Curriculum Framework

for Science

Office of Curriculum, Instruction and Student Support
Instructional Services Branch

Department of Education
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FOREWORD

Broadly defined, curriculum is the total learning experience provided by a school to its students. It includes all of the content, goals and objectives, instructional materials, instructional strategies, student support and other services, and activities provided for students by the school.

Curriculum frameworks communicate common understandings about content and performance standards, instruction, and classroom assessment in a content area. The frameworks suggest ways that classroom instruction and assessment can be designed to best address the Hawaii Content and Performance Standards (HCPS) III. The curriculum frameworks also provide a means for schools to incorporate system-wide requirements into the school curriculum to ensure educational quality and equity for all students.

This framework is one of a series of Hawaii State Department of Education publications for teachers and other educators to use in implementing the HCPS III at the classroom level. Curriculum Frameworks for each of the nine HCPS III content areas provide a framework and philosophy for curriculum, instruction, and classroom assessment in those disciplines.

Patricia Hamamoto, Superintendent

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INTRODUCTION TO THE CURRICULUM FRAMEWORK SERIES

DESCRIPTION, PURPOSES, USES

Curriculum frameworks suggest the best thinking about the knowledge, skills, and processes that characterize a particular discipline; these frameworks provide a structure within which to organize curriculum and instruction in that content area. Curriculum frameworks represent the theoretical and philosophical bases, grounded in sound research, upon which the content standards, benchmarks, performance tasks, and rubrics were developed.

The curriculum framework series for the HCPS content areas include documents that provide the rationale or statements of the values, principles, research, and assumptions which help to guide decision making and the designing of curricular and instructional programs. Curriculum frameworks provide links between theory and practice as well as up-to-date and relevant information about pedagogy, learning, and resources within a content area.

Curriculum frameworks are intended for teachers and other educators and policy-makers involved in curriculum, instruction, and other educational decision-making. The frameworks are meant to provide a level of consistency, standardization, and equity in curriculum, instruction, and assessment across all classrooms across the state. The written format allows access to this information by all educators statewide.

Curriculum frameworks can be used by teachers as a roadmap to plan and design curricular and instructional units or activities at the school level and serve as aids in selecting appropriate classroom level materials for students as well as assessments that can be used for diagnosis, progress monitoring, and measuring outcomes. The frameworks can also serve as a common reference point in discussing and aligning curriculum schoolwide or within a grade level or department.

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THE SYSTEM OF STANDARDS

Fundamentally, standards provide *all* students with access to high expectations, challenging curricula, and effective teaching. Standards associate equity with excellence and ensure that students have the knowledge and skills necessary to participate in daily activities and in the workplace and to pursue their goals and aspirations.

The HCPS III describe educational targets in all nine content areas for *all* students in grades K-5. All students, therefore, are expected to be given the opportunity to meet all of the K-5 HCPS III standards. At the secondary level, however, the standards describe different things in different content areas. For the four CORE content areas (Language Arts, Mathematics, Science and Social Studies) the standards describe expectations for all students, since all students are expected to take certain required courses in these areas. For the *extended core* (Health, Physical Education, Fine Arts, World Languages, and Career and Technical Education) they describe a continuum that should be expected by students who choose courses in these areas as electives. It should be emphasized that *all* courses, required or elective, are standards-based and are part of the *Hawaii Standards System*.

THE HAWAII STANDARDS SYSTEM

The Hawaii Standards System is more than the HCPS III alone. The Hawaii Standards System supports standards-based education through curriculum, instruction and assessment components. The system also provides student instructional support components such as Special Education and English for Second Language Learners. It also includes student and family support components such as Pihana Na Mamo and Parent Community Network Coordinators. The *Hawaii Standards System* supports school level implementation of standards-based education by

- Identifying the targets for student learning such as the Vision of the Public School Graduate, General Learner Outcomes, the HCPS III, and other course standards;
- Providing curricular and behavioral support for students through direct services to students and their families; and
- Developing, acquiring, and assuring access to support for implementation of standards-based education for teachers, school leaders, and other academic staff.

The HCPS III contain

- Essential content and skills in *nine* content areas: Career and Technical Education, Fine Arts, Health, Language Arts, Mathematics, Physical Education, Science, Social Studies, and World Languages;
- Standards that describe the educational expectations for *all* students in grades K-5

- Essential standards for all required courses in the four *core* areas: Language Arts, Math, Science, and Social Studies; and
- Essential standards that can be met through elective courses chosen by secondary students to fulfill graduation requirements in the five extended core areas: Career and Technical Education, Fine Arts, Health, Physical Education, and World Languages.

Included in the Hawaii Standards System are standards for courses not found in the HCPS III document. These standards will be found in future HCPS III publications as course standards and benchmarks as well as in the new edition of the *Approved Course and Code Numbers* (ACCN) catalog. Because *all* courses are standards-based, these specialized courses utilize

- Industry or national standards that describe essential content and skills for elective courses in areas such as Career and Technical Education and Fine Arts; and
- Content area-specific standards found in HCPS II.

THE RELATIONSHIP BETWEEN THE STANDARDS AND THE GENERAL LEARNER OUTCOMES

Content Standards define the academic content knowledge and skills that all students should know and be able to do. They are general statements of expectations for all students K-12.

Equally important to learning academic content is developing the knowledge, skills and attitudes that all students need in order to lead full and productive lives. The six General Learner Outcomes (GLOs) serve as the essential, overarching goals in the system of standards. These Outcomes are

- GLO 1: Self-directed Learner: The ability to be responsible for one's own learning:
- GLO 2: Community Contributor: The understanding that it is essential for all human beings to work together
- GLO 3: Complex Thinker: The ability to be involved in complex thinking and problem solving
- GLO 4: Quality Producer: The ability to recognize and produce quality performance and quality products
- GLO 5: Effective Communicator: The ability to communicate effectively
- GLO 6: Effective and Ethical User of Technology: The ability to use a variety of technologies effectively and ethically

These Outcomes must be an integral part of teaching and learning and the heart of every Hawaii classroom. Teachers of all subjects in all grades must contribute to the development of the GLOs while promoting the learning of subject matter as well.

The real test of the standards is their ability to improve student learning. Raising expectations is but the first step; it is what is done with the standards—how they are realized in all classrooms for all students—that will determine whether we educators can fulfill the Department's vision of Hawaii public school graduates who

- realize their individual goals and aspirations;
- possess the attitudes, knowledge and skills necessary to contribute positively and compete in a global society;
- exercise the rights and responsibilities of citizenship; and
- pursue post-secondary education and/or careers without the need for remediation.

THE HCPS III IMPLEMENTATION PROCESS MODEL

The Hawaii Content and Performance Standards (HCPS) III Implementation Process Model is a framework that has been adapted from West Ed's Learning from Assessment model. It consists of a series of six steps.

- The first step in the process asks a teacher to identify relevant benchmarks. The teacher decides which benchmarks will be the central focus of a lesson or unit.
- In the second step, the teacher determines what evidence will show that the students have met the benchmarks.
- In the third step of the process, the teacher plans the strategies and experiences which will build understanding and help all students meet proficiency.
- The fourth and fifth steps require the collection of evidence of student learning. The teacher determines what this evidence indicates about the student's progress and decides what further instruction or support is needed.
- Lastly, the teacher evaluates the work and communicates the findings.

While the model numbers the steps in the process, it is important to remember that these steps are not always followed in a lock-step fashion. For example, a teacher may work through steps one to five, and as she collects the evidence of student learning (step five), she will likely gain insight that will inform step three (determine learning experiences). In her review of the work, she may notice that many students are not meeting a certain aspect of a particular benchmark. For example, the students may be able to correctly compare fractions, but may be unable to explain why they placed the fractions in a particular order. This evidence will inform step three and the teacher will likely design additional learning experiences to help students place fractions in a particular order.

HCPS III IMPLEMENTATION PROCESS MODEL

❶	Identify relevant benchmarks.
❷	Determine acceptable evidence and criteria.
❸	Determine ***learning experiences*** that will enable students to learn what they need to know and to do.
❹	Teach and collect evidence of student learning.
❺	Assess student work to inform instruction or use data to provide feedback.
❻	Evaluate student work and make judgment on learning results and communicate findings.

Reteach or repeat the process with the next set of benchmarks.

The table on the next page shows the six-step HCPS III Implementation Process Model. It also shows the state and school support for student success that relates to each step in this model.

HCPS III IMPLEMENTATION PROCESS MODEL

Implementation Steps	State Support for Student Success	School Support for Student Success
❶ Identify relevant benchmarks. *Which benchmarks will be the central focus of the lesson/unit?*	**Benchmark Map** (http://standardstoolkit.k12.hi.us) ~ developed by State with input from field ~ includes sets of benchmarks clustered around Big Ideas or Major Understandings; clusters mapped out by quarters ~ serves as the focal point for other state-developed supporting documents and future standardized course assessments and HSA	**Curriculum Map** [Lotus Notes curriculum mapping program available at no cost (check with your principal)] ~ developed by teachers/schools to create a cohesive and articulated curriculum ~ aligned to Benchmark Map
❷ Determine acceptable evidence and criteria. *What evidence will show that the student has met the standards?*	**Instructional Map** ~ will be developed by OCISS with input from field ~ aligned to Benchmark Map ~ includes sample assessment tasks and rubrics	**Curriculum Map** (continued) ~ includes assessment tasks (may include teacher-developed tasks, or tasks from the Instructional Map, textbook, journals, publications, websites, or other resources)
❸ Determine ***learning experiences*** that will enable students to learn what they need to know and to do. *What strategies/experiences will build understanding and help all students meet proficiency?*	**Instructional Map** (continued) ~ will include sample instructional strategies to provide opportunities for ALL students to reach proficiency **Instructional Materials Review** ~ development of Recommended Textbook List that includes resources that support standards-based instruction and assessment	**Unit/Lesson Plans** ~ developed by teachers ~ aligned to Curriculum Map ~ learning experiences may come from a variety of resources: Instructional Map, textbooks, journals, publications, websites, or other resources ~ includes plans for formative assessment
❹ Teach and collect evidence of student learning. ❺ Assess student work to inform instruction or use data to provide feedback. *What does the evidence indicate about the student's progress?* *What further instruction or support is needed?*	**Instructional Map** (continued) ~ includes student work (exemplars) for the tasks that are provided	**Formative Assessments (from Step #3)** ~ used to guide instruction and inform students of their progress **Summative Assessments (from Step #2)** ~ used to assess student's level of proficiency after the student has had a chance to learn, develop, and improve
❻ Evaluate student work and make judgment on learning results and communicate findings. *What do recent assessments indicate about the student's level of proficiency?*	**Standardized Course Assessments** ~ coming soon for high school courses	**Standards-Based Grading and Reporting** ~ used to report progress/proficiency of benchmarks that were identified in Step #1
Reteach or repeat the process with the next set of benchmarks.		

