students can interview a person within the school, family or neighborhood in regard to their interests, motivation, skills and talents, and compare the results to themselves.**
Theme:	
Process:	Manipulating Information, developing generalizations

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By the end of 8th grade all students will know that --

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

Suggested Activity:

Two classes who normally use the same classroom at different times can be brought together for one period, or a classroom could have 1/3 of the seats removed before the normal population enters. No extra chairs, benches, etc. are to be added to the room and no students can leave to work elsewhere. Students will be given a writing task designed to last 15 minutes. Students will complete the assignment and pass it in to the teacher. After the writing assignment, students will be asked to write how they felt being physically crowded, lacking seats, peace, quiet, etc.

Embedded Assessment:	Students realize that overcrowding and change of routine can have many effects on human behavior.
Summative Assessment:	Students must write a short report about overcrowding in an animal species and must describe the possible effects of overcrowding on socialization, attitude, mating behavior, etc.
Theme:	Constancy and Change
Process:	Manipulating Information, esp. interpreting/evaluating data

THE HUMAN ORGANISM - **Learning**
Grade 9-12 (Benchmark 2 of 3)

By the end of 12th grade all students will know that --

The expectations, moods, and prior experiences of human beings can affect how they interpret new perceptions or ideas. People tend to ignore evidence that challenges their beliefs and to accept evidence that supports them. The context in which something is learned may limit the contexts in which the learning can be used.

Suggested Activity:

A group of pictures (from newspapers, magazines, etc.) can be presented to cooperative groups. Students will be asked to sort the pictures into occupational groups - elementary school teachers, scientists, musicians. The teacher will have a key to identify pictures with actual occupations. After 15 minutes students will be asked to listen to the answers, reasons given by a group. Then each group will be given a point for each picture/occupation properly correlated. Class discussion can then follow about stereotyping, gender bias, prejudice towards young, old, etc.

Embedded Assessment:	Students sort pictures based on some type of collective reasoning, trying to match appearance with occupation.
Summative Assessment:	Students can explain how prior misconceptions about individuals, based solely on appearance, can affect perception and judgment.
Theme:	Continuity and Change
Process:	Manipulating Information, esp. inferring

Compare the astrological signs of the students with the actual constellations in the sky at the time of their birth. Have students keep a journal of daily horoscopes which they compare, ex post facto, with daily horoscopes in the newspaper and actual events. Have them draw conclusions after a month of such data collection.

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By the end of 2nd grade all students will know that --

Eating a variety of healthful foods and getting enough exercise and rest help people to stay healthy.

Suggested Activity:

Group makes a food pyramid. Student groups work on different sections of the pyramid, cutting pictures from magazines and pasting. Develop healthy menus. Prepare a healthy breakfast or lunch as a group. Students try to bring 'healthier' lunches or snacks to school for a week.

Embedded Assessment:	**Students often tire as the day progresses. Students can do 10 jumping jacks in the morning, timed by the teacher. The same activity is done and timed in the afternoon. Students discuss how they felt and the difference (if any) in times.**
Summative Assessment:	Pick out healthy meals from pictures of several meals.
Theme:	Models
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

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THE HUMAN ORGANISM Physical Health
Grade K-2 (Benchmark 3 of 3)

By the end of 2nd grade all students will know that --

Some diseases are caused by germs, some are not. Diseases caused by germs may be spread by people who have them. Washing one's hands with soap and water reduces the number of germs that can get into the body or that can be passed on to other people.

Suggested Activity:

Put a small amount of mentholated shaving creme in your hand and shake hands with one student, who shakes hands with another, until everyone has shaken hands with someone. Though the sight and the feel of the shaving creme will probably disappear along the way, the last child should still have some of this 'germ' since they can still smell the creme. This could be expanded in a variety of ways. The teacher should point out to children that germ transmission from mouth to hand to doorknobs is documented as the #1 method of transmission of infectious agents.

Embedded Assessment:	Students can correctly deduce what the activity demonstrates.
Summative Assessment:	Present students with a series of very different scenarios and ask them to identify when washing their hands is important.
Theme:	Systems
Process:	Manipulating Information, esp. connecting new information with previous knowledge

This activity directly relates to State Health Outcomes. This is a good opportunity for the health educator and science educator to work together.

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THE HUMAN ORGANISM - Physical Health
Grade 3-5 (Benchmark 1 of 4)

By the end of 5th grade all students will know that --

Food provides energy and materials for growth and repair of body parts. Vitamins and minerals, present in small amounts in foods, are essential to keep everything working well. As people grow up, the amounts and kinds of food and exercise needed by the body may change.

Suggested Activity:

Have the children make charts showing recommended amounts and kinds of foods for different ages - babies, youngsters, teens, adults, and the elderly. Have them record their activities and individual menus for 7 days. Students will then be asked to determine if they felt that they had eaten the recommended amounts, why or why not. Students could also be asked to add vitamin/mineral records to their food diaries. Samples of cereal boxes could be brought in to examine vitamin contents. Tables of vitamin contents of meal items could be examined by teams.

Embedded Assessment:	Students can correlate their food intake with recommended daily amounts of basic food groups.
Summative Assessment:	Presented with sample meals from the school cafeteria menu and a local restaurant, students can determine the degree to which each meets daily requirements.
Theme:	Systems
Process:	Manipulating Information, esp. intergrating/evaluating data

Invite a nutrionist or an adult on a special diet to visit the class.

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By the end of 5th grade all students will know that --

Tobacco, alcohol, other drugs, and certain poisons in the environment (pesticides, lead) can harm human beings and other living things.

Suggested Activity:

Speakers from high school, college or anti-drug programs can make excellent presentations for the students.

Contact Peter DiGiulio (508-741-2684) for an extremely effective drug education approach (*Why Say No!*). The Gold Key Honor Society (Best of America Program) also provides speakers. Ask local college students to speak with students about drugs and alcohol abuse.

Embedded Assessment:	Students can describe key points derived from a guest speaker.
Summative Assessment:	Create a fictitious world where water and several other common substances on earth are dangerous drugs or poisons and have students describe how the inhabitants would cope with a visit to Earth.
Theme:	Systems
Process:	Proficiency in Informed Action

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THE HUMAN ORGANISM - Physical Health
Grade 3-5 (Benchmark 4 of 4)

By the end of 5th grade all students will know that --

There are some diseases that human beings can catch only once. After they've recovered they don't get sick from them again. There are many diseases that can be prevented by vaccination, so that people don't catch them even once.

Suggested Activity:

The teacher discusses 'diseases of the past' such as polio, measles, mumps, whooping cough. Students ask parents and grandparents about these diseases and the development of vaccines. Students report back to the class.

Embedded Assessment:	Students can describe accurately the key features and effects (biological, social, economic, etc.) of a given disease whose presence within society was a challenge faced by their ancestors or other elderly citizens.
Summative Assessment:	Have students pretend they are 70 years of age. Ask them to write an essay responding to several questions about AIDS or another common disease of the present and its input on their life and/or community.
Theme:	Constancy and Change
Process:	Language Proficiency, esp. interviewing

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From Dr. Mary Louise Greeley
Salve Regina University
Newport, Rhode Island
Middle School Activity

Careers in Medical Technology

The 8th grade biology class of the Pennfield School in Portsmouth, Rhode Island, was invited to visit the Biology and Biomedical Sciences Department at Salve Regina University. Dr. Greeley and the medical technology, cytotechnology and pre-physical therapy majors at the University took their visitors through a simulated visit to a hospital emergency room. One of the medical technology students posed as a patient, stating that she had a pain in her lower right side. Another Salve student played the role of the doctor, came in and ordered a CBC (Complete Blood Count) and urinalysis. Dr. Greeley then explained what the medical technologist can learn from the CBC and urinalysis.

All the students went on to view normal and abnormal blood slides on the biology department's microscope color video system. The Pennfield students were paired with Salve Regina students who showed them how to do a urinalysis (with simulated urine) and examined prepared blood smears with their own individual microscopes.

Dr. Greeley discussed opportunties and requirements for careers in medical technology, cytotechnology and physical therapy. The Salve Regina students passed out brochures on these biomedical careers and discussed what interested them most in their studies and the reasons they had chosen to enter these professions.

By the end of 12th grade all students will know that --

Faulty genes can cause body parts or systems to work poorly. Some genetic diseases appear only when an individual has inherited a certain faulty gene from both parents.

Suggested Activity:

Each student will be presented with a diagram of a family tree which shows the appearance of a genetically inherited disease (such as Queen Victoria - hemophilia). Students should trace the disease through specific individuals, highlighting the path. Students should decide which family individuals were carriers of one copy of the gene and which carried two copies.

Embedded Assessment:	**Students are able to successfully determine which family members contain none, one, or two genes for the specific condition/disease.**
Summative Assessment:	**Students are presented with a worksheet containing a family tree format and a descriptive paragraph. Having only the hypothetical parents listed and how many siblings produced for each generation, students should create a family tree including spouses indicating non-carriers, carriers and those affected by the disease. Family tree should accurately reflect paragraph given and choices made by students.**
Theme:	**Models, systems**
Process:	**Manipulating Information, esp. interpreting/evaluating data**

All benchmarks in this document are based on *Benchmarks for Science Literacy - Project 2061* *published by the American Association for the Advancement of Science. Reprinted with permission.*

By the end of 12th grade all students will know that --

Some viral diseases, such as AIDS, destroy critical cells of the immune system, leaving the body unable to deal with multiple infection agents and cancerous cells.

Suggested Activity:

Lecture/discussion of the functioning of the immune system and how it is affected by HIV; possibly show video on AIDS, speaker from AIDS support group. Read and discuss "Hot House" by Preston, discuss Ebola.

Embedded Assessment:	Students will diagram a model of how HIV infects the immune system
Summative Assessment:	Students will explain the relationship between HIV and AIDS.
Theme:	Systems
Process:	Developing Explanatory Frameworks, esp. linking concepts/principles

Collect current data on the effects of the Ebola virus, not only on victims but also on travel restrictions, programs at CDC (Atlanta), World Health Organization. In groups, students will develop a plan for curtailing the spread of the Ebola virus. Include medical prevention strategies, information dissemination. Invite local medical personnel (technicians, nurses, doctors) to act as resources at the presentation of these oral/visual plans by groups. Also rely on your school health educator.

All benchmarks in this document are based on Benchmarks for Science Literacy - Project 2061 published by the American Association for the Advancement of Science. Reprinted with permission.

4

"The student as worker will be able to meet performance outcomes that include, but are not limited to:

. Accessing information - acquiring, organizing, and maintaining data as well as interpreting and communicating information;

. Demonstrating interpersonal skills - working on teams, teaching and serving others, leading, negotiating, and working with people from culturally diverse backgrounds;

. Using resources - allocating time, money, materials, space, and human resources;

. Understanding political systems - operating within social, political and organizational systems, monitoring and correcting performance, and designing or improving systems;

. Using technology - selecting and applying technologies to the specific tasks including the use of computers and other emerging technologies to process information."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

Insights from Research on the Learning and Teaching of Science

The goal of science teaching is to educate all students in the science needed for today's world. This will necessitate a transformation in the way we think about science education. All of our children and young adults, not just those preparing to be professional scientists, must have an understanding of scientific ways of thinking and science knowledge in order to function in an information age. Learning science helps develop critical thinking skills and gives practice in the use of evidence in decision making. An increasing number of jobs require understanding scientific processes and principles, and most jobs call for problem solving and decision making skills that may be acquired through the study of science. Equally important is the ability for all citizens to make good decisions using a basic understanding of the science and technology behind the various social issues affecting their lives.

Science Standards: A Valuable Resource for Improved Instruction

To transform science instruction statewide, reaching schools in the various districts as well as private schools, there needs to be agreement on what students ought to know, how it should be presented, and how to measure the results. The setting of national science standards is underway with the work of the National Academy of Science through its National Research Council working with the American Association for the Advancement of Science, the National Science Teachers Association, and other professional scientific societies and the broad constituencies they represent. Working groups drafted standards for curriculum, teaching, and assessment which were publicly released in November of 1994. A consensus process is being followed to encourage broad review and discussion of the draft with a final version planned for late 1995.

The RI Science Frameworks Development team has conducted its work with a close eye on this project of national significance, as well as taking account of the already well-known and highly regarded national work of the Scope, Sequence and Coordination of Secondary Science Project of the National Science Teachers Association, and Project 2061 of the American Association for the Advancement of Science. Rigorous standards will set the framework for what young Rhode Islanders should know and be able to do when they leave school. Rhode Island is making crucial systemic changes to reach these standards, building on its initial efforts within the Rhode Island Statewide Systemic Initiative in Mathematics and Science. These changes include:

- expanding the range of state assessments;
- allowing consolidation of different federal funding streams within a district;
- promoting school-to-work connections;
- integrating social services with educational institutions;
- revising teacher certification and licensure requirements; and
- associated changes in the structure of science teacher preparation programs within the state.

Research studies show that children who are in schools with high expectations and challenging, "hands-on" curricula learn more than children who are in less demanding educational programs. Most students will work to meet whatever expectations their teachers and families have for them, however high, however low. In science we need a clear consensus on what students should know and be able to do.

The Statement of Principles on School Reform in Mathematics and Science from the U.S. Department of Education and the National Science Foundation states that "all children should receive a challenging education in mathematics and science based on world-class standards beginning in kindergarten and continuing every year through grade 12." The Special Legislative Commission on Mathematics and Science Education, convened by the RI State Legislature, concluded its 1992 report with a primary recommendation that:

"Curriculum frameworks for mathematics and science education, K-16, which align with the NCTM Standards and the AAAS Science for All Americans reports must be developed. These curriculum frameworks will:

* provide a vision of high standards for student achievement by including: a) program goals and program outcomes, b) student outcomes, c) teaching strategies, d) related materials and resources, e) assessment strategies which recognize all components of the frameworks

* guide the districts in formulating local curricula

* provide indicators to gauge the level of success in achieving the stated goals

* drive the succeeding recommendations (within the report)

* provide a model for post-secondary curriculum frameworks that will ensure a smooth transition from secondary school to college"

This framework and the state mathematics framework are first steps toward realizing this goal.

Students Learn by Constructing Knowledge

Research from the cognitive sciences and from science education has transformed our understanding of how children learn. The view of the student absorbing knowledge has shifted to one of the student constructing knowledge, called the "constructivist approach," by being involved in interpreting and understanding new content, and linking new knowledge to existing knowledge in a meaningful way (Shapiro, 1994; Fensham, Gunstone and White, 1994, Steffe and Gale, 1995).

Learners come to new situations with preconceived notions. As children develop, and long before they enter formal education, they need to make sense of the natural world about them. They begin to construct sets of ideas, expectations, and explanations about natural phenomena. Since these ideas are frequently quite different from the ones held by scientists, we sometimes refer to them as naive conceptions. For example, fifth grade students were asked "What is food for plants?" Most students gave replies of "water," "soil," or "plant food" that can be bought in stores. These students had the idea that food for plants was something similar to food for people, rather than plants' need for light to make their own food through the process of photosynthesis (Anderson & Smith, 1984).

Teaching for conceptual change or "teaching for understanding" as it is called, requires different strategies from those usually followed in the classroom. Teachers continually diagnose students' ideas and consider where they are in the process of conceptual change. Students' conceptions are addressed through exploration and discussion. Opportunities are provided for the testing of ideas, even those that are false. Materials are needed that will encourage the student's exploration of a phenomenon as a way of acquiring new knowledge. While research continues on the implications of constructivism for the curriculum and instruction, there is agreement that traditional didactic teaching is not the only effective way to promote conceptual change. Students often remain committed to their alternative conceptions while memorizing new material and doing well on tests, frequently without any real understanding of new concepts.

Hands-On, Inquiry-Based Science Instruction

In hands-on science instruction the teacher engages the students in questions that require them to think about and apply what they are doing to new situations. The "minds-on" part of instruction comes with dialogue, discussion, and exploration using hands-on materials. Experiences with a particular science phenomenon must be concrete, relevant to the students, and varied.