THE STANDARDS-BASED CLASSROOM

The standards-based classroom does not have one particular form. Rather, it can take on many forms. Characteristics to look for include the following.

What are students doing?

- Using and knowing when to use various tools and resources (such as printed materials, the microscope, a compass, graphing or scientific calculators, computers, measuring tools like scales and rulers, etc.) to learn about science
- Looking for and finding more than one solution to a problem (inquiry skills)
- Reflecting on their progress toward learning goals
- Demonstrating persistence in performing complex tasks, solving complex problems, and learning challenging concepts
- Communicating thoughts, ideas, findings, and solutions to others
- Explaining different ways to solve a problem and why one way may be better than another
- Listening actively to each person's ideas and being critical friends when someone needs help understanding a difficult concept
- Working in collaborative groups, talking and sharing ideas about science and solving problems or conducting investigations together

What are teachers doing?

- Making all tools for learning accessible to all students so that students know where to go and how to use these tools to solve problems and answer questions
- Constantly assessing where students are with respect to the focus of the lesson and adjusting the lesson based on feedback about student understanding; these assessments focus on understanding the concepts and using the processes of science, not just memorizing facts and procedures
- Asking good questions to get students to think more deeply about a posed problem or task
- Creating a climate for risk-taking and encouraging subject-matter dialogue where students exchange a variety of ideas and feel confident about asking questions
- Using text materials, tools, technology, multimedia, guest speakers, and/or field experiences to enhance learning
- Making every effort to show links between and among disciplines and how the subject matter is connected and relevant to other areas and real contexts
- Exploring career opportunities that require the understanding and application of scientific concepts and procedures with students

REFERENCE

Jamentz, K. (1998). *Standards: From document to dialogue.* San Francisco, CA: WestEd.

PREFACE

The Spirit of Science

The spirit of science
progresses by asking questions
and looking for precise answers.
This spirit has enriched our human experience,
and opens new possibilities
for thought and action.
We want to pass on the spirit of science to the next generation,
making the bond between science and ourselves
a bond between ourselves and the Future.
—From “Epic of Man and Science,”
Tsukuba Expo ‘85, IBM Japan Pavilion

Science education, driven by the Spirit of science, should open doors for exploring the possibilities and realities of the quest for truth.

Curiosity and the need to explore the unknown allow humans to better understand the world. For schools, this means a science curriculum that is inquiry-, laboratory-, and standards-based; a staff of expert teachers who seek opportunities to engage students through inquiry; assessment strategies that are multi-faceted, based on standards and consistent with the curriculum and instructional strategies; community support; and adequate funding to support a hands-on science program.

Changes in technology, how people live and work, and poor performance on international science assessments gave rise to the need for reform in science education. Scenarios of students going through thirteen years of formal education and graduating without the basic skills needed for entry-level jobs or continued post-high school education fueled a particular kind of educational reform—standards-driven reform—that gave rise to the development of national and local standards.

Standards-driven reform is a perspective of education that is not readily understood by the general community and by many in the education community. The premise of standards-driven science reform—that all students can learn challenging scientific content—is seemingly contrary to the common belief that “one must be born with the ability to do science and understand it.” Unfortunately, this belief is held by many in this nation, although not by people in other high-performing industrial nations.

The science content in these standards represents what all students need to know and be able to do in order to have choices for post-high school paths and to succeed in a rapidly-changing technological and global society. The need to understand and use science as a tool for solving problems, for making informed decisions, and for creating new technologies is critical in today's global society. The value placed on strategies for ensuring that the science education of our students is challenging and rigorous is demonstrated by numerous international and national initiatives that address strengthening the implementation of national and local standards to improve student learning and achievement in science. By strengthening the implementation of Hawaii's standards, students will be better prepared to meet the challenges of today's societal needs. The hope is that this framework will provide the teaching community with the content and process guidelines for enabling students to make the vision of a Hawaii high school graduate a reality.

This *Curriculum Framework for Science* will provide the rationale for the content delineated in the HCPS III science standards and benchmarks, a description of the entire standards system and the processes for implementing that system, and samples of the major elements of the system and commentary on their use.

The hope is that this framework will also guide teachers and administrators in acquiring the tools and materials for implementing the standards, providing the instructional strategies for helping students attain and exceed the standards, conducting the assessment necessary to guide instruction to better meet needs of students, reporting student progress to communicate to all involved on the status of students meeting standards, and involving multiple role groups in helping to educate the children in their communities.

1. GENERAL DESCRIPTION OF THE SCIENCE PROGRAM

Science is a way of interpreting and describing the environment in which we live. Therefore, it is important for the science education program to be directed toward developing a "scientifically literate" population by educating citizens to understand and appreciate the impact of science and technology on their past, present, and future environments. The science education program provides experiences which enable individuals to become independent and contributing members of a rapidly-changing society. Science shapes society and students need to understand and use the shaping forces and their related technologies in designing the kind of society and future they choose to have: a future in which they will be responsible for voting on science-related public issues as adults. Critical decisions made at the voting booth can determine the extent to which society maintains and improves the quality of life. Science education can accomplish this vision by helping students understand the connections between self, others, the world around them, and the Universe beyond.

Understanding science makes it possible for everyone to share in the richness and excitement of comprehending the natural world. Everyone can use scientific principles and processes in making personal decisions, participating in discussions, and understanding issues.

Learning goals are identified by the HCPS III Science Standards, which are benchmarked by grade level and identify what students need to show in their work. These benchmarks, along with the benchmark maps, are intended to serve as bases for assessing and planning a *customized* science curriculum for each school.

Science curricula should be designed for students—many of whom may never become scientists—who need to understand and appreciate the impact of science and technology on their past, present, and future environments. School science programs should provide experiences which enable individuals to become independent and contributing members of a rapidly-changing society. Science shapes society and students need to understand and use the shaping forces of science and their related technologies in designing the kind of society and future they choose to have.

It is hoped that as students progress through the school science curriculum they will experience the thrill and excitement of wonder and discovery, and appreciate the world in which they live. Like Princess Jasmine on her magic carpet ride with Aladdin (Disney 1992), science education can open students' eyes to see and experience:

> *"…A whole new world, a new fantastic point of view,*
> *No one to tell us no, or where to go, or say we're only dreaming*
> *A whole new world, with new horizons to pursue,*
> *A thrilling chase, a wondrous place, for you and me…"*
>
> —From "A Whole New World," Lyrics by Tim Rice

DEFINITION OF THE SCIENCE PROGRAM

Science education, in the context of Hawaii's standards-driven system, consists of curricula that support student learning and attainment of the science standards and benchmarks. Instruction in this system must engage students in various interactions and assess where they are in multiple ways to provide feedback that can be used to refine instruction and continuously advance student learning. Quality supports for students by highly-qualified instructional personnel will also be needed to ensure that all students meet the range of standards in a way that promotes positive attitudes toward science and a desire to continue to learn science.

The HCPS III science standards document provides the content foundation upon which the science curriculum should be based. However, the standards by themselves are not *the* curriculum. While schools have the flexibility of developing and implementing curriculum unique to the school, the common thread that should run across schools statewide is the HCPS III standards.

HCPS III standards-based curricula should be implemented using appropriate, current and relevant instructional programs and materials that support students in meeting standards. (See Instructional Materials Review, http://standardstoolkit.k12.hi.us/imr/index.html.) Teachers should be highly qualified and should have the skills, content knowledge, and supports for providing learning experiences using the most current research-based instructional strategies and models.

The classroom environment should be conducive to individual as well as group learning, where tools—including text, technological, and manipulative tools—are readily available and where open discussions encourage multiple perspectives on issues and problems.

The science education program reaches *all* students through four major areas.

1. *Personal Needs:* The science education program prepares all students to utilize science for improving their own lives and for coping with an increasingly technological world.
2. *Societal Issues:* The science education program produces informed citizens prepared to deal responsibly with science-related societal issues.
3. *Career Education/Awareness*: The science education program gives all students an awareness of the nature and scope of a variety of science and technology-related careers open to students of varying aptitudes and interests.
4. *Academic Preparation:* The science education program allows students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

At the elementary school level, science is taught every year. The recommended time allocation for science instruction is 225 minutes per week in kindergarten through grade 1, 250 minutes per week in grades 2-3, and 115 minutes per week in grades 4-6 (September 7, 1993 memo from Liberato C. Viduya to Lex Brodie, Hawaii State Board of Education).

National time goals recommended by the National Science Teachers Association have been set as follows: grades K-3 at 90 minutes per week and grades 4-6 at 150 minutes per week. Beginning School Year 2006-2007, students are required to earn two credits in science in the middle/intermediate school. Three credits in science are the minimum required for graduation from high school. The applicable credits may be earned at any time during grades 9-12.