All hands-on activities require the use of materials. Students learn by doing, using materials such as plants, batteries and bulbs, or water, or instruments such as the microscope, meter stick, or test tube. These instructional materials must be sequenced to facilitate students' construction of meaning. Giving students sets of activities without connections drawn among them leads to isolated bits of knowledge. Therefore, rather than presenting students with bits and pieces of information, and leaving it to them to piece these together, the teacher needs to help students see the interconnections among scientific ideas (Raizen and Michaelson, 1994).

In practice, however, despite the emphasis on "doing science" with the use of instructional materials, textbooks have defined the curriculum. In drawing a comparison one science educator commented: "Teaching with hands-on activities is demanding, but everyone is involved, eager, and active, and participants remember what they have done . . . I never saw a textbook do that" (Haury and Rillero, 1992). Textbooks may have a place in the curriculum as a support for inquiry and experimentation. However, a more experimental base is needed at all levels involving use of instructional materials and equipment and thought-provoking questions and dialogue.

Other material resources are needed to support student exploration of scientific ideas. Children's trade books and magazines are valuable resources to engage students and enrich their understanding of the natural world. Many of these resources are reviewed and evaluated periodically. An annotated bibliography is published as a guide for users by the American Association for the Advancement of Science and the National Science Teachers Association. Relevant films, videos, and computer resources are also important resources for the classroom. In addition, technical support is needed to supply teachers with science equipment, hardware, materials and to maintain and manage these resources. Updated facilities and effective maintenance plans must be created within schools in concert with these resources if they are to achieve their desired impact.

From Mr. Brown's Class
Child Street School
Warren, Rhode Island
Third Grade Activity

Integrating Science with Language Arts and Mathematics

The third grade at Child Street School is using a recycling/composting thematic unit that includes many hands-on activities. The students start by reading literature. Small groups discuss their books and then must involve the class in an activity. For example, after reading The Lorax the class might be asked to brainstorm a list of present day 'thneeds' that threaten our local environment and then suggest 'thneed' alternatives that are environmentally friendly. Where Does the Garbage Go? might lead to a day when students bring in 'throw aways' found in their families 'safe' trash and present new uses for them. Collecting and organizing the litter thrown away at lunchtime is an exciting mathematics activity for the students. Litter is sorted and classified, and the results are analyzed and displayed on graphs and charts. Each group participates in two major hands-on activities. The first activity explores the process of making compost in a plastic soda bottle. The second activity is similar. Each group of students makes a model landfill to compare the rate of decomposition of various materials. A plastic or glass jar with a lid is used. This thematic unit could culminate with a field trip to the Johnston Landfill (tel. 831-4440). The Rhode Island Solid Waste Management Corporation gives recycling information and composting demonstrations.

Suggested Literature Resources for this unit:

The Lorax by Dr. Seuss
Where Does the Garbage Go? by Paul Showers
Just a Dream by Chris Van Allsburg
Mrs. Fish, Ape, and Me, the Dump Queen by Norma Fox Mazer
Waste by Christina Milles by Louise Berry
Garbage by Karen O'Conner
Trash! by Charlotte Wilcox
Jack, the Seal, and the Sea by Gerald Aschenbrenner
Worms Eat My Garbage by Mary Appelhof
50 Simple Things You Can Do to Save the Earth by John Javna et. al.
Recyclopedia, (Games) Science Equipment, and Crafts from Recycled Materials by Robin Simons

Learning activities outside the school building and beyond the normal school day should complement and enrich science learning for all students. For this to be successful, communities must support the work of non-profit organizations, museums, libraries, nature centers, and other science education opportunities provided by the 'informal' science education sector. Parents and other significant adults in children's lives must be more fully engaged in expanding both their own and students' knowledge of science (McCaleb, 1994; Swap, 1993). A variety of national programs, competitions, internships and scholarships are also available to students to expand their awareness of and experiences in science (Grand, 1994).

"Education must be inclusionary, emphasizing parental and community involvement, intra-agency cooperation and collaboration, and partnerships with business and labor. These collaborations must begin at the grassroots. Parents, joined by business and community leaders, must serve as informed participants, meaningfully involved in decisions about outcomes and judgements concerning success of schooling."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

Exploration, Dialogue and Discourse Promote Understanding

Learning is interactive and occurs in a social context The vision is to transform the classroom into a learning community where ideas are shared, evidence is used to strengthen ideas, and there is willingness to change ideas through exploration, dialogue, and discourse.

Teachers should provide students with many opportunities to explore scientific phenomena, using examples from their everyday experience. Exploration allows students to become familiar with materials and ideas in open discussion with others. Through exploration students apply their understandings and develop explanations by experimenting. It is also a way for students to answer their questions and to formulate hypotheses.

Teachers organize the classroom. They set the social norms for discourse to help students develop understanding from experience with materials in the classroom as well as from their out-of-school experiences. As one science educator described it: "There must be opportunity for independent exploration, as well as guided group activity, for quiet reflection and for animated discussion. Small group work enables every individual to participate fully in activities and discussion, and allows children to develop leadership skills, to learn from one another, and to take intellectual risks" (Bird, 1992). Research on cooperative learning indicates several positive effects of small group, student involved or led, hands-on science lessons. However for small group cooperative learning the teacher must carefully plan the learning environment; " . . . it takes time and practice for teachers to become skilled in its use" (Blosser, 1992). Large group work brings students together to share a variety of ideas similar to professional scientists collaborating on an investigation. Through a combination of large group and small group work the teacher designs the classroom environment to promote experiential learning.

"Parental and adult participation in the school could be fostered by:

. producing school publications and information in several languages;

. organizing an orientation event before the start of each school year;

. giving each parent/adult a school calendar and a handbook of school personnel and programs;

. introducing parents/adults to all available parent organizations and services;

. arranging a personal welcome from the administrative staff; and

. ensuring early individual contact between parents and teachers."

Rhode Island's Choice: High Skills or Low Wages, RI Skills Commission, May 1992.

Discussion among a small group of students or between student and teacher, and the framing of ideas and arguments to support a particular point of view, is an important strategy for developing students' conceptual understanding. Every effort should be made to have children ask questions and then use their questions to further their investigation. By posing questions, teachers may assist children to confront their assumptions and lead them to follow new paths of inquiry.

Kev Concepts and Ideas of Science Should be the Focus

A transformation in science curricula is occurring from coverage of a large number of facts and terminology on many topics to more in-depth study of fewer, major concepts. Major scientific ideas or concepts and thinking skills need to be emphasized. Less attention should be paid to specialized vocabulary, memorized facts, and procedures. Project 2061 of the American Association for the Advancement of Science, the National Science Teachers Association's Scope, Sequence, and Coordination of Secondary Science project, and the National Science Standards recommend that instruction cover the main ideas of science and the interrelatedness among various phenomena within the disciplines. The goal is to provide a greater depth of understanding.

There are different schemata for organizing science content around topics and relating units often taught in various grade levels to the larger ideas of science. Project 2061 identifies four common themes that pervade science, mathematics and technology (scale, systems, constancy and change, and models) and suggests that science curricula should be centered around these themes. A conceptual approach to science would suggest science concepts (such as diversity, variation, order, structure, function, and change) as a way of integrating diverse topics. Other reports suggest different organizing principles, but the common element from research and studies is that the curriculum highlight major ideas, concepts, or themes, "the big ideas," so that detailed information about science becomes connected, becomes meaningful, and contributes to successful problem solving (Loucks-Horsley, et al., 1990).

More time can be spent on developing understanding of the major concepts illustrated by the topics. An illustration of how a unit on seeds can build understanding of a major idea is found in the Life Lab Science Program for elementary science education. The first grade theme of this curriculum is diversity and cycles. A unit on investigating seeds would compare and contrast seeds, monitor germination, and begin to predict the outcome of simple experiments. A study of soil and the diverse plants and animals living in it expands upon the original theme. Life, physical, and earth sciences are connected around this major idea.

The Role of the Teacher

The role of the teacher is being transformed from one of primary dispenser of knowledge to one of being a facilitator of learning. This is a more demanding role in many ways. The teacher provides information in the context of a rich learning environment, in which the student is an active learner. Rather than the teacher telling the students what they are to learn, the teacher sets up an environment where the student can be active in acquiring knowledge, mainly through the process of experimentation and discourse.

The teacher engages students in problem solving by asking probing questions, promoting inquiry, and guiding discussion with use of hands-on materials. Facilitation also requires the teacher to be familiar with resources whether they be curriculum materials, technology, community members or professional colleagues with special expertise, or institutional resources such as museums or science centers, and a capacity to draw on these resources as the need develops. "When students' investigations lead them down an exciting but unexpected path, having experimental materials or reference tools at hand or having a knowledgeable colleague to call on can turn a 'teachable moment' into a lifetime of understanding. Good teachers are accustomed to responding to children's short and long-term intellectual and emotional needs, but to do so in the context of scientific inquiry requires a special kind of preparedness and sensitivity" (Bird, 1992). It takes a deep understanding of basic science concepts and a willingness to not always be the 'authority' and to be comfortable teaching science in an experimental mode.

For teachers to be successful facilitators of children's science learning a great deal of support must be made available to them both within the school and from the broader professional community. They cannot do this without support from professional colleagues. They must have opportunities to exchange ideas and experiences with other teachers and with colleagues from the science and education community, to reflect on their teaching, to read research and contribute to it as part of a research team.

Appropriate Staff Development

The teacher is key toward improving instruction. Since teaching for understanding demands a role that the teacher's preservice training often did not model, opportunities for inservice training are essential in transforming science instruction (Fitzsimmons and Karpelman, 1994). While very capable, teachers often have not had a college program that provided a basic background in the physical, life, and earth sciences and the ways to teach science to promote understanding. Teachers do not need to be experts in

"The student as lifelong learner will possess skills, knowledge and attitudes of:

. Literacy - reading, speaking, listening, writing, and mathematics;
. Thinking - the ability to think creatively and critically, make decisions, solve problems, see things in the mind's eye, know how to learn and reason;
. Self-reliance - understanding one's own strengths and talents and having confidence in the ability to shape one's own future through one's own efforts;
. Intellectual curiousity - interest in and enthusiasm for learning; the habit of questioning; the ability to form independent judgements and theories;
. Versatility - ability to express oneself in more than one medium.

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992

"Schools must be centers of learning, student-oriented and accountable for student performance. The Department of Education is committed to supporting schools and districts which dedicate their efforts to improving student achievement through school-based management by allowing them more flexibility to decide how best to achieve good results in the classroom."

Reaching for High Standards: Student Performance in Rhode Island, RI Department of Education, December 1993.

"National research and practice tell us that teachers, working together and recognizing the social and academic needs of their students, can produce results that differ very little among economically diverse students. We believe that high expectations, appropriate instruction, strong professional development programs, and an orientation to building upon students' strengths will result in the closing of achievement gaps over time.

Teachers must show leadership by constantly seeking school improvement, promoting and employing the best practices to reach students and ensuring that the learning experience is child-centered. They must be role models for lifelong learning, taking part in professional development and in-service training. They must also take the lead in working with all stakeholders in a child's education - administrators, school committees, parents, and the public - to assure that all students do learn."

... Reaching for High Standards: Student Performance in Rhode Island, RIDE, December 1993.

every aspect of science; in fact most scientists are experts in only a narrow speciality. But they do need a general background in science content. All teachers should be better prepared in science content, pedagogical science, general knowledge of pedagogical principles and practices, curricular knowledge, knowledge of student diversity and individual differences, and professional policy and ethics.

It is most important that the inservice instructors model the teaching strategies they wish teachers to use. In addition, time for the teachers to practice new teaching behavior and continue to work with mentor colleagues is also a part of a good inservice program. Further, teachers will need to have regular opportunities to plan and collaborate with their fellow teachers at professional meetings such as national and state science teachers' meetings and at the district level.

Teaching for understanding takes not only time to learn but also support from other colleagues and the school administration. Meaningful change in teacher behavior may take years. Teachers experimenting with new strategies and programs need the time and resources to try new techniques to determine what works best. Teachers exchange ideas and they need to use the same methods to learn to teach science as the students need to learn it.

The most effective staff development activities:

* are continuous and on-going;

* are embedded within the regular school calendar, not after school or during the summer;

* model the constructivist approach to teaching that teachers will use with their students;

* provide opportunities for teachers to examine and reflect on their present practices and to work with colleagues to develop and practice new approaches; and

* provide good support structures within the group, among the group and the instructors, and from the school.

Assessment must Align with Goals for Instruction

A view of assessment as the servant not the master of curriculum is transforming assessment practice (see the subsequent section on assessment). Assessment and instruction are closely linked. Since teachers experience pressures to teach to the test, the prevalence of assessments that don't test for conceptual understanding or are limited to isolated facts has led to a curriculum that focuses on factual knowledge and vocabulary

(Madaus and West, 1992). In this way students learn discrete pieces of information and unconnected facts.

A new link between assessment and instruction is being forged through the science education reform movement (Hein, 1990). By using more authentic assessments such as performance-based or portfolio assessment or multiple choice tests that require thought beyond recognition and recall, more higher order thinking skills can be assessed, and students can learn through the process of assessment itself (Wheeler and Haertel, 1993). Children must be offered many different options for learning and communicating what they know and understand, and for raising new questions about a subject. Occasions to demonstrate ideas, quantify results, and make written, oral, kinesthetic, or visual presentations of findings and hypotheses are essential (White and Gunstone, 1992; Herman, Aschbacher and Winters, 1992). The important consideration is that the assessment measures progress toward the goal of the instruction.

Families and Other Concerned Adults Play Important Roles

The rise in informal science education opportunities and the strong influence of the family and other adults on children's science learning has the potential to transform science learning (Swap, 1993). Families and the community can encourage children's study of science both in school and in other science education activities. They can do this by supporting children in their homework, carrying out science activities at home, and participating in the growing number of informal science activities at zoos, museums, nature centers, national and state parks, and community organizations such as 4-H clubs. If families view science as an important subject for all students, they will more likely promote science activities for their children both in school and out of school. Often parents and other members of the community can bring their experiences to enrich the curriculum.

The availability of informal science education activities for young people has increased dramatically in the last few years. They vary in format from "Science by Mail," a program produced by the Boston Museum of Science, to the "Voyage of the Mimi" and "The Magic School Bus" televised science programs. Other programs help adults and children work together on science in out-of-school activities. The Family Science Program from the Lawrence Hall of Science at Berkeley (see organizations listing) encourages fun with science as a family activity. The U.S. Department of Education has published the booklet "Helping Your Child Learn Science" with many excellent opportunities to engage children in science and the National Urban League has a current project underway to expand parent attention to mathematics and science (see the latter part of the section "Organizing the System to Support Quality Science Education").

"Students can respond to performance-based assessment in a limitless number of ways, encouraging creativity as students work toward high standards. Performance-based examinations can assess a more complex understanding of material that is not easily reflected in standardized testing. Performance-based assessments also allow for revision that is not possible in a one-time test.

In working on a project, students might form teams and select team leaders to investigate a problem. Students on the team might perform different tasks, such as testing the hypotheses, documenting the experiments, or presenting the findings. A student working on an individual project might prepare interim reports of a work-in-progress, leading to a final project that represents a year's worth of research and experimentation."

... Rhode Island's Choice: High Skills or Low Wages, RI Skills Commission, May 1992.

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5

Teaching Science in an Inclusive Way

"Educating Rhode Island's children is what our schools are all about. This education process must focus on the strengths of our children, recognizing them and building upon them. It must be founded upon high expectations for children as well as for parents, teachers, and the community. We must let them know that we believe that all of them can reach high levels of performance with the appropriate instruction and support."

... Reaching for High Standards: Student Performance in Rhode Island, RIDE, December 1993.

What direction does Rhode Island plan to pursue toward creating a more positive learning environment for its children in the science classrooms? How does one begin to deal with the socioeconomic, racial/ethnic, linguistic, gender, 'gifted', and disability differences present in the Rhode Island classrooms? We must plan appropriate strategies to make science relevant, exciting, and challenging for all children.

Setting and maintaining high expectations for all students is a critical aspect of inclusive education. All students are expected to continuously progress through the goals in the state's Common Core of Learning and in specific subject matter areas, such as science. To ensure maximum growth and performance, students with diverse learning needs may require a variety of accommodations in the curriculum, in instructional practices and in pace and style of learning. School staff, family members and the student should work together to plan the student's goals in relation to the framework and the accommodations needed to support success. If the student has a Section 504 plan or Individualized Education Program (IEP), appropriate goals for science and other curriculum and skill areas should be incorporated into it. Supports, services and curricular and instructional accommodations will also be included. Observations of performance on at least a quarterly basis will demonstrate the student's learning progress and suggest areas of adjustment in the student's plan.

How can we use science education effectively to engage more students in science, technology, and career-related pursuits? Research reports validate that making connections is a prerequisite to inviting members of all underrepresented groups to science (AAUW, 1992). Demonstrating the connections between science, technology, and their life experiences is extremely enhancing for the development of all science students. These connections are part of the fabric of what has been called STS (Science, Technology & Society) education and offers teachers the possibility for changing the way many students have traditionally viewed science. STS education enables students to address scientific and technological issues that directly concern their lives while providing them with the skills and understandings they need to think through complex issues (Solomon and Aikenhead, 1994).

All students must be actively engaged in classroom conversations and all students should be exposed to scientists from diverse genders, socio-cultural groups, and the disabled population.

It is recommended that inclusive science education become a reality and concern for all teachers. Inclusive education incorporates the idea that all students - regardless of their gender and social class, their ethnic or cultural characteristics, and their disabilities or learning differences - should have an equal opportunity to learn. The basic premises of inclusive science education incorporate the following:

1. All students can learn science;
2. Every student can make a positive contribution in the science classroom; and
3. Diversity is appreciated in science classrooms because it enhances rather than detracts from the richness and effectiveness of science learning.

"A critical implication of the Regents policy is that student performance differences should not be connected to race, ethnicity, gender, poverty, community of residence or any other attributes that have historically separated students in their opportunity to succeed and in their full participation in American life."

... Reaching for High Standards: Student Performance in Rhode Island, RIDE, December 1993.

In Tomorrow's Teachers: A Report of the Holmes Group, several educational goals were identified to help science teachers strive toward meeting the needs of an increasingly diverse population:

1. Acquire knowledge and skills that social scientists and practitioners have applied to the study of children's learning;
2. Present appropriate lessons for particular students and use indirect, but powerful, teaching strategies such as role playing and collaboration to increase teachers' instructional effectiveness with diverse groups of at-risk students;
3. Eliminate school and teacher stereotypes and expectations that can narrow student opportunities for learning and displaying competence; and
4. Create and sustain a communal setting respectful of individual differences and group membership, where learning is valued, engagement is nurtured, and interest is encouraged.

"We must make education more personal, encourage teachers to collaborate more freely, and involve parents and social service organizations more directly in schools."

... Rhode Island's Choice: High Skills or Low Wages, RI Skills Commission, May 1992.

Special training should be provided for all teachers in order to improve the academic achievement of students who have historically been underachievers. A variety of effective intervention programs exist for nurturing minorities for careers in science, engineering, and mathematics. Gender/Ethnic Expectations and Student Achievement (GESA) has proven to be one successful training program. The GESA program, *The SCANS competencies include:*

Information - acquire, evaluate, organize and maintain data; interpret and communicate information.
Interpersonal Skills - work in teams; teach and serve others; lead, negotiate and work with people from culturally diverse groups.
Resources - allocate time, money, materials, space and human resources.
Systems - understand and operate within social, political and organizational systems; monitor and correct performance of systems.
Technology - select and apply tools and technologies appropriate to specific tasks, including the use of computers and technologies to process information."

... Rhode Island's Choice: High Skills or Low Wages, RI Skills Commission

commencing in 1977, was among the first to attempt to apply solutions across parallel equity issues. GESA addresses five specific areas of disparity:

1. Instructional contact;
2. Grouping and organization;
3. Classroom management;
4. Enhancing self-esteem; and
5. Evaluation of student performance.

For further information on GESA programs in Rhode Island, please contact Carol Englander at the South Kingstown School Department, telephone 792-9681.

Another effective program is MESA (Mathematics, Engineering, Science Achievement) formed in 1970. The MESA program presently works in 49 sites throughout California and has markedly increased minority enrollment and academic success in California colleges and universities. Special out-of-school enrichment opportunities, mentoring, workplace site internships, and career counseling are important components of the program. Key strategies from this program have been used to launch other successful programs throughout the country (Somerton, Smith, Finnel and Fuller, 1994).

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Organizing the System to Support Quality Science Education

The past several years have seen a renewed interest in issues associated with mathematics and science education. Spurred by a general sense that large numbers of the students in American schools are failing to acquire minimum levels of proficiency in mathematics and science, and concerned that this failure is contributing to the erosion of our country's economic competitiveness, a number of national organizations have called for reforms in both the content and delivery of mathematics and science courses in our schools and colleges. Perhaps the loudest call for change is contained in the National Goals for Education that were developed by President Bush and the nation's governors in 1990 and subsequently amended to become the basis for Goals 2000 legislation. Goal Number Four is that

"By the year 2000, US. students will be first in the world in science and mathematics achievement."

At the present time, it is clear we are a long way from meeting this goal. Small numbers of American students can clearly compete with and outperform their counterparts from other nations of the world as events like the Physics and Chemistry International Olympiads demonstrate. The annual winners of the Westinghouse Science Talent Search produce projects and research-based scientific insights which are the envy of the world. However, the majority of our students are not performing anywhere close to these high levels of attainment.

In a society that is increasingly becoming information and technology based, it is imperative that students know and can apply important mathematics and science concepts. Our population must be able to intelligently examine ethical dilemmas such as gene therapy and biological weapons, and elect officials who can make wise public policy decisions about them. Scientific and technological literacy is becoming as important as the ability to read and write.

Yet, low overall student achievement levels "for the masses" are only one indication of the nation's problems in mathematics and science. Another sign of impending trouble is that the nation's colleges and universities are not graduating the number of needed students with degrees in mathematics and the physical sciences. Not only are fewer students being prepared than are needed, but nearly half of all those we do educate to the level of graduate degrees in science, mathematics and engineering are non-citizens (National Science Foundation, 1993). Compounding this problem even further is the fact that, as a group, US students who are science, mathematics and engineering graduates remain overwhelmingly white and male. Over the past 15 years, 95% of US students receiving degrees in the physical sciences have been white, and a vast majority of these are white males. Even apart from concerns about equity and justice, the evolving work force of this country which is increasingly female and minority--demands that a better job be done to encourage minorities and women to follow careers in mathematics and the sciences. If not, the current shortage of American scientists is certain to grow worse and become a fatal flaw in the nation's technological and economic growth.

"Operating on the principle that all children can learn, the focus on learning should emphasize students as life-long learners, as citizens and as workers. The goal is to develop students who will function as caring and productive citizens. Specifically, a vision of the successful student is one who is a critical thinker and problem solver, interpersonally successful, knowledgeable and literate, self-directed and self-reliant, and an interested and involved citizen."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

Science Reform

The need to overhaul the delivery of science instruction is very real. With national attention on poor student performance, declining national competitiveness, and future labor shortages, the support for restructuring the teaching of science is widespread. As this century draws to a close, the volume of scientific content is staggering. In periods of less than ten years, the amount of scientific information doubles. How can students be expected to learn all there is to know about science topics? The time has come to determine what is essential to be learned and what skills will serve as a basis for lifelong learning.

The American Society for Engineering Education, through its Engineering Deans Council and Corporate Round Table, says that all engineering education programs must be RELEVANT, ATTRACTIVE, and CONNECTED. We believe this also holds for K-12 education. School systems and teachers must provide science education programs that are:

* *Relevant* to the lives and careers of students, preparing them for a broad range of careers, as well as for lifelong learning involving both formal programs and hands-on experience;

* *Attractive* so that the excitement and intellectual content of engineering, mathematics and science will attract highly talented students with a wider variety of backgrounds and career interests - particularly women, underrepresented minorities and the disabled - and will empower them to succeed; and

* *Connected* to the needs and issues of the broader community through integrated activities with other parts of the educational system, industry, and government (American Society for Engineering Education, 1994).

As a spin-off of the mathematics document Everybody Counts, the American Association for the Advancement of Science (AAAS) gathered a distinguished group of scientists and top educators to develop a set of recommendations on what understanding, skills, and attitudes are essential for all citizens in a scientifically literate society. The resulting document, Science for All Americans, and its accompanying document, Benchmarks for Science Literacy, differs in several basic respects from most other reform efforts in that it is:

Comprehensive. Reform must address the entire educational system.

Zero-based. Reform must start from scratch. The common core of knowledge and habits of mind must be established.

Focused. "Less is more." The present curriculum is overstuffed and undernourished. Teaching fewer concepts to a higher degree of understanding will help students better understand the principles of science.

Teacher centered. Teacher revitalization is critical to the success of the reform initiative.

Collaborative. Teachers cannot do the job alone. They need the help and cooperation of other teachers, administrators, parents and community leaders, students, university faculty, business and industry leaders, policy makers, scientists, mathematicians and professional associations.

Long term. The necessary changes will take decades to accomplish.

In line with Science for All Americans, the National Science Teachers' Association has developed a project titled Scope, Sequence, & Coordination of Secondary Science for grades 7-12. The project advocates carefully sequenced, well coordinated instruction so that students begin with descriptive and concrete elements of science, proceed to the quantitative and more abstract, and conclude with theory building. Fewer topics taught over the seven years will result in greater student understanding of science and serve to better address problems and issues of scientific and technological dimensions in the future.

Call for Systemic Changes

The NCTM Standards and Science for all Americans documents have collectively delineated a number of areas in mathematics and science education--including curriculum, instruction, and assessment--where fundamental restructuring is needed. A summary of needed changes would include the following:

Curriculum Development. Statewide frameworks which have been developed for mathematics and science education can be a fruitful starting point for local curriculum development.

Textbooks, Technology, and other Materials. The curriculum in many schools is driven by textbooks. Textbooks should not drive curriculum, even if the books have been recently revised. Calculators, computers, courseware, manipulative materials, and well equipped laboratories are necessary for quality mathematics and science programs. Textbooks should be viewed as simply another form of ancillary support material for student learning rather than the curriculum.

Tests. According to research, what is tested is taught. If problem solving and higher order thinking are the focus of the reform program then a new generation of tests that focus on these areas must be developed. Rhode Island is committed to the development of such tests.

Instruction. Because students need to be active learners teachers must use a variety of teaching methods, grouping techniques, and approaches to assessment.

Teacher In-Service Programs. Many teachers are now ready to teach the kinds of science and mathematics being advocated. Many others will need additional training and refresher courses. In-service courses must be developed in collaboration with teachers.

Teacher Education. Colleges of education and science and mathematics departments need to reconsider their programs in light of the kinds of knowledge and teaching models proposed in national and state reports.

Students with Different Needs and Interests. All students can benefit from high quality mathematics and science programs. This can be accomplished by developing a core curriculum for all, and expanding and enriching this core to meet the needs of each individual student.

Equity. Instructional activities and programs must be developed to encourage more students, especially young women and minorities, to pursue careers in science and mathematics. Every school system should have in place a framework for determining that all students have equal opportunities to learn (Stevens, 1993; Rauth, 1994).

Working conditions. In many schools, teachers will find it difficult to teach the topics or create the instructional environment envisioned in these documents because of local constraints on curriculum and facilities. Teachers often lack resources and opportunity to meet and share ideas with other teachers. The work environment must empower teachers to make curriculum decisions and must include and support professional activities.

The above changes, based on the NCTM Standards and Science for all Americans, can help to insure that all Rhode Island students have both a suitable and sufficient background as they enter the 21st century.

Over 10,500 teachers currently provide instruction to the 145,000 public school students who attend the 302 schools in the 36 public school districts of Rhode Island. Approximately 3,500 of these are elementary classroom teachers who are responsible for providing instruction in the areas of science and mathematics. Another 750 teachers are content area (mathematics or science) specialists teaching in middle schools, junior highs, or high schools. The districts range in size from the largest (Providence) which serves approximately 23,000 public school students of whom nearly 70% are minority, to New Shoreham (Block Island) serving approximately 118 students. Some districts, such as Foster/Glocester and Exeter/West Greenwich, have regionalized to improve services and consolidate costs. An emerging trend has been the establishment of educational collaboratives. These collaboratives (Northern Rhode Island, Southern Rhode Island, East Bay Educational, and West Bay), although differing in their priorities and levels of organizational development, share some common features. All are intended to achieve fiscal economy while improving services to member districts and retaining the local autonomy of the individual school districts.

In addition to its public elementary and secondary school population, the state also has approximately 26,000 students in grades K-12 who attend private or parochial schools, and approximately 68,000 (39,000 in public) students enrolled in undergraduate programs in the public and independent institutions of higher education.

As we approach the 21st century, we want Rhode Island students to meet the highest national and international standards. Rhode Island students currently have similar achievement levels to United States students as a whole. The key to interpreting this information is to recognize that national performance results are far below what they should be. Many reform efforts nationwide are now committed to setting and achieving higher standards.

A key indicator of national performance comes from the National Assessment of Educational Progress (NAEP). The National Education Goals Panel, in its September 1993 report on progress toward the national education goals, adopted the NAEP 'proficient' definition as its target performance goal for all students. However, in the 1992 NAEP mathematics assessment, no more than a quarter of United States students met this target level.

Within Rhode Island, there are major differences in the educational achievement of students when one compares the average performance levels of different groups. These differences may be so large that they virtually guarantee lack of opportunity, limited employment opportunities and a life of barriers for a great many students (Rhode Island Department of Elementary and Secondary Education, 1995).

<u>Student "persistence" in science</u>

In addition to less than acceptable achievement levels, another serious dilemma facing the nation and Rhode Island is the diminished student interest in mathematics, science and engineering as they progress through the system. Student participation in science is virtually cut in half by ninth grade; cut again in half as they enter college science courses; and cut again in half as they enter post graduate and doctoral programs. In Rhode Island these factors are reflected in a relatively high dropout rate of 18%, a rate that ranges up to over 35% in our urban areas that serve large numbers of minority students. The situation is even more discouraging when one examines the limited number of students with ability in science who are interested in entering the teaching profession. This is particularly evident in the minority teaching base in Rhode Island where of the 750 teachers of secondary science and mathematics in public schools, there are fewer than ten science or mathematics teachers who are of African-American descent.

RECOMMENDATIONS

The status of mathematics and science education in Rhode Island is generally reflective of the nation as a whole. While Rhode Island has taken some significant strides toward addressing its problems in the areas of mathematics and science, much remains to be done. Toward these needed actions the following recommendations for the state as a whole, school districts, and individual schools are made:

Curriculum Frameworks:

Local curriculum frameworks for mathematics and science education, K-12, which align with the NCTM Standards and the Science for All Americans report must be developed. This state science framework and the state mathematics framework are the first step in this process. These curriculum frameworks:

· Provide a vision of high standards for student achievement by including:

- Student curriculum benchmarks and sample activities
- Teaching strategies through vignettes from RI classrooms
- Program goals and evaluation advice
- Assessment strategies
- Related materials and resources

· Guide districts and schools in formulating local curricula

· Drive the succeeding recommendations in this chapter

· Provide a model for post-secondary curriculum frameworks that will ensure a smooth transition from secondary school to college

Professional Development:

Efforts need to be undertaken to attract, train, and retrain teachers and administrators who are capable of implementing the content and teaching approaches described in the RI mathematics and science curriculum frameworks.

· In-service programs are needed that will provide high quality, long-term training to all current teachers and administrators as they work to develop and implement changes consistent with their schools' mathematics and science programs.

· Undergraduate teacher preparation programs need to be reviewed and revised to ensure that they adequately prepare new teachers to teach in ways consistent with the curriculum frameworks and current research.

· Teacher certification requirements need to be revised to include standards that result in well-prepared teachers of mathematics and science. Flexibility must be provided for certification of teachers in those districts that engage in experimental practices.

· Current efforts to recruit and retain high quality teachers into careers as mathematics and science teachers, particularly from those groups historically under-represented, need to be expanded.

Access and Equity:

Special efforts need to be undertaken to insure that ALL students have an opportunity to experience a high quality mathematics and science program. Schools need to increase motivation, incentives, and opportunities for all students to pursue study and/ or careers in mathematics, science, and related fields. In particular, the state, districts, and schools need to:

. Provide alternative paths to learning goals for students including the use of varied instructional approaches.