RATIONALE FOR THE SCIENCE PROGRAM

Science education in the last decade has undergone major shifts in the way it is viewed. Science is seen as both a science of pattern and order and as a form of communication for describing the world. As such, instructional practices must actively involve students in exploring, conjecturing, analyzing, applying science in both real-world and scientific contexts, and communicating scientific ideas. Moving the instructional emphasis from just "getting the correct answer or formula" to "justifying the hypothesis and then communicating how that solution was found" demands the use of a variety of methods to assess scientific understanding as an integral part of instruction. Assessment must link directly to the student learning of those standards that it seeks to measure. As part of this change, the use of scientific tools and representation has also become necessary to help students see and understand concepts as they "do" science.

The challenges posed by a highly technical world—in which technologies change so rapidly yet demand a citizenry able to maintain the pace of change while creating new technologies—require education in science that goes far beyond *scientific literacy*; what is expected is *scientific proficiency*. Success in tomorrow's job market will require the ability to use science as a tool to solve any problem as well as the ability to think scientifically to create new ideas. Students must have the tools necessary to achieve and compete in the global marketplace.

Why Science? First, science is an important tool for thinking about and understanding the world. Second, science uses a vast bank of knowledge. Scientists and ordinary people use this tool, known as Scientific Inquiry, and ways of thinking, known as scientific Habits of Mind, to accumulate this knowledge. As students learn how to use Scientific Inquiry and apply knowledge to answer questions about themselves, others, the world, and the universe, they experience the richness and excitement of comprehending the natural world. Third, science is important for all students because its tools and knowledge can be applied to the innate human need of satisfying curiosity. Science offers a means for humans to answer the questions and wonderings they have. An understanding of science makes it possible for everyone to share in the richness and excitement of comprehending the natural world. Everyone can use scientific principles and processes in making personal decisions and participate in discussions and decisions that affect society. A sound grounding in science strengthens many of the skills that people use every day—solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. Additionally, the economic productivity of our society is intimately linked to the scientific and technological skills of our work force.

BELIEFS AND ASSUMPTIONS ABOUT TEACHING AND LEARNNG SCIENCE

Teaching science is complex, contextual, and requires a commitment to the belief that *all* students can learn challenging scientific concepts and that it is the teacher's responsibility to determine what needs to be done in classroom instruction to ensure that all students have the opportunity to learn and demonstrate that they have met the expectations set by the standards.

In a standards-driven system, teaching becomes more complex. Traditionally, teaching, especially in science classrooms, followed a formula—correct homework in the first five to ten minutes, teach a new concept (usually a lecture), illustrate the new concept with problems, assign homework, then do some homework problems. While many science classrooms today are more progressive and reflect changes in instructional strategies (e.g., hands-on activities, collaborative groups, inquiry-based investigations), lessons still tend to aim for the average student and culminate with an evaluative activity and the attitude that "It's just too bad ten out of twenty-five students didn't pass the test" prevails. The teacher still goes on to the next lesson or unit. Standards-driven teaching provides opportunities for *all* students to meet standards and pass the test. Teachers need strategies that help each and every student to succeed.

Teachers need to ensure that the classroom environment is safe, nurturing, and that it facilitates active learning, supports investigations, and provides rich experiences that are contextually grounded for student learning. Accommodations must be made, and differentiated teaching needs to occur to ensure that all students meet standards. A major challenge for teachers and teaching is determining when and how to provide additional experiences for these students who need supplemental help to learn.

The expectations of Hawaii's content standards require teachers to have strong science content background and experiences with the concepts, procedures, and skills addressed by the standards. With strong content backgrounds, teachers will be better able to ask good questions to stimulate student thinking and discussions about the science concepts being taught. Teachers will also be able to anticipate student questions and possible barriers to learning those concepts, model scientific content in multiple ways, and accommodate multiple ways for solving problems. Possessing a strong content background enables teachers to design scientific tasks that are rich and engaging; develop important and relevant scientific concepts and skills; find connections within and outside of science that are consistent with Hawaii's standards; support problem identification and formulation, problem solving, and scientific reasoning; promote communication about scientific ideas; and stimulate positive attitudes and feelings toward science.

Teaching needs to be student-centered; it must accept and respect the diversity of cultures, intellects, and learning styles found in the classroom. Teaching needs to take students from where they are and build upon their prior knowledge, interests, and levels of understanding. This calls for effective strategies based on cognitive and metacognitive practices that can help all students come to view science not as an isolated set of rules to be memorized but as a composite of ideas, scientific domains, and procedures that are to be used as tools for understanding their world and creating new knowledge relevant to current and future needs.

Effective science teaching requires a positive attitude toward science and learning science. The attitudes that "it's OK if you can't understand the scientific concept because I didn't like science either and I'm successful" or "Not everyone can understand science" need to be dispelled. Teacher beliefs about science are communicated not only in what is said, but also in what is not said. Students can sense attitudes and often "learn" or assume the same attitudes about science presented by their teachers.

Science is for all students. All students can learn science and deserve the opportunity to do so. The HCPS III apply to all students, define science literacy, and set expectations for learning, regardless of socio-economic status, age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science. All students can develop the knowledge and skills described in the HCPS III, even as some students go well beyond these levels.

Different students will achieve understanding in different ways, and different students will achieve different degrees of depth and breadth of understanding depending on their interests, abilities, and contexts. In summary:

- Students foster the scientific endeavor by asking important questions and seeking answers to those questions.
- Science is basic to students' perceptions and understandings of their world.
- Students must honor their own curiosities to contribute to their natural environment.
- Students' actions may maintain and improve the quality of their lives and the lives of all organisms on Earth.

BELIEFS AND ASSUMPTIONS ABOUT LEARNING

Students' beliefs about their success in science influence their motivation toward learning science. Student motivation is not only dependent on anticipation of success, but also on the value placed on the task, and on how well the student is engaged by the task. Students' beliefs about their ability or lack of scientific ability also influence their performance and success in science. The challenge most teachers face is changing negative attitudes that students—and sometimes their parents—have about their abilities to learn and do science.

Objective, non-threatening feedback to students about how they can improve their performance leads to improved performance and greater learning. Classroom assessment that is an integral part of instruction and that is accompanied by criteria or a rubric for judging performance promotes improved learning, especially when what is being assessed and the tools for evaluating student performance are shared with the student. (Doing this provides clear expectations.) Opportunities to revise and craft quality work also result in more learning. Student self-assessment has also been shown to result in improved learning and greater effort to complete and take responsibility for completion of tasks.

Research has shown that conceptual learning is facilitated by good questions, contextual problems, opportunities to collaborate and communicate scientific methodology, and use of concrete models to illustrate abstract ideas. Thinking about one's thinking, or metacognition, has also supported learning of scientific concepts.

Learning higher-level scientific concepts and processes is not necessarily dependent upon prerequisite knowledge and skills. The traditional notion that students cannot learn concepts from higher-level course content (like chemistry and physics) if they don't have the basic understanding of concepts, ideas, and the ability to formulate a hypothesis has been contradicted by evidence to the contrary. Low-performing students who would not have been placed in college-preparatory courses have demonstrated learning of higher-level concepts in innovative, non-traditional programs that stress problem-based or project-based learning approaches. In addition, scientific concepts, procedures, and skills taught in the context of relevant themes or problems and investigations have been more readily learned and not forgotten by these students, who show depth of understanding as well as the application of this knowledge in their work.

Research has proven that active participation by students, teachers, and parents in meaningful science through scientific modeling, problem solving, and reasoning leads to more in-depth learning. Additionally, time to conduct investigations, to learn difficult concepts, and to reflect on one's learning contributes to increased learning. The use of writing to clarify one's thoughts about scientific ideas and talking about scientific concepts and ideas will also result in increased learning and improved performance.

Reading is a critical factor in learning science. The skills necessary for reading in science, however, are a little different than that for reading other text or narratives. Reading skills in science require getting information from left to right, up and down, down and up, diagonally, from every part and in every direction of the page. Comprehension is also dependent on language labels for concepts that are highly abstract. The usual tools for comprehension—syntax and context—don't always apply in scientific word problems. Students must move for the concept of learning to read and use strategies and skills that allow them to read to learn.

LEGAL AUTHORITY FOR THE SCIENCE PROGRAM

The legal authority for the Science program is described in the Department's Policies and Regulations, Curriculum and Instruction 2000 Series handbook. Relevant Board of Education policies and Department of Education regulations are listed here.

ACADEMIC PROGRAM
(HAWAII STATE BOARD OF EDUCATION POLICY 2100)

The Board of Education recognizes that one of the key components to student achievement and success is a quality, standards-based academic program. Therefore, the Department of Education shall provide an academic program to equip each student with the knowledge, skills, attitudes, and values needed to attain the Hawaii Content and Performance Standards and to give responsible direction to one's own life. The Department of Education shall provide standards-based learning experiences to develop and nurture a variety of intelligences.

Effective learning shall be facilitated through the maximum and active participation of each student in the learning process, insuring that personal meaning is derived from curriculum content, appropriate and relevant teaching and learning strategies, and self-assessment as well as standards-based assessment, grading and reporting procedures. The learning experiences shall be included in concepts commonly taught in, but not limited to, language arts, mathematics, science, social studies, health, physical education, fine arts, world languages, and career and life skills, or a combination of the above subject areas.

Each school shall offer a comprehensive program of academic education to meet the needs, interests, and abilities of all students.

Adopted: 10/70
Amended: 08/86; 03/88; 01/99; 01/05/06

ACADEMIC PROGRAM
(DEPARTMENT OF EDUCATION REGULATION 2100.1)

1. It is the right of every student to have access to a learning program which will permit optimum development as an educated person.
2. The academic program shall include a desirable mix of appropriate and comprehensive learning activities in the areas of (a) communications, (b) humanities, and (c) environmental studies.
3. The basic program, to be offered at each school, shall consist of the knowledge, skills and processes, and attitudinal development to be required of each student as the foundation for attainment of higher academic learning.
4. The minimum elective program enhances the basic program and consists of desirable courses in the major subject areas which may be scheduled in accordance with student interest, staffing, and related considerations.
5. The specialized elective program, which shall be planned to meet the unique needs and interests of students and school committees, shall reflect current and emerging concerns of the community, the nation, and the world.