· Support efforts such as magnet programs in mathematics and science and centers for talented students, develop alternatives to the tracking system, and provide greater access to positive role models.

· Assist teachers and parents to overcome stereotypes, provide early intervention and counseling, and stress technology related careers.

· Encourage active engagement of parents and communities in mathematics, science, and technology programs to increase participation by under-represented groups.

· Use college outreach programs, dual enrollment, advanced placement, and financial aid awards in post-secondary institutions to target under-represented groups for mathematics, science, and technical studies, with a special emphasis upon those preparing to be teachers of these subjects.

Learning Environment:

Responsibility and support must be given to local schools and teachers to develop and experiment with their own ways of using time, space, materials, and human resources in the student learning environment. The learning environment should include:

- The system of professional development for school personnel and pre-service training for those entering education is not adequate to meet the needs of a restructured school environment.
- The new realities facing public education -- the dissolution of the family, the lack of school readiness, the hunger and physical and emotional neglect of students -- affect the system's ability to be successful with many students. Solutions to educational problems that focus on the school system alone will continue to fail."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

· Equipment, objects, and other "things" that students can get their hands on to observe, measure, sort, and use in doing mathematics and science.

· Alignment with the state curriculum frameworks.

· Use of educational technology that is incorporated into the mathematics and science courses as an integral part of the curriculum.

"In the past, teaching and learning policies -- those related to curriculum, instruction, assessment, and teacher preparation -- frequently emphasized inputs such as courses offered and time on task. In the future, policies must be focused on outcomes -- on a commitment to provide all students with basic knowledge and higher level thinking skills."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

· Use of the mathematics-rich and science-rich resources in the community, such as business and industrial sites, museums, zoos, technology, and environmental education centers.

· Common planning time for teachers engaging in innovative classroom practices.

Outreach:

Schools and teachers need to promote community awareness of the need to reform science and mathematics education. Schools must develop and expand partnerships with public policy makers, community leaders, colleges and universities, hospitals, museums, business and industry to create a solid network of support.

· The Governor and state agencies can play a leadership role in building public support for systemic change in science, mathematics, and technology education as part of an economic recovery strategy.

· The Legislature can support school boards through legislation that provides mathematics and science program incentives, or loan forgiveness for those who become mathematics and science teachers.

· Business and industry can provide technical assistance, equipment, volunteers, and internship opportunities for students and teachers.

· Community leaders can publicize exemplary school programs and address civic organizations and parent groups on awareness of the need for change.

Support:

Efforts must be undertaken to direct resources to the reform of mathematics and science education. Although this will certainly require some additional investment of resources, innovation in the ways current resources are coordinated and expended need to be encouraged. Several existing sources of funds (e.g., Goals 2000 monies; IASA funds, especially Chapter 1 and Title 2; Literacy funds) need to be aligned with each other and with the state's frameworks and goals for mathematics and science instruction. In addition, aggressive attempts to secure other additional funds from federal and private funding sources need to be undertaken to provide resources to supplement state efforts.

Conclusion

Preparing Rhode Island students to be informed citizens and well educated workers for the workplace of tomorrow will not be easy, quick, or without costs. It is important to realize that the changes needed in mathematics and science education will not only improve our economic competitiveness, they will also begin the needed process of reform and change throughout our state's school systems. Many of the changes called for in this section of the science framework do not involve increased costs, nor must they all be done at once. The reform of mathematics and science education is a statewide priority, and the process of reform needs to continue and deepen. Only by involving all the key actors at the school, community, district, and state levels, can we hope to reach our goal.

"School finances must be based on equity, adequacy, tax fairness and effectiveness.

Rather than focus on equal dollars, the finance system must address equal learner outcomes, and funding reforms should be connected to both adequacy and improved learning and teaching practices. The manner in which the state distributes financial aid must not ignore strategies for making schools more effective."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

"The governance system must be structured to support student achievement. Accountability and responsibility for learning should be assigned to those closest to the student if the diverse and complex needs of children are to be met. Barriers to ensuring student success must be removed. The governance system must be based on the concept that form follows function and that leadership can originate at all levels when empowered by a shared vision."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

Cumberland School District
Cumberland, Rhode Island
Town-Wide Activity

A Unique Approach to Financing Technology

"... through the gift of computer access, the community will be empowering students with skills for their lifetime: the skills needed to explore, understand, and solve the problems of the real world."

Computers in Classrooms, a plan by Mayor Edgar R. Alger III, Cumberland, RI

Cumberland's Systemwide Technology Committee created a multi-year technology plan for the district's schools K-12. While many school districts are working on plans of this type, Cumberland may have found an innovative solution to financing the equipment called for by this plan -- by having the COMMUNITY develop the plan and be responsible for its success. The Technology Committee defined a basic level of service for an elementary, a middle level, and a high school classroom. They also added basic services which should be available at each school or department and administrative office. They have pledged to provide every classroom with basic services BEFORE any additional items are added. For example, the 'middle school classroom basic computer standard' consists of two networked computer/media centers with Apple Macintosh stations; four Apple MacIntosh computers, CD/ROM and a networked printer. Other desirable classroom items include a large screen display, an additional CD/ROM and an additional computer, but these would not be purchased until every middle school classroom in the system has met the basic levels. The technology plan also details how curriculum and instruction need to be modified and the type of staff training and support required.

A funding partnership is being solidified between the Town, the School Department, the State, local businesses and foundations, and parents groups. Mayor Edgar R. Alger III has released a written plan called Computers in the Classroom which outlines 'Cumberland's Commitment to Excellence in Education.' In addition to the commitment of substantial funds from the town and the school department, the Mayor has secured funding from several businesses and foundations. The final funding piece comes from the local PTA's and PTO's, who are being asked to contribute $2,000 per group per year of the plan.

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7

Assessment in Science and Mathematics

Educators and others use assessment for a variety of reasons. Such reasons include the desire to measure student learning, to identify areas of difficulty for individual students, to provide opportunity for students to apply their problem solving skills, to plan instructional strategies, and to provide evidence of the effectiveness or impact of an educational program. No single assessment instrument can accomplish all of these tasks. Multiple instruments are needed.

It should be said at the outset that a comprehensive portrait of achievement by American students in science and mathematics requires input from all levels. These include the classroom, school, state, nation, and the world. Cooperation, therefore, between constituencies at all levels is essential.

Student assessment at each level brings with it a unique set of issues, complexities, and reasons for assessing students. Nonetheless, some principles apply to student assessment at any level. First, effective assessment should begin with identifying the purpose and context in which the assessment is to be used, the type of information sought, and the use to which the information will be put. Assessment instruments designed for specific purposes should vary; most often, an assessment program should include the application of a variety of assessment instruments.

Second, an assessment program at every level should be aligned with rigorous and challenging content standards of what students should know and be able to do. In this document, standards include content and performance standards, benchmarks, and principles or guidelines that provide a vision of what we want students at the elementary and secondary levels to know and be able to do in mathematics and science. The standards may be developed at the local, district, state, and national levels. At each level, these standards should be developed with the strong support and involvement of content experts and key constituencies.

Assessments at the national level may not be consistent with all aspects of every state's content standards, since standards in different states may not be consistent with each other. Similarly, international assessments may not be aligned with all national goals among different nations. Nevertheless, assessments at the national and international levels should support and align with these goals when possible and where appropriate.

In addition to these two fundamental principles, an assessment program at each level should:

* assess student knowledge and understanding of science and mathematics in ways that are more complex and demanding than traditional tests, by including the assessment of higher order thinking skills and problem-solving ability;

* be valid, reliable, and fair;

* be based on knowledge of how students learn and develop;

* be implemented in such a way that each assessment instrument is used and interpreted only for the purpose for which it was intended and in a context where that purpose is clear to all groups involved in the assessment and use of its results;

* use assessment results in the process of improving instruction strategies and curriculum development; and

* promote equity by providing each student optimal opportunity to demonstrate scientific and mathematical knowledge and skills.

ASSESSMENT FOR STUDENTS

When appropriately and effectively applied, student assessment measures what we value. Many different methods of assessment should be used to assure that all students -- those with various abilities, backgrounds, and levels of English language proficiency -- have ample opportunity to be challenged by assessment. Moreover, assessment should be an integral part of the learning process, not the end result. An assessment program for students should:

* be coherent and comprehensive;
* be equitable and engage all students;
* be integrated with instructional strategies and curriculum materials to promote effective student learning; and
* provide information that will help yield valid inferences about students' learning.

From Dr. Berg's Class
Coventry Middle School
Coventry, Rhode Island
Eighth Grade Activity

Performance Assessment in the Science Classroom

Performance assessments are processes whereby students use knowledge, skills and competencies to construct responses to problems. In performance assessments, students are doing, telling about, writing about, and visually representing what they know, often in the context of a real-life situation. These types of assessment provide important information about student understanding that cannot be obtained, for example, from a multiple-choice test.

Early in the year, Dr. Berg used a performance assessment to pre-test his students knowledge of, familiarity and comfort with some of the techniques and tools scientists use. The room was set with fourteen individual stations which the students moved through, completing a two-minute task at each station. The tasks were process based -- the students were required to draw, measure, weigh, read and create charts and graphs, and interpret information. At one station students demonstrated their understanding by calibrating and using a balance correctly.

The findings of this pre-test will allow Dr. Berg to see how well the students have mastered the tools and techniques necessary to fully participate in the learning and exploration of science. The assessment also gave the students a CLEAR indication of the many types of knowledge, skills and competencies they will be required to master and use if they are going to be successful students.

TEACHERS AND ASSESSMENT

Teachers must be actively involved in the entire assessment process if learning, instruction, and assessment are to become integrated in the classroom. Teachers need training, time and support to be able to:

* understand the variety of assessment designs and strategies as well as the strengths, applications, and limitations of each assessment instrument;

* have effective instruments for each assessment purpose;

* assess students informally and frequently;

* make sound judgments of individual student achievement based on the results of assessments; and

* report student progress to students, parents, and administrators in a timely and meaningful way.

SCHOOLS, COMMUNITIES, AND ASSESSMENT

A school uses student assessment in a variety of ways. Some student assessments are geared to measuring individual student achievement. Others are used to evaluate the effectiveness of the school's programs in light of local, regional, or state expectations. It is important to report on the effectiveness of the school's programs to students, parents, teachers, school boards, other policymakers, and the community at large. Because statistical data and changes in assessment techniques which are left unexplained often can be confusing, such aspects of the assessment process should be open to review and scrutiny.

To provide effective assessments of the school's programs for the community and clear understanding of the results of assessment, the school should:

* align classroom student assessment with adopted school curricula and educational objectives for students;

* make clear to both students and parents what assessment instruments are measuring when they are applied;

* facilitate public, and in particular, parental understanding of the variety of assessment techniques being used in the schools; and

* ensure that student progress is reported to parents, and that the school's performance is reported to the community in an open and meaningful manner.

Educational reform revolves around three central issues; what students should learn, how they should be taught, and how progress should be measured.

Curriculum, instruction, and assessment must mutually support one another in the educational process, with each serving common goals and high standards. Assessment, in particular, must cease to be an independent function designed principally for the efficiency and economy of administration. Instead, educators should use it to measure all facets of curriculum and instruction and consider its contribution to students' learning.

In science and mathematics, the new and broader aims of assessment can be captured in three broad educational principles, as defined by the Mathematical Science Education Board's publication entitled Measuring What Counts:

1. The Content Principle: Assessment should reflect the sciences and mathematics that are most important for students to learn.

2. The Learning Principle: Assessment should support good instructional practices and enhance learning.

3. The Equity Principle: Assessment should support every student's opportunity to learn important science and mathematics.

These three principles place special demands on assessment reform at the classroom, school, district, state, and national levels if assessment is to be interwoven into the fabric of educational reform. An effective assessment should provide information that can be used to improve students' access to scientific and mathematical knowledge and to help each student prepare to function effectively in our complex and changing society.

MEASURING ACHIEVEMENT OF THE SCIENCE CURRICULUM BENCHMARKS

Changes in science and mathematics curricula and instructional goals, as set out in the benchmarks of the science framework, require changes in assessment, if real reform is to occur. Assessment can no longer simply mean that teachers administer norm-referenced tests or end-of-the-unit tests; but rather, a system of assessments intimately related to instructional goals must be created. Such a system can include some familiar types of tests but there is also a need for much greater reliance on performance assessment strategies and portfolios.

We must, of course, assess student knowledge, but we also need to assess student understanding through application of their knowledge. This can be done by implementing assessments that require students to use their knowledge. With our growing understanding of how people learn and our recognition that each student has multiple intelligences and preferred learning styles, our instruction and assessment strategies must be varied to assure that all students can learn and achieve at high levels. Equity in learning opportunities and assessments require this.

PERFORMANCE ASSESSMENTS

Performance assessments are processes whereby students use knowledge, skills and competencies to construct responses to problems. Responses are rated according to preestablished scoring guides (rubrics). In performance assessments, students are doing, telling about, writing about, and visually representing what they know, often in the context of a real-life situation. Performance assessment methods can take many forms, including demonstrations, displays, speeches, videotapes, artifacts created with paper and pencil, observations, open-ended responses and oral responses.

These types of assessments provide important information about student understanding that cannot be obtained, for example, from a multiple-choice test. They may be implemented to a whole class at the same time, as one would test with traditional approaches, or they may be completed by individuals or groups of students as appropriate within the instructional process. The assessment purpose, for example, assigning a grade, deciding whether to provide additional learning experiences for a given concept to some or all of the students or providing a statewide picture of student achievement would determine when and how an assessment is given.

Effective performance assessments can do all of the following:

* balance content and cognitive processes;

* allow students to demonstrate what they know, as opposed to what they don't know;

* provide opportunities to see real-life connections in their classroom instruction; and

* emphasize how an answer is obtained or what an answer means, in addition to the answer itself.

Performance tasks provide students with a situation to investigate. The teacher facilitates and observes the processes and then examines the results/products to determine, using a structured scoring guide (rubric), what the students actually know and can do. Such an assessment may involve the use of manipulative materials or equipment, and may involve an instructional component. Students are required to be active rather than passive, and the investigation portion may be accomplished individually, in a group, or through a combination of group and individual work.

Open-ended questions provide for multiple solutions and thus allow students to respond in a variety of ways. There may be one answer or many answers and many ways to arrive at an answer. Responses can be verbal, written, graphic/pictorial or a combination. They can be evaluated on how the solution was reached and on clarity of presentation in addition to the answer.

For a more thorough discussion of performance tasks and their grading through rubrics, please refer to pages 9-10 of the *Mathematics and Science Performance Assessment Handbook for Teachers and Administrators, available from the Office of Outcomes and Assessments at RIDE.* Pages 10-14 discuss a plan for professional development that could easily be adapted to the science classroom.

References and Further Reading:

American College Testing (ACT) (1994). Are Our High School Graduates Prepared in Mathematics and Science? ACT Publications.

Ann Arbor Public Schools (1993). Alternative Assessment - Evaluating Student Performance in Elementary Mathematics. Palo Alto, CA: Dale Seymour Publications.

English, Fenwick W. (1992). Deciding What to Teach and Test. Newbury Park, CA: Corwin Press.

Gellman, Estelle S. (1995). . School Testing: What Parents and Educators Need to Know. Westport, CT: Praeger Press.

Gipps, Caroline and P. Murphy (1994). A Fair Test? Assessment, Achievement and Equity. London: Open University Press.

Herman, Joan L., P. Aschbacher and L. Winters (1992). A Practical Guide to Alternative Assessment. Alexandria, VA: Association for Supervision and Curriculum Development.

Kulm, Gerald and S. Malcolm (Eds.) (1991). Science Assessment in the Service of Reform. Washington, DC: American Association for the Advancement of Science.

Linn, Robert L. (Ed.) (1989). Educational Measurement, Third Edition. New York: American Council on Education - Macmillan Publishing Company.

Mitchell, Ruth (1992). Testing for Learning: How New Approaches to Evaluation Can Improve American Schools. New York: The Free Press.

Perrone, Vito (Ed.) (1991). Expanding Student Assessment. Alexandria, VA: Association for Supervision and Curriculum Development.

Pole, Christopher J. (1993). Assessing and Recording Achievement. London: Open University Press.

Riding, Richard and S. Butterfield (Ed.) (1990). Assessment and Examination in the Secondary School. London: Routledge Press.