Adopted: 10/70
Amended: 8/86, 3/88

K-12 LITERACY
(HAWAII STATE BOARD OF EDUCATION POLICY 2010)

The development of student literacy in all content areas and in all grade levels is an educational and cultural imperative. Literacy shall be attained through an appropriate framework of curriculum and instruction. Literacy is the ability in any content or context to read, write, and communicate. Literacy shall include mathematical and scientific literacy. Other skills that enhance literacy include relating, expressing, speaking, understanding, listening, critical thinking, analyzing, and problem solving.

The language arts standards in the Hawaii Content and Performance Standards specify what all students should know and be able to do to become literate. To attain this goal, all schools shall provide a balanced and comprehensive reading and writing program that includes the direct teaching of: (1) comprehension of content and language in both oral and written forms; (2) organized and explicit skills instruction, that includes phonemic awareness, phonic analysis, and decoding skills, especially in the early grades; and (3) fluency and vocabulary development that includes an understanding of how words work. The reading and writing program shall also provide: (4) ongoing diagnosis and assessment that ensures accountability for results; (5) effective writing practices to be integrated into the reading and writing program; and (6) timely intervention services to assist students who are at risk of failing attainment of literacy.

An effective early reading and writing program shall be implemented to assure that every child will become a proficient reader and writer, as defined by the Department of Education, by the end of third grade.

In the instructional program for grades 4-12, all content areas shall further support the development of literacy skills such that students can access and communicate the subject area content and concepts using a wide variety of print and non-print materials.

Students identified by the Department of Education as not proficient will receive appropriate assistance and support.

Adopted: 10/94 (Curriculum and Instruction Policy
Amended: 4/98; 6/02; 10/19/06

CURRICULUM AND INSTRUCTION IN THE EDUCATION PROCESS (DEPARTMENT OF EDUCATION REGULATION 2010.1)

The roles of the curricular and instructional programs for the public schools of Hawaii shall be both broad and inclusive, bringing focus to experiences which will equip students for a lifetime of effective living and learning, permitting them to meet successfully today's problems and opportunities as well as on those in the yet-unknown future.

Curriculum and instruction shall provide experiences which will enable students to learn to think and act intelligently in achieving maximum self-fulfillment and in attaining the knowledge, skills, abilities, attitudes, and appreciations essential for preserving and contributing to the strength of the community, state, nation, and world.

Effective learning shall be predicated on maximum participation of each student in the learning process, insuring that personal meaning is derived from curriculum content, instructional modes, and evaluative procedures.

Provisions shall be made for incorporating many diverse experiences throughout the school years to assist learners in realizing to the fullest their unique potentialities, as well as to make certain that appropriate attention is directed toward the problems and progress of society. The emphasis and degree of sophistication of these experiences shall be appropriate to the needs and characteristics of the learners.

School experiences which contribute to self-fulfillment and productive life shall include the following:
1. Development of basic skills for learning and communication, including, speaking, reading, writing, listening, computing, and thinking.
2. Development of positive self-concept, including understanding and accepting self and understanding and relating effectively with others.
3. Development of decision-making and problem solving skills.
4. Development of independence in learning, including demonstrating initiative and responsibility for continuous learning.
5. Development of physical, social and emotional health, including demonstrating good health, fitness and safety practices.
6. Recognition and pursuit of career development as an integral part of growth and development.

7. Development of a continually growing philosophy based on belief and values and including responsibility to self and others.
8. Development of creative potential and aesthetic sensitivity.

Adopted: 10/70
Amended: 3/88; 10/94

HAWAII CONTENT AND PERFORMANCE STANDARDS
(HAWAII STATE BOARD OF EDUCATION POLICY 2015)

To ensure high academic expectations, challenging curriculum, and appropriate assessment and instruction for all students, the Department of Education shall implement the Hawaii Content and Performance Standards as approved by the Board of Education. The standards shall specify what students must know and be able to do.

Schools shall articulate and align their curricular, assessment and instructional program—by grade level, subject area, courses, and/or other appropriate units—with the Hawaii Content and Performance Standards and evaluate the effectiveness of their efforts to help all students attain the standards. The school's articulated curricular, assessment and instructional program shall be shared with parents and students with the intent of involving parents/guardians as partners in the education of their children.

The Superintendent shall develop and implement a plan to create a standards-based and performance-oriented education system that will ensure that all students attain the standards.

Approved: 10/95
Amended: 11/01; 06/23/05

HAWAII CONTENT AND PERFORMANCE STANDARDS
(DEPARTMENT OF EDUCATION REGULATION 2015.1)

1. The Hawaii Content and Performance Standards shall be implemented as approved by the Board of Education and distributed to the schools.
2. Each school shall describe its implementation of the standards in its Standards Implementation Design (SID).
3. The Department of Education shall develop and implement a continuum of professional development activities that enable teachers to implement the standards.
4. The Department of Education shall develop an assessment and accountability system that measures and reports on student attainment of the standards and holds everyone accountable for that performance.
5. The Department of Education and the Board of Education shall coordinate the review and revision of the standards every five years.

DOE: 11/01

RESPONSIBILITY FOR CURRICULUM DEVELOPMENT AND IMPLEMENTATION (HAWAII STATE BOARD OF EDUCATION POLICY 2030)

The Department of Education shall provide guidance to schools in developing and implementing curriculum and instruction for the public school system.

The responsibility for developing curriculum shall be shared by the Superintendent and the schools. The responsibility for developing and delivering the instructional program shall rest primarily with the schools. The Superintendent shall provide the general direction in curriculum and instruction by providing guidance in the use of effective teaching, learning, and assessment strategies appropriate to the Hawaii Content and Performance Standards.

Former Code No. 6123.2
Former Policy Approved: 07/60
Amended: 10/70; 03/88; 03/99

CURRICULUM DELIVERY (HAWAII STATE BOARD OF EDUCATION POLICY 2101)

The Board of Education recognizes that a strong, challenging curriculum is key to student success and achievement. Therefore, all elementary (grades K-5) and secondary schools (middle/intermediate and high) shall design a program of studies—or curriculum—that enables all students to attain, to the highest degree possible, the Hawaii Content and Performance Standards (HCPS). The curriculum shall include:

- Units of study or lessons, delineating content or topics to be taught;
- Relevant instructional activities and materials to be used, aligned with the HCPS;
- Specific learner outcomes or expectations that result in student attainment of grade level benchmarks;
- A timeframe in which outcomes are expected to be achieved; and
- Assessment tools and methods, including collection and analysis of student work, to measure student attainment of outcomes and benchmarks.

With continued emphasis on improving student achievement, the articulation and coordination of curriculum and curricular services between and among grade levels and subject areas shall be addressed at every school. Articulation of services between schools within a complex shall also be addressed.

The curriculum or program of studies shall include academic courses, subjects, and/or units as well as planned, systematic co-curricular activities and student academic support services, such as assessment, counseling, and guidance to facilitate student attainment of standards. The Department of Education shall adopt regulations to assist schools in the implementation of this policy.

Approved: 11/03/05

INSTRUCTIONAL MATERIALS
(HAWAII STATE BOARD OF EDUCATION POLICY 2240)

The Board of Education understands that implementation of standards-based education requires instructional materials that are aligned with the Hawaii Content and Performance Standards (HCPS). Therefore, printed materials, media and technology which overtly address the HCPS benchmarks shall be selected for classroom use.

The Office of Curriculum, Instruction and Student Support shall provide a list of recommended textbooks and other instructional materials for select curricular areas. It shall also provide general and content-specific evaluation criteria for schools to use when evaluating instructional materials.

Schools that select texts and instructional materials not on the list of recommended texts and instructional materials shall demonstrate that these materials will better support their students' learning needs. Evidence shall include statewide assessment results and other data documenting student achievement.

Schools shall also develop and implement a multi-year textbook acquisition/replacement plan that is based on instructional needs. This shall be a key component of a schools' academic and financial plan. Schools shall inform parents and make available to their school communities, the textbook acquisition/replacement plan, its adequacy in meeting students' needs for textbooks in a given year, and the textbook series, by subjects, used in classrooms.

Former Code Nos. 6134 Textbooks and Reference Materials
6134.1 Approval of Reference Materials Offered by Special Interest Groups
Former Policy 6134.1 Approved 01/55; Reviewed 07/60; Revised and included above 4/70
Approved: 10/70
Amended: 03/88; 05/95; 03/97; 09/98; 01/05/06

PROGRAM GOALS

VISION

Ultimately, science develops students who can maintain and improve the quality of their lives by being able to imagine, create, explore freely, and challenge both themselves and others by asking important questions then seeking precise answers. They make personal and societal decisions rationally; they shape and choose the kind of future they envision for themselves and for future generations.

This vision goes beyond what needs to happen in the classroom where current, relevant, research-based instructional practices are a part of each teacher's repertoire; where students are engaged in stimulating accountable science talk about challenging concepts and processes of important science in rich, meaningful tasks; where scientific tools and technology are accessible to each student and used in the context of solving problems and communicating ideas; and where teachers collect critical assessment data of student progress toward meeting HCPS III science standards as well as where students do their own self-assessments and take responsibility for their learning. Beyond the classroom, science education must address all of the supports that are necessary for quality instruction to occur.

This *Curriculum Framework for Science* describes the content and uses of the tools of Hawaii's system of standards.

Professional learning experiences are a key facet and integral part of this vision. The "what" of professional learning experiences needs to address: 1) the knowledge background required for teaching the content of the standards; 2) the latest research-based instructional practices that make up exemplary pedagogy; and 3) the most current research on purposes, methodologies, and practices of assessment, evaluation, grading, and reporting student progress. The "who" of professional learning experiences must include the range of instructional personnel who provide scientific learning experiences for students. The "who" includes teachers, administrators, students, parents, and community members who may be involved in providing direct and supplemental instructional services. With limited personnel resources at the state and district/complex level, this vision of science education relies on someone at the school-level who is regarded as a science education support person or specialist that can provide immediate support to teachers on scientific content, pedagogy, and classroom management practices. When funding permits, a teacher-specialist position will be part of a trained statewide cadre with frequent, on-going, state-initiated professional development. This support person can then take what is learned and provide school-level professional learning experiences to the rest of the faculty. The teacher-specialist can also mentor beginning teachers and help all teachers at the school test and practice new ideas or programs in their classrooms.

The "how" of professional improvement needs to include long-term, sustained institutes and courses for teachers to learn, experiment with, and reflect on innovative, research-based programs that will help students meet challenging academic standards. The "how" also requires multiple opportunities for within grade level, across grade levels, within school, and across school articulation for the purpose of ensuring best practices and *all* students meeting standards. This aspect of professional improvement must also include articulation, collaboration and partnerships between and among the Department of Education and post-high school institutions, community colleges and universities. Working together, all members of Hawaii's learning community can truly personify the idea that "it takes a village to educate a child."

The mission of Hawaii's Science Program is to provide a clear picture of what is needed to help all students meet challenging standards and to provide the leadership and support that ensures students will have the opportunities to learn that they are entitled to so that they can make informed choices for post-graduation paths and find success in the paths they choose without the need for remediation.

MISSION

To develop students who are rational, scientifically literate, and have the necessary intellectual resources, inquiry skills, and habits of the mind to understand the Natural World.

GOALS

To prepare students for a rapidly-changing technological world, the science program goals are for *all* students.

- **To acquire and value scientific literacy and fluency.**
  Students will be living in a world where their decisions must be based on quantitative understanding and reasoning. It will be essential for all students to recognize and value the necessity for lifelong learning of relevant science.
- **To develop cultural literacy.**
  Science is contextual and relies upon agreements among the people who use it. All citizens should learn to appreciate this aspect of science as a world-wide intellectual and cultural achievement. Understanding the history of science in their culture and using science successfully celebrates this achievement and allows further evolution of science.
- **To become confident problem solvers.**
  Students should be able to use science as a tool for solving problems they encounter. Every student should acquire a repertoire of problem solving strategies and develop the confidence needed to meet the challenges of a rapidly changing world.
- **To communicate scientific ideas in speaking, in writing, and through scientific representation to various audiences.**
  Science allows people to deal with aspects of reality and provides the language for describing certain phenomena. Students will need to be able to discuss scientific ideas with people who may not have the scientific background or experience to understand the concepts involved or the thinking that resulted from these ideas.

The Science Program Objectives are

1. To nurture in our students a curiosity and excitement about the bio-physical environment.
2. To teach students to value science as one way of learning and communicating effectively about self, others, and the environment. (To develop a longing to know and understand.)
3. To foster students' appreciation for the practical and aesthetic contribution of science to improve the quality of life and to promote in our students the desire to take an active part in that contribution.
4. To foster the intellectual virtues of science, such as honesty, objectivity, impartiality, open-mindedness, creativity, inventiveness, self-direction, and rationality.

Additionally, *Project 2061* recommends that students should leave school with the following knowledge, skills, and understandings.

- Scientific endeavor stems from the union of science, mathematics, and technology.
- Science, mathematics, and technology have roots going back into history and into every part of the world.
- Science, mathematics, and technology are expressions of both human ingenuity and human limitations embedded with intellectual, practical, emotional, aesthetic, and ethical dimensions.
- Technology extends our abilities to change the world.
- Technology and social systems strongly interact with each other.

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2. THE SCIENCE STANDARDS

THE NEED FOR STANDARDS

Standards serve as a catalyst or guide for focused and sustained improvement in science education. The science content standards are comprehensive and broad outcomes that identify what students should know about science and be able to do with science in order to make sense of the world around them. Standards ensure that *all* students are provided the opportunities and support necessary to learn significant science with depth and understanding and to become scientifically literate. The standards are developed for two primary reasons.

1. *To promote equity and excellence for all.* Standards for all students are necessary to promote high expectations and to ensure equitable educational opportunities—qualified teachers, access to resources, and a fair opportunity to learn toward high expectations. The National Science teachers Association (NSTA) in *Science for All Americans* (2004) makes clear that standards promote an opportunity for academic achievement for all students.
2. *To ensure that students are scientifically literate to meet the demands of society now and in the future.* The future will require scientifically-literate citizens who can function in a highly technological and communication-oriented society. Scientific competencies once achieved by a few will be needed by all to live and contribute successfully to society. These competencies go beyond the ability to do arithmetic and solve simple problems. They include the ability to make decisions based on data, to use technology to represent and solve complex problems, and to communicate verbally and symbolically the processes and information required for various situations.

THE SETTING OF THE STANDARDS

The HCPS III science standards and benchmarks were developed with HCPS II as the starting point. Science curriculum staff of the DOE worked with Mid-Continent Research for Education and Learning (McREL) consultants through the development process. McREL is one of ten regional educational laboratories that make up the Regional Educational Laboratory System, which serves education agencies and schools across the nation. McREL is known for its extensive work with standards and is at the forefront of standards-based education. The following specifications were followed in the development of HCPS III standards.

- Essential standards, benchmarks, and performance indicators were used as the foundation for the HCPS III standards.
- As the new standards statements were developed, they were also compared against national standards and other highly-regarded state standards.

- Analysis of the standards led to the elimination of overlaps and/or redundancies within and between content areas.
- The standards and benchmarks were reviewed for consistent grain size (benchmarks that were of approximately the same instructional size)
- Standards, benchmarks, sample performance assessments, and rubrics were written in plain language, understandable to primary audiences (teachers and school administrators) and secondary audiences (students and parents).
- Benchmarks were written as describing "proficient" performance. Attention was paid to the taxonomic level of the benchmarks so that they would appropriately scaffold and challenge students.
- The standards needed to be implementable. The benchmarks were written with consideration of the delivery of instruction (i.e., integrated elementary curriculum, required and elective courses at the secondary level).

Benchmarks and sample performance assessments were written to be measurable through the examination of student work from which valid inferences about student learning could be made.

The refinement process involved numerous professionals, from practicing classroom teachers to university professors to national experts. An advisory group was formed to help refine the standards and to ensure that the standards: 1) were consistent with the guidelines developed for the U.S. Department of Education and the Council of Chief State School Officers (Hansche, 1998) ; 2) incorporated the still relevant and appropriate concepts and skills described in the original HCPS document; and 3) incorporated lessons learned from the results of the Third International Science and Science Study (TIMSS).

THE ORGANIZATION OF THE STANDARDS

The eight science content standards are organized into three content strands: *Inquiry or The Scientific Process*; *Life and Environmental Sciences*; and *Physical, Earth, and Space Science*. The General Learner Outcomes are linked with these process standards and should be emphasized in instruction.

Each of the science benchmarks is further grouped into quarterly clusters. The benchmarks indicate developmentally appropriate content knowledge and skills to be learned by the end of each grade-level cluster. The benchmarks further serve to translate the content standard into an expectation appropriate for students within the grade-level cluster.

STANDARDS AT-A-GLANCE

The key features of the science standards can be found in the chart on the following page.

STRAND	SCIENCE STANDARDS/ TOPICS
THE SCIENTIFIC PROCESS	**Standard 1: SCIENTIFIC INVESTIGATION** Discover, invent, and investigate using the skills necessary to engage in the scientific process • Scientific Inquiry • Scientific Knowledge
	Standard 2: NATURE OF SCIENCE Understand that science, technology, and society are interrelated • Science, Technology, and Society • Unifying Concepts and Themes
LIFE AND ENVIRONMENTAL SCIENCES	**Standard 3: ORGANISMS AND THE ENVIRONMENT** Understand the unity, diversity, and interrelationships of organisms, including their relationship to cycles of matter and energy in the environment • Cycles of Matter and Energy • Interdependence
	Standard 4: STRUCTURE AND FUNCTION IN ORGANISMS Understand the structures and functions of living organisms and how organisms can be compared scientifically • Classification • Cells, Tissues, Organs, and Organ System
	Standard 5: DIVERSITY, GENETICS, AND EVOLUTION Understand genetics and biological evolution and their impact on the unity and diversity of organisms • Unity and Diversity • Heredity • Biological Evolution
PHYSICAL, EARTH, AND SPACE SCIENCES	**Standard 6: NATURE OF MATTER AND ENERGY** Understand the nature of matter and energy, forms of energy (including waves) and energy transformations, and their significance in understanding the structure of the universe • Nature of Matter • Waves • Energy and Its Transformation
	Standard 7: FORCE AND MOTION Understand the relationship between force, mass, and motion of objects; and know the major natural forces: gravitational, electric, and magnetic • Forces and Motion • Forces of the Universe
	Standard 8: EARTH AND SPACE SCIENCE Understand the Earth and its processes, the solar system, and the universe and its content • Forces That Shape the Earth • Earth Materials • Earth in the Solar System • The Universe

UNPACKING AND CLARIFYING THE STANDARDS

The following discussion uses the SEE (**S**tate-**E**laborate-Give **E**xamples) strategy to clarify each of the eight HCPS III science standards. Each discussion includes an elaboration of the standard, key concepts, and examples of what it would look like in the classroom.