Wheeler, Patricia and G. D. Haertel (1993). Resource Handbook on Performance Assessment and Measurement: A Tool for

Students, Practitioners, and Policymakers. Berkeley, CA: The Owl Press.

White, Richard and R. Gunstone (1992). Probing Understanding. London: The Falmer Press.

Wiggins, Grant P. (1993). Assessing Student Performance: Exploring The Purpose and Limits of Testing. San Francisco, CA: Jossey-Bass Publishers.

8

Evaluating the School Science Program

The school science program includes teaching staff and their ongoing professional development, school facilities and science materials, the science curriculum, activities and events both within and outside of the classroom, and assessment tools which are in use to judge the value and impact of science teaching and learning. An informal survey of district-level supervisors for science within RI during the course of the development of this framework, indicated that most districts within the state do not have a formal means of science program evaluation in place. This section will provide for all RI districts and schools an orientation to the purposes and possible format of science program evaluation

The RI state science framework, with its associated benchmarks for K-12 science teaching and learning, provides a common frame of reference for the design of local science curricula and a basis for ongoing evaluation of its design, implementation, and continued refinement. Evaluation of the school science program and implementation of the science benchmarks advocated here can proceed at three distinct but interrelated levels:

1) State assessments: The committee's development of this statewide science framework is coupled with the state's recognition of the need for a statewide assessment system which includes the sciences. This statewide assessment system will include a science component focused on performance-based assessment of science learning on the part of students. A sense of what these items might look like can be gained by studying the prototype state performance assessment items in science available from the Office of Outcomes and Assessment, RI Department of Elementary and Secondary Education.

2) System assessments: Each school district should develop a comprehensive approach to evaluating its science program with provision for input opportunities from a wide spectrum of the local community. This evaluation plan can build upon excellent instruments already developed and tested by the National Science Teachers Association (see Chapter 9 for contact information). The team which develops these instruments for district evaluation should have significant representation from those closest to the actual delivery of the curriculum -- the

teachers and instructional support staff. Local business leaders, especially those conversant with the development of quality indicators, can bring needed expertise to the development of appropriate and effective indicators of quality for the school science program.

3) Site assessments: Every school building and each classroom teacher of science should engage in an annual evaluation of the science program within their building/classroom. This would include attention to student perceptions of the science program, parent and administrator perceptions, analysis of student assessment information in light of possible program changes (including grade distributions disaggregated by race, gender, and special needs), and attention to the scope and sequence of the science curriculum within the building to ensure that it is developmentally appropriate, conceptually linked, and focused on science understandings that are crucial to general scientific literacy. It is critical also to involve guidance counselors, school psychologists, and specialists in special needs populations, LEP, and equity to ascertain to what degree the school science curriculum is addressing the needs of all students. One useful template for the development of such a site-based science program evaluation is the Elementary Science Program Evaluation Test II in use across New York State and available from the New York State Education Department Publications Sales Desk (518-474-3806).

To facilitate an evaluative judgment of the success of the science curriculum within each school system, data must be collected in a variety of forms, and whenever possible, at all three levels indicated above. These data can also be thought of as falling into three distinct categories of data:

Type 1: Quantifiable data: Factual data such as enrollment figures in science courses, written policies, records of classroom visits, test results, etc.

Type 2: Qualitative data: Data to which a professional or personal judgment could be applied such as student portfolios of exemplary work, displays of children's work, resource materials developed by teachers for the curriculum, observations of classroom learning situations, etc.

Type 3: Inferred data: Data based on impressions of professionals regarding such items as student involvement in science projects, environmental problems in the community and student engagement in such problems, "science fair" participation, science Olympiads, contests, etc. Teacher participation in workshops, science conventions, professional organizations, etc. can also be included in this type of data.

The following table illustrates a suggested basis for evaluating the school science curriculum with reference to the RI state science going evaluation comprised of samples like these should occur through all phases of development, implementation, and refinement.

PHASE	STANDARD	QUANTIFIABLE INSTRUMENT	QUALITATIVE INSTRUMENT	INFERRED INSTRUMENT
Implementation	All students (K-12) are provided opportunities to attain all of the state science benchmarks.	Records of student enrollment and adequate certified teaching staff	Science programs are engaging all students	Students scientific literacy is increasing
Implementation	Students are engaged in opportunities to attain the benchmarks in the RI State Science Framework	Progress reports at appropriate grade levels of student achievement on evaluative instruments	Science instruction provides opportunities for student achievement as evidenced by student portfolios	Student's know more about science and connect it to everyday life and events
Ongoing	Staff development opportunities are available and funding sources are being actively sought	Records of workshops, course reimbursements or incentives are available to teaching staff	Teachers and staff are involved in workshops as active participants	Enthusiasm of professional staff as indicated by organization memberships, teaching awards, grant proposals, etc.
Ongoing	Curriculum revision opportunities are scheduled and supported	Records of periodic meetings of curriculum teams and records of document revision	Teacher feedback of progress and needs	Instructional staff aware of ongoing curriculum efforts and its relation to current curriculum

"Children are the living messages we send to a time we will not see."

Neil Postman from The Disappearance of Childhood, 1982.

Good science programs are characterized by many common features. Exemplary science programs from across the United States have been featured in a series of monographs published by the National Science Teachers Association. Project PRISM, a program of the National Urban League, Inc. in association with the National Council of La Raza, the NETWORK, Inc., and Thirteen/WNET, funded by the Annenberg/CPB Math and Science Project, have identified ten things to look for in science programs:

1. Science is "hands-on" and "minds-on."

2. Students are encouraged and taught to ask questions about nature.

3. Students learn how to find out.

4. Students practice skills in order to become good at them.

5. Students learn to think for themselves and recognize false claims.

6. Students work in groups.

7. Teachers use different ways to find out what their students have learned.

8. Students study science every day.

9. Teachers expect all students to succeed and set high goals for themselves.

10. Teachers have opportunities to improve their science teaching skills.

References and Further Reading:

Eisner, E. (1994). The Educational Imagination: On the Design and Evaluation of School Programs. New York: Macmillan College Publishing.

Joint Committee on Standards for Educational Evaluation (1994). The Program Evaluation Standards 2nd edition. Thousand Oaks, CA: Sage Publications.

Payne, D. (1994). Designing Education Project and Program Evaluations. Boston, MA: Kluwer Academic Publishers.

Rossi, P. and H. Freeman (1993). Evaluation - A Systemic Approach. Newbury Park, CA: Sage Publications.

Tovey, P. (1994). Quality Assurance in Continuing Professional Education - An Analysis. New York: Routledge Press.

Wholey, J., H. Hatry, and K. Newcomer, ed. (1994). Handbook of Practical Program Evaluation. San Francisco, CA: Josey-Bass Publishers.

9

Organization and Information Resources for RI Schools

Listings in this section --

A. Resources Within Rhode Island

Note: A more extensive directory of resources available to RI schools, "What's Out There? A Directory of Science and Mathematics Resources for Educators", is available from the Rhode Island Mathematics and Science Education Coalition, PO Box 6248, Providence, RI 02940, telephone 455-4058, Fax 331-3842, e-mail: sxs@math.ams.org. ***A copy should already be available in your school.***

A highly useful resource to determine prime nature spots for class investigations is A Guide to Rhode Island's Natural Places, published by the University of Rhode Island. Copies are available in book stores throughout the states (ISBN 0-938412-38-8). A second valuable resource for every school would be Marine Animals of Southern New England and New York, recently published by the Connecticut Department of Environmental Protection, and available for $39.95 to teachers. To order, call 860-424-3555.

Ag (Agriculture) in the Classroom, State Leader Carol Stamp, 1 Stamp Place, South County Trail, Exeter, RI 02822, 942-4742

Audubon Society of RI, 12 Sanderson Road, Smithfield, RI 02917, 949-5454, FAX 949-5788

Aviation Education Resource Center, Warwick Public Schools, Attn: Anthony Gagliardi, Warwick Career and Technical School, 575 Centerville Road, Warwick, RI 02886, 737-3300

Beaver River Associates, P.O. Box 94, W. Kingston, RI 02892, 782-8747

Brown University, American Civilization Dept., Prof. Susan Smulyan, Providence, RI 02912, 863-1000

Brown University, Geology Department, Prof. Bruno Giletti, Providence, RI 02912, 863-2242

Brown University, Graphics Lab, Providence, RI 02912, 863-7693

Brown University, Urban Studies Department, Prof. Patrick Malone, Providence, RI 02912, 863-1000

Children's Museum of Rhode Island, 58 Walcott Street, Pawtucket, RI 02860, 726-2591

Coastal Resources Management Council, Laura Kelley Miguel, Marine Resources Specialist, Stedman Government Center, Tower Hill Road, Wakefield, RI 02879, 277-2476.

Department of Environmental Management, Christine A. Dudley, Senior Fisheries Biologist, Division of Fish & Wildlife, Field Headquarters, Box 218, West Kingston, RI 02892, 789-0281.

East Bay Collaborative, Judy Wilson, Mathematics Resource Specialist; Ron DeFronzo, Science Resource Specialist; P.O. Box 754, Portsmouth, RI 02871, 254-1110

4-H Youth Development Program, Dr. J. Whitney Bancroft, University of Rhode Island, Woodward Hall, Kingston, RI 02881-0804

Frosty Drew Nature Center, Ninigret Park, Charlestown, RI 02813, 364-9508

A Guide to Rhode Island's Natural Places, published by the RI Sea Grant at the University of Rhode Island, Narrangansett Bay Campus, Narrangansett, RI 02882-1197

Haffenreffer Museum of Anthropology (Brown University), Tower Street, Bristol, RI, 02809-4050, 253-8388

Herreshoff Marine Museum, 7 Burnside Street, PO Box 450, Bristol, RI 02809, 253-5000, FAX 253-6222

Hospital Association of RI (HARI), provides speakers, newsletters, presentations and tours, 880 Butler Drive, Providence, RI, 02906, 453-8400

Marine Education, University of Rhode Island, Graduate School of Oceanography, Narragansett Bay Campus, Narragansett, RI 02882-1197, 792-6211

Museum of Natural History, Roger Williams Park, Providence, RI 02905, 785-9457, FAX 941-5920

Narragansett Bay National Estuarine Research Reserve, PO Box 151, Prudence Island, RI 02872, 683-6780

Narragansett Electric Company, Educational Services, 25 Research Drive, Westboro, MA 01582, 508-366-9001, ext.2605, Fax 508-898-2985

NASA Space Grant Program, Jane Aubele, Brown University, Lincoln Field Building, Providence, RI 02912, 863-2889, FAX 863-3978

Naval War College Museum, 686 Cushing Road, Newport, RI 02841-1207, 841-4052

Ninigret National Wildlife Refuge, Outdoor Recreation Planner, Shoreline Plaza, Route 1A, PO Box 307, Charlestown, RI 02813, 364-9124

Norman Bird Sanctuary and Museum, 583 Third Beach Road, Middletown, RI 02840, 846-2577

Northern RI Collaborative, Janet Blair and Diane Bartlett, Science Resource Specialists; Judi Keeley, Mathematics Resource Specialist; 2352 Mendon Road, Cumberland, RI 02864, 658-3077

NYNEX Educational Programs, 234 Washington Street, Providence, RI 02903

Planetarium at the Rogers Williams Museum of Natural History, Judith Sweeney, Curator of Education, 1100 Elmwood Ave., Providence, RI 02907, 785-9450

Providence College, Department of Biology, Dr. Robert Krasner, River Street, Providence, RI 02918, 865-1000

Providence Journal Bulletin, Newspapers in Education, 75 Fountain Street, Providence, RI 02902, 277-7230

Public Archaeology Lab, Inc., 210 Lonsdale Avenue, Pawtucket, RI 02860, 728-8780, FAX 728-8784

Quonset Air Museum, PO Box 1571, North Kingstown, RI 02852,392-3344

Regional Laboratory for Educational Improvement of the Northeast and Islands, 300 Brickstone Square, Suite 900, Andover, MA 01810, (508)470-0098, FAX (508)475-9220

RI Department of Elementary and Secondary Education, 22 Hayes Street, B-4, Providence, RI 02908, 277-2821, FAX 351-7874, E-MAIL fiske@ride.ri.net

Dr. Dennis Cheek, Coordinator of Mathematics, Science & Technology, ext. 2150; Dr. Diane Schaefer, Mathematics Specialist and Coordinator of Mathematics Framework, ext. 2152; William Fiske, Technology Specialist and Coordinator, Goals 2000 State Technology Plan, ext. 2153; Dr. Ellen Hedlund, Evaluation and Assessment Specialist, ext. 2111; Latham, State Eisenhower Coordinator, ext. 2371; Faith Fogle, National Diffusion Network Facilitator, ext. 2133

RI Dept. of Environmental Management, Div. of Waste Management, 291 Promenade Street, Providence, RI 02908, 277-2797 ext. 7508

RI Dept. of Environmental Management, OSCAR Program, Ocean State Cleanup and Recycling, 83 Park Street, Providence, RI 02908, 800-253-2674

RI Division of Fish and Wildlife, Project Wild and Project WET State Coordinator, Chris Dudley, PO Box 218, West Kingston, RI 02892, 789-0281

RI Environmental Education Association, Lori Ross, President, Capron Park Zoo, Attleboro, MA 02703, 508-222-3047

RI Fishermen and Whale Museum, 18 Market Square, Newport, RI 02840, 849-1340

RI Robotic Design Project and RI School of the Future, Janice Kowalczyk, Project Director, PO Box 4692, Middletown, RI 02842, 846-4048

RI Science Teachers Association, Dr. Kenneth P. Kinsey, President, Associate Professor of Biology, Rhode Island College, FLS 249, Providence, RI 02908, 456-8010/8705; Janet Miele, Secretary/Treasurer, Woonsocket High School, 777 Cass Avenue, Woonsocket, RI 02895, 401-767-4600

RI Solid Waste Management Corporation, 260 W. Exchange Street, Providence, RI 02903, 831-4440

RI Wild Plant Society, 12 Sanderson Road, Smithfield, RI 02917, 949-0195, FAX 949-5788

Roger Williams Park Zoo, Keith Winsten, Director of Education, 1100 Elmwood Ave., Providence, RI 02907, 785-9450

Save The Bay, Inc., Teacher Resource Library, 434 Smith Street, Providence, RI 02908, call EBEC for contact at 254-1110

Seagrave Memorial Observatory, 47 Peeptoad Road, North Scituate, RI 02857, 726-1328

Southern RI Collaborative, Judith Leonard, Mathematics Resource Specialist, 904 Boston Neck Road, Narragansett, RI 02882, 782-6540

Taco, Inc., 1160 Cranston Street, Cranston, RI 02920, 942-8000

Thames Science Center, 77 Long Wharf, Newport, RI 02840, 849-6966, FAX 849-7144, e-mail: x1952@applelink.apple.com

Times2, 797 Westminster Street, Providence, RI 02903, 272-5094

U.S. Environmental Protection Agency, Environmental Research Laboratory, 27 Tarzwell Drive, Narragansett, RI 02882, 782-3028

U.S. Geological Survey, Water Resources Division, 237 Pastore Federal Building, Providence, RI 02903-1720

URI Alton Jones Campus, West Greenwich, RI, 397-3302

URI Cooperative Extension, Kingston, RI 02881, 792-4280

URI Fisheries Center, East Farm Campus, Kington, RI 02881

URI Marine Education Programs. Narragansett Bay Campus, Narragansett, RI

WSBE/Channel 36, Providence, RI, 277-3636

B. Resources in Adjacent States

Capron Park Zoo, Attleboro, MA 02703 (508) 222-3047

The Children's Museum (Boston), 300 Congress Street, Boston, MA 02210-1034, (617) 426-6500, Fax (617) 426-1944

The Computer Museum, 300 Congress Street, Boston, MA 02210-1034, (617) 426-2800, Fax (617) 426-2943

The Discovery Museum of Science, Inc., 177 Main St., Acton, MA 01720, (508) 264-4201

Laboratory Safety Workshop's Two Day Lab Safety Video Short Course, 192 Worcester Road, Natick, MA 01760-2252, 508-647-1900.