STANDARD 1: THE SCIENTIFIC PROCESS

State
Scientific investigation – students discover, invent, and investigate using the skills necessary to engage in the scientific process

Elaborate
In other words, scientific investigation is about the wonder of discovery, the pride of invention, and the satisfaction of increasing knowledge about the world. It is a six-year old child, observing with awe a beautiful butterfly emerge from a chrysalis. It is a proud eleven-year-old student who invents a candy tablet dispenser to keep hands clean. And it is a twelfth grader confidently explaining his new discoveries about fruit fly resistance to pesticides. All of these students use science inquiry skills and processes that are part of a series of steps that are followed to investigate a question or curiosity. These steps or skills help students understand and support their discoveries.

The key concepts in this standard are

- Use the senses to make accurate observations.
- Ask questions based on own knowledge.
- Develop hypotheses based on knowledge that can be tested.
- Design an experimental procedure to verify a hypothesis.
- Collect, organize, and analyze data or evidence.
- Formulate and defend conclusions based on data or evidence.
- Participate in peer review.
- Understand the importance of ethics and integrity in scientific investigations

Learning scientific inquiry skills is facilitated when they are learned in combination with science concepts throughout the entire school year. Many of the benchmarks identified in Standards 2 through 8 can be addressed through Standard 1, the Scientific Process. For example, students know that light is necessary for plants to grow. Students learn that sunlight is made up of different colored lights. They hypothesize that perhaps different colored lights affect plant growth; they devise an experiment, collect data, and come to a conclusion. In this investigation, students have applied the skills of Standard 1 to learn about Standard 3, Organisms and the Environment.

Key Concepts	Examples
Scientific investigation	• Students ask questions about what they observe in the natural world and actively seek answers to their questions. • Students conduct observations using the five senses; these observations inspire questions and questions drive the inquiry or investigation. • Before designing and conducting any experiment, students find out what is already known about the topic they are investigating. • Research helps to form a testable hypothesis to structure the experimental design (i.e., variables, controls, appropriate materials, number of trials). • Students collect and record data accurately and precisely. • Students analyze or decide what their data means, using appropriate charts and graphs to determine patterns. • Students draw conclusions that are based on evidence from observations. • Students share their questions, ideas, and results with others; this gives them a chance to improve the quality of their work and to get new ideas for other investigations.
Discover, invent, investigate	• Students observe that many ants were entering the house from outdoors and wonder if naturally fragrant materials (rather than toxic commercial products) could be used to alter the ants' path. • Students wonder if the air pressure in a soccer ball affects the distance that the ball could be kicked. • Students notice how much dirt ran into the neighborhood stream after a heavy rain and wonder if native or introduced groundcover plants affected the amount of dirt held by the roots.
Scientific process skills	• These skills are necessary for inquiry and enable students to solve problems. • Examples include observing, classifying, measuring, collecting and organizing data, graphing, making hypotheses, identifying and controlling variables, and using equipment and apparatus.

STANDARD 2: THE NATURE OF SCIENCE

State
Understand that science, technology, and society are inter-related

Elaborate
In other words, the connection between science, technology, and society is people using knowledge, tools, and systems to make their lives more efficient, easier, and/or better. Science deals with developing understanding and technology deals with carrying out actions. The scientific process and knowledge are connected to discoveries and disciplines in technology in how they affect or are influenced by problems and needs of society or how they improve the quality of life.

The key concepts in this standard are

- Science, scientific investigation, and problem solving.
- Technology.
- Society's needs and wants, the problem solving process, and the connection to science and technology.

Scientific investigation is the process by which scientists observe, study, and build a body of knowledge about the natural world. Using the process of inquiry in the sciences has helped humankind understand why objects fall to Earth (Physical Science), why certain plants are found in deserts (Botany), why steel exposed to oxygen will rust (Chemistry), why cross-pollinating plants can produce predictable results (Biology), and why oil is most likely found near certain rock types (Geology).

Technology deals with the human-made world and the means people use to solve problems, improve their surroundings, or do tasks efficiently. People use technology to control the world in which they live. It is the design, development, and use of tools or machines to control or change the natural and human-made world to make it suit human needs (e.g., transportation, manufacturing, construction, communication, nutrition). Technology can be something as simple and everyday as a paperclip or safety pin or as elaborate as the software and hardware of a computer that enables a high number of replications of a genetic model or experiment to find out if a disease is congenitally or environmentally caused.

Society refers to groups of people that are associated through commonalities such as culture, nationalism, ethnicity, geographic location; it can even extend to civilizations and all of humanity. Societies can have different needs, wants, problems, or issues based on culture, economies, events, or geography. But all of humankind could potentially benefit from solutions generated by science and technology to address specific societal needs.

Key Concepts	Examples
Science and Scientific investigation	• Students observe and ask questions about what they observe in the natural world and actively seek answers to their questions.

Key Concepts	Examples
	• Students observe and ask questions about problems and issues and actively seek to understand them in order to generate solutions. • Students find out any relevant and significant information regarding the investigation, experiment, or problem. They find out what is known so that they can form a testable hypothesis to structure the experimental design or generate possible solutions and their implications. • Students test their hypothesis or solution, collect data, make conclusions, and revise their design or solution accordingly.
Technology and invention	• Students use computers to collect data, insert variables, and create models that are more complex than in the past and that add to the body of scientific knowledge. • Multi-dimensional computer models of physical oceanography and the movement of water in regards to thermal-driven surface currents and deep water currents, as well as chemical-driven surface and deep water currents are used by scientists to determine the effects and behavior of oil spills, circulation of toxins, migration of fish, direction of warm water currents like El Nino, and other phenomena related to ocean currents. • The use of listening tubes to enable 19th century physicians to listen to the heart beat more clearly became the stethoscope today.
Science, technology, and society connections	• Scientific knowledge about human physiology, forces, and gravity led to technology and the development of flight suits that enable pilots to stay conscious during mach speed, enable fighter planes to be faster, and make the country militarily advanced. • Scientific knowledge about the behavior of gasses and electrical current combined with the ability to measure the amount of electricity used to produce light and heat and resulted in the development and refinement of the fluorescent light bulb, which uses less energy and lasts longer than the incandescent light bulb. The demand for more energy-efficient lighting has its impetus in the desire for society to conserve energy because of higher petroleum costs as well as the need to conserve resources and minimize waste. • Scientific knowledge about the biological characteristics of certain bacteria, the chemical composition of certain human waste products, the capacity of bacteria to use waste as food, and the chemical by product of this transfer and cycle of energy has led to biotechnology and the use of the bioremediation process as a means of waste disposal.

STANDARD 3: ORGANISMS AND THE ENVIRONMENT

State
Understand the unity, diversity, and interrelationships of organisms, including their relationship to cycles of matter and energy in the environment

Elaborate
This standard focuses on the interdependence between organisms and the relationship(s) between living things and their environment—in other words, ecology. All organisms interact with other organisms in a variety of ways. All living things depend on their environment and other living things to survive. Matter interacts—in particular, certain atoms like carbon, hydrogen, oxygen, and nitrogen; and molecules such as O_2, CO_2, and H_2O—and there is energy flow between organisms and also between organisms and the environment.

The key concepts in this standard are

- Organisms and the environment.
- Unity, diversity, and the interrelationships among living things (interdependence).
- Flow of matter and energy.

"Organisms and the environment" refers to the different types of living things (e.g., plants and animals in the lower elementary grades) and their environmental requirements—the things they need to survive. For example, the amount of water in a certain location can determine the types of plants that grow there. Trees, like ohia-lehua and hapu'u (fern), grow in wet to very wet conditions. Grazing animals are better suited to grasslands than forests. Coral reefs grow only in areas that meet very specific requirements of temperature and water clarity.

The second key concept—unity, diversity, and interrelationships—looks at similarities and differences between organisms, how environment affects behavior, the various trophic (feeding) relationships, and balance in whole ecosystems. Animals are living things that must consume other organisms (unity) but there is a great difference in obtaining energy for survival between single-celled animal plankton that feed on microscopic plants and an elephant that eats whole trees! The elephant, a mammal, shares some characteristics with a bat (also a mammal), but they differ greatly in their behaviors and live in different habitats. Many interrelationships revolve around eating and being eaten. Various alga, phytoplankton (microscopic plants), and specialized algae living within coral polyp animals form the basis of coral reef food chains (primary producers). Some organisms (primary consumers or herbivores), like surgeon fish or snails, feed on the algae. Secondary consumers or carnivores, like eels, feed on these fish. On land, grasses and trees (also called primary producers) are the initial source of food in an ecosystem. In some instances, severe drought causes a decrease in plants, followed by a decrease in herbivores (plant-eaters, or primary consumers). This effect ripples through a food chain, affecting the populations of prey organisms, and top predators.

Lastly, the flow of matter and energy covers the important nutrient cycles, how living things contribute to and take from their environment, and how energy is utilized by living systems, primarily through the processes of photosynthesis and cellular respiration. Feeding relationships transfer matter and energy from one organism to another. Grass, made of cells that contain atoms like C, H, O, and N is eaten and these nutrients are passed up a food chain. Decomposers—organisms like fungi and bacteria—recycle these atoms and molecules and make them available to plants as nutrients in the environment and to other animals as a food source. Carbon and nitrogen move through the atmosphere, land, oceans, and organisms in many varied cycles. Plants, through photosynthesis, capture the light energy of the sun and transform this into chemical energy that is ultimately used by plants and animals for growth, maintenance of cells, reproduction, movement, etc. All cells that make up organisms undergo cellular respiration. This process changes the energy of a storage molecule glucose—$C_6H_{12}O_6$, made by plants—into a form of chemical energy that all cells can utilize.

Key Concepts	Examples
Organisms and the Environment	• At any level, students can make simple observations that compare plants and animals. In general, plants are green, they do not move like animals, they require sunlight, water, and other nutrients. • All ecosystems (unique environments that contain certain organisms and specific physical factors) contain biotic and abiotic components. Students can observe the various biotic (living) factors and their populations. All of these are dependent on certain abiotic (non-living) factors like amount of sunlight, temperature, water presence (fresh or salt), nutrient presence, amount of wind, etc. For example, strong winds bring nutrients to an area, shape trees, and keep certain insects away. • Students can create their own ecosystem like a terrarium or aquarium. Organisms included (and their populations) could be affected by various abiotic factors: Is the ecosystem kept in sunlight? How clean is the water? What is in the dirt?
Unity, Diversity, and Interrelationships	• In any given or observed ecosystem, students can analyze food chains. Usually, there will be producers at the beginning—plants going through the process of photosynthesis. This is followed by different consumers: “primary” organisms that eat plants or herbivores; “secondary” consumers (or carnivores) that eat other animals; “tertiary” consumers; etc. • Food chains—who eats whom—are always part of larger food webs—a complex combination of many food chains in a given ecosystem. For example, a mynah bird may feed on different bugs, may eat worms or berries, and may feed on flies on the back of a cow. These different feeding strategies tie a mynah bird into different levels of a food web.

Key Concepts	Examples
	• Students could examine Hawaiian forests and streams—the plants and animals that arrived and evolved into unique species in Hawaii. In these ecosystems, the effects of introduced (alien) species are almost exaggerated—how humans impacted flora and fauna, how aquarium fish dumped into streams impact native fish, how miconia could potentially transform forests, how mosquitoes affect native bird populations, etc. • Students could compare the characteristics and behaviors of coral reef organisms (protective coloration, shelters, behaviors) versus organisms in the open ocean (coloration patterns, no shelter, schooling behaviors, body form /shape).
Cycles of matter and energy	• Certain atoms and molecules are a key to life—namely carbon, hydrogen, oxygen, and nitrogen. These atoms move through environments and organisms in various cycles. Students could diagram cycles such as the relationship between O_2 / CO_2 cycling between plants and animals. Nitrogen, contained in the atmosphere, is required by all living things; however, most are unable to tap this into atmospheric source. Nitrogen-fixing bacteria, in a unique relationship with specific plants, make this available for other organisms. Carbon cycles between the abiotic and biotic components of an ecosystem. • Students could assess environmental sites, test water quality (using tests for oxygen, nitrates, potassium, etc.) Certain nutrients, like O_2 or NO_3 can indicate the overall health of an ecosystem. The amount of sediment in a stream or clarity of ocean water, could affect the amount of photosynthesis that occurs, which ultimately affects the basis of the food chain. • In a laboratory experiment students could observe the relationship between producers and consumers. For example, snails and algae could be placed in a test tube, and one tube could be in the sunlight, the other in the dark. No sunlight = no photosynthesis = no O_2 = no snail

STANDARD 4: STRUCTURE AND FUNCTION IN ORGANISMS

State

Understand the structures and functions of living organisms and how organisms can be compared scientifically.

Elaborate

In other words, this standard focuses on the building blocks (or parts) of organisms and how these parts maintain life. One of the most important concepts in this standard is “All living things are made of one or more cells." Ultimately, all functions—including reproduction—occur at the cellular level, though other levels of organization are important in multi-cellular organisms. In addition, this standard includes the concept of classification (how organisms are similar, related and therefore grouped together).

The key concepts in this standard are

- Structure relates to function (at all levels of organization).
- Cell structure, function(s), and specialization.
- Modern classification system.

In the early grades, the first key idea (regarding structure/function), identifies unique structures and their importance to an organism's survival. All living things possess certain parts that allow them to do certain functions. For example, plants have roots, stems, and leaves—these anatomical structures help the plant take in nutrients, transport materials to other plant parts, and capture sun energy to produce food. Fish have fins that propel them through water and whales have flippers that do the same. Birds have feathers and reptiles have scales. Each of these structures helps the organism to survive.

These examples show that increasingly complex levels of organization (chemical, cell, tissue, organ, system, whole organism) allow for certain processes or functions to occur. For example, certain proteins must be produced by a cell to create a muscle cell that forms skeletal muscle tissue. These cells/tissues combine with other tissues (like connective and nervous) to form a specific organ like the biceps brachii—a muscle in your upper arm. This particular skeletal muscle functions as part of the skeletal system that contributes to the survival of the whole organism.

All life functions—including reproduction—occur at the cellular level; hence the need to understand all of the cellular components (organelles) and their contributions to various life processes. Each part of a cell (structure) contributes to the survival of the cell. Each structure performs a specific function. For example, all cells have a cell membrane that separates the interior of the cell from its surroundings (could be a single cell or part of a multi-cellular organism. This membrane primarily transports materials in and out—for instance, O_2 and CO_2—and serves as the communicator between the cell and other cells. The mitochondrion changes the food molecule glucose into a form of chemical energy (ATP) that all cells can utilize. Chloroplasts, found only in plant cells, contain a chemical (chlorophyll) that captures the energy of sunlight to produce the food molecule glucose. This example shows how cells can become very specialized structurally in order to perform a specific function. Another example might be an osteocyte, or bone cell, that produces a substance similar to concrete—it helps form structures that support and also protect other vital organs.

These similarities and differences in structure/function at all levels, allow biologists to create a classification system that shows the degree of relatedness among organisms. This relatedness connects to the content in Standard 5. Some cells possess a cell wall (outside the membrane); these cells/organisms are different from those that do not have a wall. Some organisms possess cells that have a well defined nucleus that separates DNA—deoxyribonucleic acid—from the rest of the cell and other cell types have the DNA free floating in the cytoplasm. Structures such as heads, legs, or wings also show the relatedness of different organisms. All of these examples have led biologists to create a classification system of organisms that shows relatedness. Over time, technological advances—for example, those that aid in our understanding of DNA—have caused modifications in this system.

Key Concepts	**Examples**
Structure and Function (at all levels of organization)	• Students begin to understand this idea when they observe differences between living and non-living things. The overview of biological standards points out the key distinctions. • At various levels, students can observe and compare how structures (leaves, roots, wings, fins, etc.) help organisms survive. Certain plants have leaves that grow at ground level and can survive in low levels of light. Other plants shoot massive leaves above other trees in an effort to compete for sunlight energy. Without hair and a fat layer, polar bears would have a difficult time surviving in their environment. • Certain molecules are present in all living things on Earth. All cells, and the multi-cellular organisms they build, are formed from certain proteins, carbohydrates, lipids, and nucleic acids. These complex large molecules build cells and life. Carbohydrates are primarily used for energy; proteins form the structure of cells, regulate their chemistry, help transport materials and nutrients, and regulate other cells. Lipids store energy, serve as chemical messengers, and contribute to the basic cell structure. Nucleic acids, like DNA, determine the proteins that a cell produces and uses.
Cell Structure, Function(s), and Specialization	• With a microscope, students can identify the primary differences between plant and animal cells. They can see that plant cells have a cell wall outside the membrane, usually have large vacuoles (storage structures), and most possess chloroplasts that are green structures under magnification.
Cell Structure, Function(s), and Specialization (cont.)	• All cell parts (organelles) contribute to major cell processes like transportation, protein synthesis, photosynthesis, reproduction, and cell respiration. The membrane brings substances in and transports waste out; the nucleus—containing chromosomes made of DNA—provides the instructions to build proteins, and the ribosomes are the factory where the amino acid building blocks are put together. Chromosomes and centrioles aid in producing more cells; mitochondria produce chemical energy for the cell in the process of cellular respiration. • Students could contrast red blood cells with nerve cells. The structure of RBC, with the protein hemoglobin that carries oxygen, is quite different from cells that conduct electric

Key Concepts	Examples
	impulses. • Different cell types (with certain structures) form different tissues. Some cells are quite thin and are specialized for transport—epithelial. Others, like muscle cells, have proteins that allow for contraction. Nerve cells can conduct impulses and a variety of connective tissue cells help to bind, store, and protect. All of these cell types form the basis of multicellular organisms.
Modern Classification System	• In any given ecosystem, a variety of organisms are present. Students could classify using the modern system and describe the diversity of the ecosystem. • In the past, organisms were classified according to physical characteristics; now, taxonomists (biologists that classify living things) form groups based on evolutionary descent. The ability to analyze nucleic acids (DNA and RNA) has increased the biologist's ability to determine relatedness between organisms. • The modern classification system organizes life on Earth into domains and kingdoms. Most students will tend to focus on the six kingdoms now recognized: Eubacteria, Archaebacteria, Protista, Fungi, Plantae, and Animalia. Characteristics such as cell type, cell structures, number of cells, and mode of nutrition determine the classification. • Students can use classification keys to determine the type of organism they are looking at. For example, two fish in a classroom aquarium could be called gobies by students but they are actually different species that only reproduce with their own kind. • Using a key, students focus on specific physical characteristics like number of fins, coloration, behaviors, etc. and are then able to identify the specific organism.

STANDARD 5: DIVERSITY, GENETICS, AND EVOLUTION

State

Understand genetics and biological evolution and their impact on the unity and diversity of organisms

Elaborate

In other words, standard 5 deals with the role DNA plays in determining the structure and function of cells and organisms, how genetics (DNA) relates to the passing of traits to offspring, and how the process of evolution leads to organisms changing over time. Ultimately, this change in organisms affects the interrelationship between organisms and their environment. In one sense, this standard—Diversity, Genetics, and Evolution—explains the mechanisms that underlie both Standard 3 and Standard 4.

The key concepts in this standard are

- DNA structure and function at a cellular level.
- Role of DNA in reproduction and heredity.
- Theory of Evolution.

The structure of DNA, similar in all organisms, but unique to each individual, ultimately controls the structure and function of each and every cell and, therefore, each multi-cellular organism. DNA, deoxyribonucleic acid, is sometimes called the molecule of life. All organisms on Earth have this molecule in each of their cells. The molecule looks the same in all organisms—a double helix (spiral) shape, made of four different nitrogenous bases, phosphate molecules, and a sugar called deoxyribose. This molecule instructs the cell to produce certain proteins (a process called protein synthesis) which, in turn, determines the structure and function of that particular cell. Though the molecule is similar in all organisms, it is also the source of differences between species. The order of the nitrogen containing bases varies between species and is actually unique for individuals in a given species.