Marine Museum at Fall River, Inc., 70 Water Street, Fall River, MA 02721-1598, (508)674-3533

Museum of Science (Boston), Science Park, Boston, MA 02114-1099, (800) 729-3300 or (617)723-2511, FAX (617)589-0474

Mystic Marinelife Aquarium, 55 Coogan Boulevard, Mystic, Connecticut 06355, (203) 572-5955, Fax (203) 572-5969

New England Aquarium, Central Wharf, Boston, MA (617) 973-6590, Fax (617) 720-5098

New England Science Center, 222 Harrington Way, Worcester, MA 01604, (508) 791-9211, Fax (508) 752-6879

Regional Laboratory for Educational Improvement of the Northeast and Islands, Andover, MA, 303-337-0098.

BEST COPY AVAILABLE

C. National Organizations Supporting Science Education Reform

Note: A more extended listing is available in IdeAAAS, Sourcebook for Science, Mathematics and Technology Education, Barbara Walthall, Ed., 1995 (contact the Learning Team, Inc., 10 Long Pond Road, Armonk, NY 10504, tel. 914-273-2226, Fax 914-273-2227)

Aerospace Industries Association, c/o Cimena 70, Inc., (516) 883-5558. To obtain videotapes and other resources designed to inform young audiences of opportunities available in science, math, technology, and related fields.

Aircraft Owners and Pilots Association, 421 Aviation Way, Frederick, MD, 21701, (301) 428-9530.

Airline Pilots Association, 537 Herndon Parkway, Herndon, VA 22070, (703) 689-2270.

American Association for the Advancement of Science, Directorate for Education and Human Resource Programs, 1333 H Street NW, Washington, DC 20005 (202)326-6670, Fax 203-371-9849, e-mail smalcom@aaas.org (Project 2061 Headquarters, publishers of Science Books & Films, Science, convenes annual conference related to K-12 science education as well as many scientific meetings)

American Business Conference, 1730 K Street NW, Suite 1200, Washington, DC 20006 (202)822-9300

American Association of Physics Teachers, One Physics Ellipse, College Park, MD 20740-3845, (301)345-4200, e-mail hubisz@pyvax.physics.ncsu.edu

American Astronomical Society, University of Texas at Austin, Austin, TX 78712-1083, (512)471-1083

American Chemical Society, 1155 16th Street NW, Washington, DC 20036-4800, (202)872-4388, e-mail mkt@acs.org, Dr. Sylvia Ware, Director of Precollege Education; Education Division sponsors Wonder Science Magazine and many other resources, P. O. Box 57136, Washington DC, 20077-6702

American Geological Institute, Andrew Verdon, Director for Education, National Center for Earth Science Education, 4220 King Street, Alexandria, VA 22302-1507, (703)379-2480, Fax 703-379-7563

American Geophysical Union, 2000 Florida Avenue, NW, Washington, DC 20009-1277, (202)462-6900, e-mail fireton@kosmos.agu.org

American Institute of Aeronautics and Astronautics, 370 L'Enfant Promenade, SW, Washington, DC 20024, (202)646-7444, Fax (202) 646-7508

American Institute of Biological Sciences, 730 11th Street NW, Washington DC, 20001-4521, (202) 628-1500, e-mail aibs@gwuvm.gwu.edu

American Institute of Chemical Engineers, 345 East 47th Street, NY, NY 10017-2330, (212)705-7460, Fax (212) 752-3294

American Institute of Chemists, Northeast Missouri State University, Kirksville, MO 63701, (816)785-4524, Fax (816) 785-4045

American Institute of Mining, Metallurical and Petroleum Engineers (AIME), 345 East 47th Street, NY, NY 10017, (212)705-7675
(The Transformations Project underwritten largely by AIME is presently working with teams of teachers from 80 middle schools in 37 states, including two in RI, to improve MST instruction in middle schools. These teams provide team-to-team workshops in local regions across the U.S. For information contact Transformations Project, Inc. 243 Weld Street, Roslindale, MA 02131, (617)323-4514, e-mail transproj@aol.com)

American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3845, (301) 209-3100

American Meteorological Society, 1701 K Street, Suite 300, Washington, DC 20006-1509, (202) 466-5729

American Nature Study Society, Pocono Environmental Education Center, RD #2 Box 1010, Dingmans Ferry, PA 18328, (717)828-2319

American Nuclear Society, 555 North Kensington Avenue, LaGrange Park, IL 60525, (800) 323-3044

American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, (301) 209-3200, e-mail apscp@aps.org

American Society for Cell Biology, 9650 Rockville Pike, Bethesda, MD 20814, (301)530-7153

American Society for Engineering Education, 11 DuPont Circle #200, Washington, DC 20036, (202)293-7080, Fax (202) 265-8504

American Society for Microbiology, Science Education Network, Office of Education and Training, 1325 Massachusetts Avenue NW, Washington, DC 20005-4171, (202) 942-9264, FAX (202)942-9329

Association for the Education of Teachers in Science, 5040 Haley Center, Auburn University, Auburn, AL 36849-5212, (205)844-5785

Association of Science-Technology Centers, 1025 Vermont Avenue, NW, Suite 500, Washington, DC 20005-3516, (202)783-7200, e-mail astc@olt.compuserve.com

Assocation for Supervision and Curriculum Development, 1250 North Pitt Street, Alexandria, VA 22314-1453, (703)549-9110, Fax (703) 549-3891

ASCD Network for Science, Mathematics and Technology, Dr. Dennis W. Cheek, Facilitator, RI Department of Education, 22 Hayes Street B-4, Providence, RI 02908, 277-2821 ext 2150, Fax 351-7874, e-mail ststoday@aol.com.

Association for Women in Science, 1522 K Street NW, No. 820, Washington, DC 20005, (202) 408-0742, Fax (202) 408-8321

Aviation Education Resources Center, State University at Salina, 2408 Scanlan Avenue, Salina, KS, 67401-8196, (913) 825-0275.

Biological Sciences Curriculum Study, 830 N. Tejon Street, Suite 405, Colorado Springs, CO 80903, (719)578-1136

The Business Roundtable, 200 Park Avenue, NY, NY 10166, (212)682-6370
(several publications on education reform, school-business partnerships)

Center for Excellence in Education, 7710 Old Springhouse Road, Suite 100, McLean, VA 22102, (703)448-9062

The Center for Teaching and Learning, University of North Dakota, Box 8158, University Station, Grand Forks, ND 58202, (701)777-2674

Coalition for Earth Science Education, Geological Society of America, 3300 Penrose Place, PO Box 9140, Boulder, CO 80301, (303)447-2020

The Conference Board, 845 Third Avenue, NY, NY 10022 (212)759-0900

Consortium for Policy Research in Education, Carriage House at the Eagleton Institute of Politics, Rutgers University, 86 Clifton Avenue, New Brunswick, New Jersey 08901-1568, 908-932-1331, fax 908-932-1551.

Council for Elementary Science International, Department of Curriculum and Instruction, 212 Townsend Hall, University of Missouri, Columbia, MO 65211, (314)882-7247

Council of State Science Supervisors, c/o Thomas Keller, Science Consultant, Maine Department of Education, State House Station No. 23, Augusta, ME 04333, (207) 287-5920, Fax (207) 287-5927

Dwight D. Eisenhower Mathematics and Science Education Program, U.S. Department of Education, 555 New Jersey Avenue, NW, Room 522, Washington, DC 20208, (202)219-1496, telnet or gopher: enc.org, WWW: http://www.enc.org, via modem 800-362-4448.

Educational Products Information Exchange, PO Box 839, Water Mill, NY 11976, (516)283-4922

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, Fax (614)292-2066

ERIC Clearinghouse on Elementary and Early Childhood Education, University of Illinois, College of Education, 805 West Pennsylvania Avenue, Urbana, IL 61801-4897

ERIC Clearinghouse on Handicapped and Gifted Children, Council for Exceptional Children, 1920 Association Drive, Reston, VA 22091-3660

ERIC Clearinghouse for Science, Mathematics and Environmental Education, Ohio State University, 1929 Kenny Road, Columbus, OH 43210-1079, (614)292-8389

Environmental Protection Agency, Public Information Center and Library, 401 M Street SW, Wasington, DC 20460, (202)260-2090

EPA Regional Office, Environmental Education Coordinator, JFK Federal Building, Mail Stop RPM, Boston, MA 02203, (617)565-9447, FAX (617)565-3415

Family Involvement Partnership for Learning, 600 Independence Avenue SW, Washington, DC 20202-8173, 1-800-USA-LEARN.

Fermilab National Accelerator Laboratory Science Education Center, Fermilab MS 777, Box 500 Batavia, IL 60510, (708)840-2031

Foundation for Advancements in Science and Education, 4801 Wilshire Boulevard, Suite 215, Los Angeles, CA 90010, (213) 937-9911, fax (213) 937-7440, e-mail fasenet@aol.com

Industry Initiatives for Science and Math, c/o Deskin Research Group, 2270 Agnew Road, Santa Clara, CA 95054, (408) 496-5340, Fax (408) 496-5333

INISTE/Project 2000+, Science and Technology Education Section, UNESCO, 7 Place de Fontency, 75352 Paris 07-5P, France, e-mail edeap@frunes21.bitnet

International Technology Education Association, 1914 Association Drive, Reston, VA 22901-1502, (703)860-2100

Junior Engineering Technical Society (JETS), 1420 King St., Alexandria, VA 22314-2750, (703) 548-5387, Fax (703) 548-0769

Lawrence Hall of Science, University of California, Berkeley, CA 94720, (510)642-6594, Fax (510) 642-1055

National Aeronautics and Space Administration, Goddard Space Flight Center, Public Affairs Office, Mail Stop 130.3, Greenbelt, MD 20771, (301) 286-7207

National Alliance of Business - Center for Excellence in Education, 1201 New York Avenue NW, Suite 700, Washington, DC 20005, (202)289-2925

National Assessment of Educational Progress (NAEP), PO Box 6710, Princeton, NJ 08541-6710, (609)734-1614 (publishes many reports summarizing national assessments in various subject areas, for RI specific information contact the RI Department of Elementary and Secondary Education, Office of Outcomes and Assessment, 277-3126)

National Association of Partners in Education, 209 Madison Street, Alexandria, VA 22314, (703)836-4880

National Association for Research in Science Teaching, Center for Science Education, 219 Bluemont Hall, Kansas State University, Manhattan, KS 66506, (913) 532-6294, Fax (913) 532-7304, e-mail staver@ksuvm.bitnet

National Association for Science, Technology & Society, Penn State University, 133 Willard Building, University Park, PA 16802, (814)865-9951

National Association of Biology Teachers, 11250 Roger Bacon Drive, #19, Reston, VA 22090, (703)471-1134, Fax (703) 435-5582

National Association of Geology Teachers, Dept. of Geology, Western WA University, Bellingham, WA 98225, (206) 650-3587, Fax (206) 650-7295, e-mail xman@henson.cc.wwu.edu Can provide speakers for workshops on curricular reform, some funding may be available on a competitive basis.

National Audubon Society, 613 Riversville Road, Greenwich, CT 06830, (203)869-5272

National Center on the Educational Quality of the Workforce Results, University of Pennsylvania, 4200 Pine Street, 5A, Philadelphia, PA 19104-4090, 1-800-437-9799, e-mail eqw-request@irhe.upenn.edu, fax 215-898-9876.

National Center for Research on Evaluation, Standards, and Student Testing, University of California at Los Angeles, 310-206-1532. This group can answer your questions about improved assessment strategies.

National Consortium for Environmental Education and Training, University of Michigan, School of Natural Resources and Environment, 430 East University, Dana Bldg., Ann Arbor, MI 48109-1115, (313)998-6726, Fax (313) 936-2195, e-mail nceet@nceet.snre.umich.edu

National Coalition for Aviation Education, P.O. Box 28086, Washington, DC 20038

National Earth Science Teachers Association, American Geophysical Union, 2000 Florida Avenue NW, Washington DC, 20009-1277, (202) 462-6900 ext. 243, Fax (202) 328-0566, e-mail fireton@kosmos.agu.org

National Energy Information Center, EIA, Room 1F-048, 1000 Independence Avenue, SW, Washington, DC 20585, (202) 586-8800, Fax (202) 586-0727

National Oceanic and Atmospheric Administration, National Weather Service Office of Warning and Forecast, 8060 13th Street, Silver Spring, MD 20910, (301)443-8910

National Board for Professional Teaching Standards, 300 River Place, Suite 3600, Detroit, MI 48207, (313)259-0830 (Developing advanced certification endorsements for teachers, including many specific to science)

National Center on Education and the Economy, 39 State Street, Suite 500, Rochester, NY 14614, (716)546-7620

National Center for Improving Science Education, 2000 L Street, NW, Suite 603, Washington, DC 20036, (202)467-0652, Fax (202) 467-0659 (Publishes a number of studies of elementary, middle, and high school science education)

National Center for Science Teaching and Learning, The Ohio State University, Research Center, 1314 Kinnear Road, Columbus, OH 43212, (614)292-3339
(Funded by the U.S. Department of Education, conducts and publishes research regarding science education)

National Education Goals Panel, 1850 M Street NW, Suite 270, Washington, DC 20036, (202)632-0952 (Publishes an annual report of progress toward the national goals, including goal 4 related to mathematics and science education, in addition to a series of background reports)

National Energy Foundation, 5160 Wiley Post Way, Suite 300, Salt Lake City, UT 84116, (801)539-1406
National Research Center on Student Learning, University of Pittsburgh, 412-624-3051. Develop and test strategies to improve thinking and reasoning skills in the core academic areas.

National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230, (703)306- (teacher enhancement 1613), (instructional materials development 1614), (students, parents, and public 1615), (Division of Elementary, Secondary and Informal Education 1620)

[The premier funder of science education research and development projects in the United States. NSF publishes a variety of summaries of awards with contact information on a semi-annual basis, convenes national meetings regarding K-12 science education, and supervises large-scale reform efforts under the rubric of systemic change initiatives.]

National Science Resources Center, Arts and Industries Building, Room 1201, Smithsonian Institution, MRC-50-2, Washington, DC 20560, (202)357-2555, Fax (202) 786-2028, e-mail dlapp@nas.edu (Publishes guides to curriculum and produces a series of hands-on science kits for elementary science coupled with national workshops)

National Science Teachers Association, 1840 Wilson Boulevard, Arlington, VA 22201-3000, (703)243-7100, FAX (703)243-7177, WWW: http://www.nsta.org (Publish a wide range of curriculum materials and journals for elementary, middle, high school, and college science teaching. Actively involved in reforming the secondary science curriculum through the Scope, Sequence and Coordination of Secondary Science Project.)

National Science Supervisors Association, Glastonbury Public Schools, 330 Hubbard Street, Glastonburgy, CT 06033, (203)633-5231, ext. 490, Fax (203) 659-3366, e-mail kroy@igc.apc.org

National Wildlife Federation, 8925 Leesburg Pike, Vienna, VA 22184, 1-800-432-6564. Publish an annual *Conservation Directory*.

NOMAD Tactile Graphics (for the visually impaired), Quantum Technology Pty. Lted., c/o APH, 1839 Frankfort Avenue, Louisville, KY 40206, 1-502-895-2405. Produce software and related products which allow standard graphics to be printed as tactile graphics.

Optical Society of America, 2010 Massachusetts Avenue, NW, Washington, DC 20036, (202)416-1960, Fax (202) 233-1096

Oak Ridge Institute of Science and Education (ORISE), Science Engineering/Education Division, PO Box 117, Oak Ridge, TN 378331-0117, (615)576-6220, Fax (615) 576-0202

Office of Civilian Radioactive Waste Management Information Center, PO Box 44375, Washington, DC 20026, (800)225-6972 (publish a four volume set of free educational materials)

Population Association of America, Center for Demographic Studies, U.S. Bureau of the Census, Building 3, Room 3081, Washington, DC 20233, (202)429-0891

Project PRISM (Partners for Reform in Science and Mathematics), National Urban League, 1-800-TO-PRISM, national database of reforms (pc and modem only), dial 1-800-836-6734.

School Science and Mathematics Association, Bowling Green State University, 126 Life Sciences Building, Bowling Green, OH 43403, (419)372-7393

Society for Social Studies of Science, Department of Sociology, Louisiana State University, Baton Rouge, LA 70803, (504)388-1645

Soil and Water Conservation Society, 7515 Northeast Ankeny Road, Ankeny, IA 50021, (515)289-2831, Fax (515) 289-1227, toll free (800) THE-SOIL

Triangle Coalition for Science and Technology Education, 5112 Berwyn Road, 3rd floor, College Park, MD 02740, (301)220-0870, Fax (301) 474-4381 (Sponsors annual meetings, newsletter, Congressional lobbying on behalf of K-12 science education, fosters business-industry-school partnerships)

U.S. Geological Survey, Distribution Branch, Box 25286, Federal Center, Denver, CO 80225, (703)648-6515

U.S. Metric Association, 10245 Andasol Avenue, Northridge, CA 91325-1504, (818)368-7443, Fax (818) 368-7443

The Wildlife Society, 5410 Grosvenor Lane, Bethesda, MD 20814, (301)897-9770

Young Astronaut Council, Box 65432, 1308 19th Street, NW, Washington, DC 20036, (202)682-1984, Fax (202) 775-1773

D. Resource Organizations for Underrepresented Groups in Science Education

American Association of University Women, 1111 16th Street, NW, Washington, DC 20036, (202) 728-7605

American Indian Science and Engineering Society (AISES), 1630 30th Street, #301, Boulder, CO 80301, (3) 492-8658, Fax (303) 492-3400

ASPIRA Association, Inc., 1112 16th Street, NW, #340, Washington, DC 20036, (202) 835-3600, Fax (202) 223-1253 (Puerto Rican and Latino youth)

Association of Puerto Ricans in Science and Engineering (APRSE), 1333 H Street, NW, Room 1103, Washington, DC 20005, (202) 326-6670.

Association for Women in Science, 1522 K Street NW, Suite 820, Washington, DC 20005, (202)408-0742, Fax (202) 408-8321

Brown University Multifunctional Resource Center, 401-274-9548.

Center for Multisensory Learning, Lawrence Hall of Science, University of California, Berkeley, CA 94720, (510) 6423-8941, Fax (510) 642-1055

The Council of Interracial Books for Children, 1841 Broadway, NY, NY 10023, (212)757-5339

ERIC Clearinghouse on Handicapped and Gifted Children, Council for Exceptional Children, 1920 Association Drive, Reston, VA 22091-3660

Exceptional Children Science Education Project, Science for the Learning Disabled, Charlotte-Mecklenberg Schools, PO Box 140, Charlotte, NC 28230

Foundation for Science and the Handicapped, West Virginia University, Morgantown, WV 26506-6057, (304)293-5201

Girls Can!, American Association of University Women's Educational Foundation, 1111 16th Street NW, Washington, DC 20036, (202)785-7700

Girls Inc., Operation SMART, 30 East 33rd Street, NY, NY 10016-5394, (212)689-3700, Fax (212) 683-1253

Making Mathematics Work for Minorities, Beverly Anderson, Director, Mathematical Sciences Education Board, 818 Connecticut Avenue NW, #500, Washington, DC 20006, (202) 334-3294.

Mathematics, Engineering, and Science Achievement Programs (MESA), University of California, 300 Lakeside Drive, 7th Floor, Oakland, CA 94612-3550, (510) 987-9337, Fax (510) 763-4704

Mid-Atlantic Equity Center, The American University, School of Education, 5010 Wisconsin Avenue NW, Washington, DC 20016, (202)885-8517

Minority High School Student Research Apprentice Program, National Center for Research Resources, National Institutes of Health, Westwood Building, Room 10A11, Bethesda, MD 20892, (301)496-6743

National Action Council for Minorities in Engineering, Inc. (NACME), 3 West 35th Street, New York, NY 10001-2281, (212) 279-2626.

National Association for the Professional Advancement of Black Chemists and Chemical Engineers, 1265 Main Street, W-6, Waltham, MA 02254, (617)725-2000

National Center for Research on the Education of Students Placed at Risk at Johns Hopkins and Howard Universities, 410-516-8800.

National Clearinghouse for Bilingual Education at George Washington University, 800-321-NCBE.

National Council of La Raza, Los Angeles Office, 900 Wilshire Boulevard, #1520, Los Angeles, CA 90017-4716, (213) 489-3428, Fax (213) 489-1167

National Information Center for Children and Youth with Disabilities, 1-800-695-0285.

National Network for Minority Women in Science, AAAS, 1333 H Street, NW, Washington, DC 20005, (202)326-6757, Fax (202) 371-9849

National Science Foundation, Program for Women and Girls, Education and Human Resources Directorate, 4201 Wilson Boulevard, Arlington, VA 22230, (703)306-1774

National Society of Black Engineers (NSBE), 344 Commerce Street, Alexandria, VA, 22314, (703) 549-2207, Fax (703) 683-5312

National Technical Assoication, P.O. Box 7045, Washington, DC 30032-0145, (202) 829-6100.

Native American Science Education Association, 1333 H Street NW, Washington, DC 20005, (202)371-8100

Options for Girls: A Door to the Future, Foundation for Women's Resources, 3500 Jefferson Street, Suite 210, Austin, TX 78731, (512)459-1167

The Project on the Handicapped in Science, American Association for the Advancement of Science, 1776 Massachusetts Avenue, NW, Washington, DC 20036

Say Yes to a Youngster's Future, National Urban Coalition, 8601 Georgia Avenue, #500, Silver Spring, MD 20910, (301) 495-4999.

Science Lives: Women and Minorities in the Sciences Radio Series, University of Minnesota, Media Distribution, Box 734, Mayo Memorial Building, 420 Delaware Street SW, Minneapolis, MN 55455, (612)624-7906

The Society for the Advancement of Chicanos and Native Americans in Science, Sinsheimer Laboratories, University of California, Santa Cruz, CA 95064, (408)429-4272, Fax (408) 459-3156, e-mail sacnas@cats.ucsc.edu

Society of Hispanic Professional Engineers (SHPE) Foundation, 5400 East Olympic Boulevard, #225, Los Angeles, CA 90022, (213) 888-2080.

Teacher Education Equity Project, Center for Advanced Study in Education, CUNY Graduate Center, 25 W. 43rd Street, Suite 400, NY, NY 10036, (212)642-2672

E. Selected Curriculum Projects

Note: *The RI Department of Elementary and Secondary Education provides this listing solely for the purpose of making schools aware of these resources which are from smaller publishers. It does not in any way endorse the content or worth of these materials. Many of the programs listed were funded by the U.S. Department of Education and/or the National Science Foundation. An up-to-date listing of curriculum materials is available from the Eisenhower National Clearinghouse for Mathematics and Science Education via INTERNET. For access information contact the Clearinghouse at (614)292-7784, e-mail: info@enc.org or Fax (614)292-2066. They are housed in same building as the ERIC Clearinghouse for Mathematics, Science, and Environmental Education. Three other helpful resource guides to science curriculum are the Science Curriculum Resource Handbook, eds. D.W. Cheek, R. Briggs, R.E. Yager, 1992 and Environmental Education Teacher Resource Handbook, ed. R.J. Wilke, 1993, available from the Corwin Press, 2455 Teller Road, Thousand Oaks, CA 91320-2218; and the annual editions of the Educational Programs That Work from the National Diffusion Network (contact Faith Fogle at RIDE at 277-2706, ext. 2133).*

Active Watershed Education, The Southern RI Conservation District, 5 Mechanic Street, Hope Valley, RI 02832, 539-7767.

Activities to Integrate Mathematics and Science (AIMS), PO Box 7766, Fresno, CA 93747, (209)291-1766

Arkansas Project MAST: Mathematics and Science Together, University of Arkansas, College of Education, Gifted Programs, 2801 South University, Little Rock, AR 72204, (501)569-3410

Astronomical Data Service, 3922 Leisure Lane, P.O. Box 26180, Colorado Springs, CO 88093, 719-597-4068. Catalog of computer programs to observe satellites and almanacs.

Aviation Distributors and Manufacturers Association, 1900 Arch Street, Philadelphia, PA 19103, 215-565-3484. Educational materials directory.

Biology in the Community (Biocom), Dr. John Penick, Science Education Center, University of Iowa, Iowa City, IA 52242-1478.

Bottle Biology, Department of Plant Physiology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706, (608)263-5645

Chemical Education for Public Understanding (CEPUP), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (510)642-8718

Chemicals, Health and Environment (CHEM), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (510)642-8718

Conservation for Children, 1140 Boston Avenue, Longmont, CO 80501, (303)651-2829

Curriculum in Human Biology for the Middle Grades (HUMBIO), Stanford University, School of Education, Stanford, CA 94305-3096, (415)723-4662

Design and Technology Initiative, 3 Armstrong Hall, Trenton State College, Trenton, NJ 08650-4700. Videos about the teaching of design, problem-solving, and technology.

Developmental Approaches in Science and Health (DASH), University of Hawaii, Manoa, College of Education, 1776 University Avenue, Honolulu, HI 96822, (808)956-6918

Eco-Inquiry, New York Botanical Garden, Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545-0129, (914)667-5976

Education in Global Change Project, Joseph P. Stoltman, Department of Geography, Western Michigan University, Kalamazoo, MI 49008-5053, 616-387-3429, fax 616-387-0958.

Eighteenth-Century Electricity Kit, The Bakken Institute, 3537 Zenith Avenue South, Minneapolis, MN 55416, (612)927-6508

Elementary School Science and Health, BSCS, 830 North Tejon, Suite 405, Colorado Springs, CO 80903, (719)578-1136

Elementary Science Study (ESS), Education Development Center, Inc., Newton, MA 02160, (617)969-7100

Expedition-Based Education, American Canoe Association, Suite B-226, Alban Station Road, Springfield, VA 22150, 703-451-0141, fax 703-451-2245.

Explorations in Middle School Science, Jostens Learning Corporation, 6170 Cornerstone Court East 5300, San Diego, CA 92121-3710, (619)391-9900

Explorations in Science, Roy Beven, Jostens Learning Corporation, 6170 Cornerstone Court East, San Diego, CA 92121, (800)521-8538, ext 6372

Fish Banks Ltd., Institute for Policy and Social Science Research, Hood House, University of New Hampshire, Durham, NH 03824-3577, (603)862-2186

FOR SEA: Investigating Marine Science, Assistant Superintendent, Olympic Educational Service District 114, 105 National Avenue North, Bremerton, WA 98312, (206)479-0993

Foundation and Challenges to Encourage Technology-based Science (FACETS), American Chemical Society, 1155 16th Street, NW, Washington, DC 20036, (202)872-6179

Foundational Approaches in Science Teaching (FAST), Curriculum Research and Development Group, University of Hawaii, 1776 University Avenue, Room CM 117, Honolulu, HI 96822, (808)956-7863, FAX (808)956-4114

Full Option Science System (FOSS), Lawrence Hall of Science, UC-Berkeley, Berkeley, CA 94720, (415) 642-7771

Franklin Activity Kits, Franklin Institute Science Museum, Museum to Go Science Resource Center, 20th and the Parkway, Philadelphia, PA 19103, (215)448-1297

Geology Is, Rion D. Turley, O'Fallon Township High School, 600 South Smiley, O'Fallon, IL 62269, (618)632-3507

GeoMedia Educational System, Project Chief, U.S. Geological Survey, 801 National Center, Reston, VA 22092.

The Globe Program, an international environmental education and science partnership, 744 Jackson Place, NW, Washington, DC 20503, 202-395-7600, fax 202-395-7611, e-mail info@globe.gov.

Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (415)642-7771

GrowLab, National Gardening Association, 180 Flynn Avenue, Burlington, VT 05401, (802)863-1308

Hands-On Elementary Science, Helen Herlocker, Carroll County Public Schools, PO Box 661, Hampstead, MD 21074, (410)374-1358, FAX (410)239-4373

Hands-On Science, Hands-On Science Outreach, Inc., 4910 Macon Road, Rockville, MD 20852, (301)460-5922

Health Activities Project (HAP), Lawrence Hall of Science, University of California, Berkeley, CA 94702, (415)642-4193

Horizons Plus, Houston Museum of Natural Science, 1 Hermann Circle Drive, Houston, TX 77030, (713)639-4632

Image Processing for Teaching, Center for Image Processing in Education, 5343 East Pima Street, Suite 201, Tucson, AZ 85712, (800) 322-9884

Improving Middle School Science: A Collaborative Approach, Education Development Center, Inc., 55 Chapel Street, Newton, MA 02160, (617)969-7100

Improving Urban Elementary Science: A Collaborative Approach, Education Development Center, Inc., 55 Chapel Street, Newton, MA 02160, (617)969-7100

Informal Science Study (IFSS), Howard Jones or Stephanie Hendee, National Training Network, 500 Coffman, Suite 204, Longmont, CO 80501, (800)659-5004 or (303)651-0833

Insights: A Hands-On Elementary Science Curriculum, Education Development Center, Inc., 55 Chapel Street, Newton, MA 02160, (800)225-4276

Investigating and Evaluating Environmental Issues and Actions, Stephanie Hendee, National Training Network, 500 Coffman, Longmont, CO 80501, (800)659-5004

Iowa Chautauqua Program (ICP), Science Education Center, The University of Iowa, Iowa City, IA 52242, (319)335-1189

JASON Foundation for Education, 395 Totten Pond Road, Waltham, MA 02154, (617)487-9995

Joint Education Initiative, Robert W. Ridky, Director, 3433 A.V. Williams, University of Maryland, College Park, MD 20742-3281, 301-405-2324, e-mail jei@earthsun.umd.edu, fax 301-405-9377.

Kids as Global Scientists, Attention Holly Devaul, School of Education, Campus Box 249, University of Colorado, Boulder, CO 80309-0249, 303-492-3424, e-mail kgs@spot.colorado.edu.

Kindergarten Integrated Thematic Experiences (KITE), Jeanne Stout Burke, Director, Sunshine Gardens School, 1200 Miller Avenue, South San Francisco, CA 94080, (415)588-8082

K-6 Project STARLAB, Young Astronaut Council, 1211 Connecticut Avenue, NW, Suite 800, Washington, DC 20036, (202)682-1084

Learning About Plants (LEAP), Cornell Plantations, Cornell University, One Plantations Road, Ithaca, NY 14850, (607)255-3020

Life Lab Science Program, 1156 High Street, Santa Cruz, CA 95064, (408)459-2001, FAX (408)459-3483

Mechanical Universe: High School Adaptation, Richard P. Olenick, Department of Physics, University of Dallas, 1845 East Northgate Drive, Irving, TX 75062-4799, (800)526-8472

Microcomputer-Based Laboratory Tools, Technical Education Research Centers (TERC), 2067 Massachusetts Avenue, Boston, MA 02140, (617)547-0430

Middle School Life Science Program, Jefferson County Public Schools, Science Department, 1209 Quail Street, Lakewood, CO 80215, (303)231-2351

Model Elementary Science Program, District of Columbia Public Schools, 415 12th Street, NW, Washington, DC 20004, (202)767-8666

NASA Spacelink, electronic information system designed to provide current educational information. Spacelink Administrator, Education Programs Office, Mail Code CL01, NASA Marshall Space Flight Center, Huntsville, AL 35812-0001. 205-544-6360, e-mail comments@spacelink.msfc.nasa.gov.

National Geographic Kids Network, National Geographic Society, Educational Services, Dept. 5397, Washington, DC 20036, (800)368-2728

National Library of Education, 1-800-424-1616 or Library@inet.ed.gov

National SERIES Project, 300 Lakeside Drive, Oakland, CA 94612, (510)987-0119

National Urban League Preschool Science Collaborative, National Urban League, NY, NY 10021, (212)310-9214

NSTA-NASA Space Shuttle Student Program, National Science Teachers Association, 1742 Connecticut Ave. NW, Washington, DC 20009, 202-328-5800. Periodicals, teaching activities, classroom resources, science fairs and projects, etc.

New York Science, Technology and Society Education Project, State Education Department, 675 EBA, Albany, NY 12234, (518)473-1726

Operation SMART, 2336 Kahn Street, Port Townsend, WA 98368, (206)385-7585

Outdoor Biology Instructional Strategies (OBIS), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (415)642-4193

Pablo Python Looks at Animals, Annette Berkovits or Julie Gantcher, Bronx Zoo, 185th Street and Southern Boulevard, Bronx, NY 10460, (718)220-5135 or (800)937-5131

Physics Resources and Instructional Strategies for Motivating Students (PRISMS), Roy Unruh or Tim Cooney, Physics Department, University of Northern Iowa, Cedar Falls, IA 50614, (319)273-2380, (319)273-2918

Physics - Teach to Learn, Pamela Williams or Charles Schleiden, Los Angeles Unified School District, Bell High School, Bell, CA 90201-3201, (213)773-2408, FAX (213)560-7874

Polar Regions, Milton Anisman, Disseminator, Environmental Programs Center, 6625 Balboa Boulevard, Van Nuys, CA 91406, (818)997-2389

Project First STEP (Science and Technology Education Program), U.S. Space Foundation, 1551 Vapor Trail, Colorado Springs, CO 80916, (719)550-1414

Project Learning Tree, 1250 Connecticut Avneue, NW, Suite 320, Washington, DC 20036, (202)463-2455

Project STAR, Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, (617)495-9798

Project STARWALK, Lakeview Museum Planetarium, 1125 W. Lake Avenue, Peoria, IL 61614, (309)686-6682

Relationships and Math-Friendly Physical Science (RAMPS), Madeline P. Goodstein, PRIMAK Educational Foundation, PO Box 701, Devon, PA 19333, (215)687-6252

SETQuest, (Careers in Science, Engineering and Technology) COMAP Inc., Suite 210, 57 Bedford Street, Lexington, MA 02173, 1-800-722-6627, fax 617-863-1202.

Science Activities for the Visually Impaired/Science Activities for Learners with Physical Handicaps (SAVI/SELPH), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (415)642-8941

Science, Discovery and Laughter multicultural video and guidebook. Activities in kitchen chemistry, junk drawer physics, and backyard biology. Order from Science Club, 55 First Place, NW, Suite 4, Issaquah, WA 98027, 1-800-391-6939. Available in Spanish and English.

Science and Technology: Investigating Human Diversity, BSCS, 830 North Tejon, Suite 405, Colorado Springs, CO 80903, (719)578-1136

Science and Technology for Children (STC), National Science Resources Center, Arts and Industries Building, Room 1201, Smithsonian Institution, Washington, DC 20560, (202)357-2555

Science Olympiad, 5955 Little Pine Lane, Rochester, MI 48306, 313-651-4013. Information on the National Science Olympiad.

Science-Technology-Society: Issues and Solutions, Harold Hungerford or Trudi Volk, Science and Environmental Education Center, Department of Curriculum and Instruction, Southern Illinois University, Carbondale, IL 62901, (618)453-4211 or 453-4214

Science-Technology-Society: Preparing for Tomorrow's World, David Linstrom, 1140 Boston Avenue, Longmont, CO 80501, (303)651-2829, FAX (303)776-5934

Science - A Process Approach, American Association for the Advancement of Science, 1333 H Street, NW, Washington, DC 20005, (202)326-6400

Science Curriculum Improvement Study (SCIS, SCISII, SCIIS), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (415)642-8718

Science for Life and Living: Integrating Science, Technology and Health, BSCS, 830 North Tejon, Suite 405, Colorado Springs, CO 80903, (719)578-1136

Science Helper K-8, Room 302, Norman Hall, University of Florida, Gainesville, FL 32607, (904)392-0761

Science Vision, Interactive Media Science Project, 205 Carothers Hall, Florida State University, Tallahassee, FL 32306, (904)644-8422

Sci-Math, Kirsti Aho or Carolyn Hubachek, Sci-Math Education and Technology Foundation, 4655 25th Street, San Francisco, CA 94114, (415)824-5911, FAX (415)282-4294

Scientific American Frontiers on PBS, videotaping rights and teaching guides, call GTE at 800-315-5010.

The Second Voyage of the Mimi, Wings for Learning, 1600 Green Hill Road, PO Box 660002, Scotts Valley, CA 95067-0002

Self-Help Elementary Level Science (SHELS), Florida State University, Gainsville, FL 32611, (904)392-0761

Star-Walk (elementary), Bob Riddle, Southwest Science/Math Magnet High School, 6512 Wornall Road, Kansas City, MO 64113, (816)871-0913

Stones and Bones, Milton Anisman, Disseminator, Physical Anthropology Center, 6625 Balboa Boulevard, Van Nuys, CA 91406, (818)997-2389

TLTG Physical Science, TLTG Math for Science, Texas Learning Technology Group, PO Box 2974, Austin, TX 78768-2974, (512)467-0222

Terracorps, Upland Unified School District, 904 West 9th Street, PO Box 1239, Upland, CA 91786, (714)981-1603

T/S/M (Technology/Science/Mathematics) Integration Activities, Virginia Polytechnic Institute and State University, 144 Smyth Hall, Blacksburg, VA 24061-0432, (703)231-6480

Transformations: Science, Technology and Society, Target Marketing, Inc., 243 Weld Street, Roslindale, MA 02131, (617)323-4514, FAX (617)323-8687

Turner Adventure Learning, 105 Terry Drive, Suite 120, Newtown, PA 18940-3425, 1-800-344-6219, Fax 215-579-8589.

Unified Science and Mathematics for Elementary Schools, Education Development Center, Inc., Newton, MA 02160, (617)969-7100

Excelling in Math and Science, Selected Programs of the U.S. Department of Education, 1-800-USA-LEARN.

The Universe in the Classroom, publication by the Astronomical Society of the Pacific, available free of charge, 390 Ashton Avenue, San Francisco, CA 94112, 800-335-2624, e-mail asp@stars.sfsu.edu.

The Video Encyclopedia of Physics Demonstrations, The Education Group, 1547 Sunset Plaza Drive, Los Angeles, CA 90069, 310-659-8842, Fax 310-855-8061.

Videodisc-Based Instruction in Core Science Concepts, Alan Hofmelster or Judy Fifield, Technology Division, Center for Persons with Disabilities, Utah State University, Logan, UT 84322-6800, (801)750-3718

Wildlife Inquiry through Zoo Education, Annette Berkowitz or Donald Lisowy, Bronx Zoo, New York Zoological Society, 185th Street and Southern Boulevard, Bronx, NY 10460, (718)220-5135 or (800)937-5131

Wisconsin Fast Plants Program, Department of Plant Pathology, University of Wisconsin - Madison, 1630 Linden Drive, Madison, WI 53706, (608)263-2634

A World of Motion (elementary schools), SAE International, John Boynton, Education Director, 400 Commonwealth Drive, Warrendale, PA 15096-0001, (412)776-4841, FAX (412)776-5760

A World of Motion II: The Design Experience (middle schools), Educational Development Center, Inc., Attn: Marilyn Quinsaat, 55 Chapel Street, Newton, MA 02158, (617)969-7100

World Wide Web, and the Global SchoolNet Foundation have constructed a 'Global Schoolhouse'. Explore a virtual heart on the Franklin Institute homepage http://sin.fi.edu/TOC.biosci.html; Nasa's homepage for space shuttle information at htto://shuttle.nasa.gov; Great Canadian Science Web Site at http://fas.sfu.ca/css/gcs/main.html; the World of Escher at http://www.texas.net/escher/; Washington State University College of Education's World Wide Web Virtual Science and Mathematics Fair at http://www.educ.wsu.edu/fair_95/announcement.html; Save the Beaches Project at http://www.ednhp.hart.ford.edu; Balloonin' USA at balloon@sdakota.sdserv.org; The Scholastic Publishing Company's Ask A Scientist at adriennes@aol.com; The Primate Info Net gopher at gopher.primate.wisc.edu; and Usenet Newsgroups for other internet science projects at schl.call.mathsci.

Young Astronaut Council, 1211 Connecticut Ave. NW, Washington, DC 20036, 202-682-1985. Curriculum materials on aeronautics.

Zoo Opportunities Outreach, Steve Binkley, Carolina Biological Supply Company, 2700 York Road, Burlington, NC 27215, (919)584-0381

Science Literacy for ALL Students
The Rhode Island State Science Framework

Science Literacy for All Students - The Rhode Island State Science Framework is the end product of the work of hundreds of individuals across the state over the past three years. This effort was also informed by advice from a statewide Frameworks Advisory Committee comprised of over 40 individuals representing a broad spectrum of organizations, public and private, across the state.

The framework development team was composed of 89 individuals from public and private K-12 schools across the state, university and college educators and scientists, and representatives from business, industry, and the RI Department of Elementary and Secondary Education. Broad support for the effort was also received from many organizations, including the Rhode Island Science Teachers Association, the Rhode Island Environmental Educators Association, and the American Association for the Advancement of Science.

The framework is directly linked to Project 2061 of the American Association for the Advancement of Science, a major national reform initiative in mathematics, science, and technology education. Project 2061 has a lead document, Science for All Americans, which describes what every American student should know, be able to do, and value in the sciences. This document was based on careful work by panels of experts in various scientific fields which defined key concepts and principles in their respective fields of endeavor. The RI science framework development team accepted the deliberations and recommendations of Science for All Americans as a common starting point for its work.

A second document from Project 2061, Benchmarks for Science Literacy, offers 855 curriculum benchmarks organized into grade levels of K-2, 3-5, 6-8, and 9-12. It was compiled by a team of several hundred science teachers and scientists from across the nation, as well as reviewed by thousands of others in draft form.

The science framework committee carefully considered this document and concluded that RI schools, administrators, and teachers would benefit from linking their science education efforts directly to relevant Project 2061 benchmarks for the following reasons. First, because the benchmarks reflect the best collective thinking of the science community regarding standards for K-12 science education. Second, because Project 2061 is committed to linking concepts and principles not only across the sciences (e.g., biology, chemistry, astronomy, oceanography, mathematics) but also to other important areas of human endeavor such as history, philosophy, communication arts, engineering and allied fields, and the social sciences. Sustained use of the Benchmarks for Science Literacy enables schools to appropriately tailor their efforts to reflect local concerns and needs while ensuring that such efforts in the science curriculum area are linked to rigorous, nationally agreed-upon standards in science education.

The benchmarks have been carefully organized to reflect cross-linkages of concepts among the sciences and with other disciplines. The major chapters and their subheadings are:
1. The Nature of Science: the scientific world view, scientific inquiry, the scientific enterprise.
2. The Nature of Mathematics: patterns and relationships, mathematics, science, and technology, mathematical inquiry.
3. The Nature of Technology: technology and science, design and systems, issues in technology.
4. The Physical Setting: the universe, the earth, processes that shape the earth, structure of matter, energy transformations, motion, forces of nature.
5. The Living Environment: diversity of life, heredity, cells, interdependence of life, flow of matter and energy, evolution of life.
6. The Human Organism: human identity, human development, basic functions, learning, physical health, mental health.
7. Human Society: cultural effects on behavior, group behavior, social change, social trade-offs, political and economic systems, social conflict, global interdependence.
8. The Designed World: agriculture, materials and manufacturing, energy sources and use, communication, information processing, health technology.
9. The Mathematical World: numbers, symbolic relationships, shapes, uncertainty, reasoning.
10. Historical Perspectives: displacing the earth from the center of the universe, uniting the heavens and the earth, relating matter and energy and time and space, extending time, moving the continents, understanding fire, splitting the atom, explaining the diversity of life, discovering germs, harnessing power.
11. Common Themes: systems, models, constancy and change, scale.
12. Habits of Mind: values and attitudes, computation and estimation, manipulation and observations, communication skills, critical-response skills.

The work of Project 2061 has dramatically influenced work on the national science standards (about 80% of it is virtually identical to the benchmarks), state science frameworks, and assessment projects like the National Assessment for Educational Progress (NAEP) and the New Standards Project, whose science performance standards are directly tied to Project 2061 (RI is a partner in both assessment projects).

The framework development committee adopted the Project 2061 Benchmarks as its foundation. The development team enhanced 2061's focus on the science curriculum by featuring engaging science activities currently taught in selected RI schools linked to particular benchmarks. In addition, the framework provides background materials and supplemental resources to assist schools in reforming their science education efforts:

* chapters presenting a philosophy of education and definitions of key terms used in the framework, issues of equity and access, assessment concerns, professional development considerations, program evaluation suggestions, and curriculum analysis and change.
* a systematic approach to science process skills with a taxonomy which shows their relationship to science teaching and learning.
* a resource section which lists organizations and information delineated by organizations found within the state, those located in adjacent states, and national and international organizations.
* useful curriculum materials in science which promote the teaching of science in a hands-on, minds-on manner consistent with the focus of the framework and the 2061 Benchmarks.

All principals, district superintendents, assistant superintendents, directors of curriculum, Regents, collaborative directors and specialists, and members of the framework development team have received a copy of the framework. Its pages can be reproduced by schools and school districts and used in a wide variety of ways to promote quality instruction in science. Members of the framework team and state education department staff are available to work with schools and districts in understanding and implementing the framework. For further information or to schedule assistance call 277-2821, ext. 2150 and leave a detailed message or send an e-mail to ststoday@aol.com. The Department of Education is interested in obtaining copies of any local curriculum documents, units, or activities you develop in light of the framework. These items can be mailed to Mathematics, Science & Technology Programs, RI Department of Elementary and Secondary Education, Shepard Building, 255 Westminster Street, Providence, RI 02903-3400. We hope to also make these available electronically along with instructional vignettes keyed to specific benchmarks in the near future.

A SAMPLE PAGE FROM THE RI SCIENCE FRAMEWORK ...

A benchmark taken from Project 2061 and either adapted or adopted ➡

A real-life science teaching activity currently being used in a Rhode Island classroom ➡

A way to check on student understanding of the benchmark while they are engaged in the activity ➡

The 'big' themes identified in Project 2061 are constantly reinforced. ➡

THE PHYSICAL SETTING - Structure of Matter
Grade 6-8 (Benchmark 2 of 7)

By the end of the 8th grade all students will know that –

Equal volumes of different substances usually have different masses.

Suggested Activity:

Have students determine the mass of two identical size cubes made of different materials of the same state. Use two balloons, fill one with air and one with water. Determine that the volumes are equal by measuring the circumference and calculating. Repeat the experiment with 2 gases like CO_2 (heavier than air) and He (lighter than air). Use different liquids.

Embedded Assessment:	Have students determine the density of their samples.
Summative Assessment:	Explain how equal volumes of different substances can have different masses.
Theme:	Patterns
Process:	Manipulating Information, esp. developing generalizations

A way to determine if students fully understand the concept expressed in the benchmark

The science framework address process skills in a way that makes them meaningful to classroom teachers and curriculum developers.

The science framework directly builds upon the state's Common Core of Learning. The Common Core describes what every graduate of Rhode Island schools should know and be able to do in the arenas of Communication, Problem-Solving, Body of Knowledge, and Responsibility. The learning goals of the Common Core are realized through the school curriculum, learning activities, and assessment tasks. The activity above, for example, increases a student's Body of Knowledge. It focuses primarily on developing student understanding of the relationships between volume and mass. If students communicate their results and understandings to one another throughout the activity, it also provides opportunity to improve communication skills.

A 'Classroom Vignette' Related to the Benchmark ...

From Mr. Palano's class, Northern Cumberland Middle School, Cumberland ...

Mr. Palano's second class of the day is his smallest, only eight students with a classroom aide. While teaching the concepts of density, mass and volume he is using a <u>*Computer Assisted Science Labs*</u> *package. Students are instructed to select a variety of wooden blocks, measure the mass and volume using rulers and a triple-beam balance, and finally calculate the density. They work in pairs. As each pair completes a set of calculations, they move to a special computer workstation attached to a scale. They place their wooden block on the scale and enter their calculated values in the computer. In seconds the accurate results (mass, density and volume) are displayed on the screen, along with an accuracy rating from 0 to 5. Students know immediately if their measurements were very exact (rating of 4.7 or more), if they were close but not terribly accurate (between 4.2 and 4.7) or if they have made an error somewhere along the line. When they score below a 4.7 they go back to their stations and try to identify the problem. Mr. Palano circulates around the room, offering helpful advice at each station. Students let out a little cheer when the computer verifies their measurements as accurate. This activity will be repeated throughout the day with Mr. Palano's other classes. What makes this class unique is that the students are in a self-contained classroom for the rest of the day. Keeping the class size small and having a familiar classroom aide allows these students to fully participate in the eighth grade science laboratory experiences.*

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