The second key concept explains the importance of DNA as the molecule that passes on the instructions to offspring and enables the offspring to share similar traits with the parents. Since DNA is the molecule that controls the production of proteins (and these proteins determine structure and function), this information must be passed on to the offspring. For a sea cucumber to be a sea cucumber, it must make cells that form the whole organism. The genes (pieces of DNA that code for a specific protein) passed on to the offspring tend to follow certain rules governing the hereditary process.

It is this molecule—DNA—that changes over time and has led to the unity and diversity of life seen on Earth (and can see from fossils). Many organisms have existed on Earth, and the fossil record shows that organisms have changed over time. They have developed new structures that helped them survive. The environment affects the survival of organisms and only those best suited for life reproduce and pass on their DNA; this idea forms the basis of the theory of evolution. Because of their individual DNA, some individuals in a species possess advantages that aid in their survival; they in turn, reproduce and pass on the genes to their offspring. For example, a reef fish that looks more like the surrounding rocks (camouflage) will probably survive and reproduce. Over time, these fish may become a unique and different species (theory of natural selection).

Key Concepts	Examples
DNA Structure and Function	• The overall structure of DNA is the same in all life on Earth. This structure, and the ability to copy itself (replication), determines the structure and function of each cell and, ultimately, the entire organism. The sides of a DNA double helix molecule are made of phosphates and sugars and the interior of the molecule is made of pairs of nitrogen containing bases

Key Concepts	Examples
	• The order of the nitrogenous bases determines the structure (and the function) of the protein to be built. DNA technologies have allowed biologists to understand the language/code of the bases and how amino acids (the building blocks of proteins) are assembled into the protein.
Reproduction and Heredity	• Organisms pass on "traits" (e.g. blue eyes or brown hair) to their offspring. In reality, these characteristics come from the proteins that the cells produce. These proteins are determined by the DNA. The traits are said to be inherited; genetics is the study of these inherited traits. • Chromosomes are structures contained in the nucleus of cells and are made of the DNA molecule. When a cell reproduces, it makes copies of these chromosomes; often the copies contain no mistakes. However, mutations (changes in the DNA) do occur and sometimes these flaws in chromosome structure are passed on to offspring. Sometimes these benefit survival; at other times they are lethal, causing death. • The specific genes inherited by organisms determine their physical characteristics. For example, the pair of genes for coat color a dog inherits may include a dominant gene for brown hair (more "powerful") and a recessive gene for white hair (easily "overpowered"). The puppy will be a brown haired dog. Gene pairs interact in many different ways.
Theory of Evolution	• In any given species, variations or differences exist. For example, do all Dalmatian dogs look exactly alike? Do they have the same size, same spots, etc? Obviously, they do not. In nature, variation gives individuals better opportunities for survival. If a cheetah is born with a physique that allows it to run slightly faster than others, its chances of survival increase, therefore it will pass on these genes to its offspring. • The geologic (evidence in the rocks) record provides evidence of environmental changes. Critical changes in temperature, or in levels of light could cause many organisms to die and not pass on DNA to offspring. Organisms that survive these changes because of their DNA/physical characteristics survive and reproduce. • The fossil record provides initial evidence for the theory of evolution; many organisms have lived on Earth and are not alive today. For many organisms (e.g., the modern horse), fossils show the progression of horse-like animals (and the times they lived) that eventually developed into the animal we now call the horse.

STANDARD 6: NATURE OF MATTER AND ENERGY

State
Understand the nature of matter and energy, forms of energy (including waves) and energy transformations, and their significance in understanding the structure of the universe.

Elaborate
In other words, the universe is made of matter and energy. The interaction of matter and energy determines the structure of the universe. Matter is usually found in the physical states of solid, liquid, or gas. The state matter takes is determined by its chemical and physical properties and by how much energy it has. Physical and chemical properties are observable characteristics of substances. Matter can undergo physical changes and chemical reactions that can be predicted by the organization of atomic structure and reaction patterns.

Energy is the ability to change matter (form, properties or position) or transform itself. There are many forms of energy such as electrical, chemical, light, sound, nuclear, and heat. Waves are a disturbance and can transmit or carry energy through matter or space, but do not transport matter. Energy can be transformed from one form to another such as radiant energy (light) to electrical energy. As energy is used and changed, it eventually transforms into heat that is scattered. The total amount of matter and energy in the universe is constant. This means that matter and energy in the universe are conserved.

The key concepts in this standard are
- Physical and chemical properties of matter.
- Physical and chemical changes of matter.
- Different forms of energy.
- Transformation, transfer, and transmittal of energy.
- Conservation of matter and energy.

Key Concepts	Examples
Physical and Chemical Properties of Matter	• Properties are used to identify substances. Physical properties (e.g., color, luster, density, boiling point, smell) are observable and measurable. Chemical properties describe how substances may change to form other substances (e.g., when hydrogen gas and oxygen gas react to form water). • The usual forms or states of matter are solid, liquid, or gas. Whether a substance is solid, liquid, or gas depends on its physical properties, heat applied, and pressure. For example, as ice (solid) is heated it melts and takes the form of water (liquid). If the water is heated even more, it becomes water vapor (gas).
Physical and Chemical Changes of Matter	• Matter is made of atoms and molecules either as pure elements or compounds (combinations of elements). The periodic table organizes elements according to atomic structure and chemical properties. This helps predict how

Key Concepts	Examples
	chemicals will react. Elements in group 1 easily combine with elements in group 17. Sodium metal (group 1) will spontaneously react with chlorine gas (group 17) to produce sodium chloride (salt). • A chemical change occurs when the physical and chemical properties of a substance change. When iron reacts with oxygen, rust is produced. Iron is magnetic and metallic. Oxygen is a gas. The product of the reaction is a non-magnetic, red, and crumbly substance. The physical and chemical properties of the iron and oxygen have completely changed in this reaction. • Chemical reactions can either produce or absorb heat. Reactions that produce heat are exothermic. Those that absorb heat are endothermic. When gasoline and oxygen burn, heat is produced. The chemical reaction is exothermic. Boiling an egg produces a chemical change in the egg. This is an endothermic reaction because the egg needs heat to cook. • A physical change may alter the form of the substance, but not the molecular composition. A paper can be torn up, but the pieces remain paper. Water can be frozen into ice, but the ice can easily be turned back into water. In this case, the state of matter of the water has changed from a liquid to a solid, but not the composition. • Chemical reactions can be classified according to patterns: decomposition, single replacement, synthesis, and double replacement. Identifying a reaction pattern enables the product to be predicted. The synthesis pattern of $A + B \rightarrow AB$ is applied to a reaction between carbon and oxygen. The reaction equation of $C + O_2 \rightarrow CO_2$ is easy to compare and predict using the pattern..
Different Forms of Energy	• Energy is the ability to change matter (form, properties or position) or transform itself. Energy can change the state of matter such as heat energy can melt a solid chocolate bar. It can change the properties of matter. For instance, plants store sunlight and use it to make carbohydrates (starches and sugars) from carbon dioxide and water. Matter can be moved with energy. An example is electrical energy running a motor that turns a fan to create a cool breeze. Energy can transform; sunlight hitting a car can make it very hot. • There are many different forms of energy such as heat, light, electrical, chemical, atomic, sound, and mechanical. There is also energy of motion (kinetic energy) and energy due to position (potential energy). Moving objects have the

Key Concepts	Examples
	ability to change matter and therefore have energy. People are afraid of a large, speeding meteor possibly hitting the Earth because the effect of its kinetic energy would equal that of many atomic bombs. Potential energy is stored energy due to position. Water saved behind a dam has potential energy because as it falls it can turn a turbine and create electricity.
Transformation, Transfer, and Transmittal of Energy	• Conduction, convection, and radiation are methods of transferring energy. Conduction is transfer of energy by touching so that heat energy always flows from hot objects to cold objects. Heat from the stove flows into the cooking food. Convection occurs when heat is carried in a mixing motion such as when hot air rises and cold air sinks. Radiation transfers energy through space. Heat from the sun travels through space as radiant energy to warm the Earth. • Energy can convert into many forms. The classic example is the nuclear energy of the sun which radiates to the Earth as light rises to the surface as heat. This light can power a solar cell that creates electricity to run a calculator. Eventually, all the energy is scattered as heat into the environment. • Waves transmit energy through matter or space, but do not transmit matter. Waves are created by a disturbance. For example, a tidal wave can be produced by an earthquake. A tidal wave traveling across thousands of miles of ocean transmits the energy that created it, but it does not transport the ocean water with it. The ocean remains in place, merely rising and falling as the wave passes. On the open ocean, the wave is only a foot high. When the wave reaches land, it rises higher because the ocean bottom pushes it up. • Waves transmit energy through matter or space but do not transmit matter. Speaking creates a disturbance in the air. This disturbance is called sound and sound waves travel through the air until they reach an ear where it makes the eardrum vibrate so the person can hear the sound. The air does not travel into the ear; just the vibration does. • Electromagnetic (EM) waves can travel through matter or space. EM waves are produced by moving electrons and transmit energy at the speed of light. Radio, infrared, visible, ultraviolet, x-rays, and gamma rays have different wavelengths, but are all EM waves
Conservation of Matter and Energy	• In all physical changes, matter and energy are conserved. In a physical change such as tearing up a piece of paper, the

Key Concepts	Examples
	amount of paper before and after being torn is the same. If a block of ice is melted, the amount of ice and the amount of water after melting are the same. This is the Law of Conservation of Matter and Energy. • In a chemical reaction, matter and energy are conserved. If alcohol and oxygen were burned together, the mass of the substances before would equal the mass of all the products after being burnt—water and carbon dioxide. Matter and energy are conserved. • The Law of Conservation of Matter and Energy applies to the universe. Matter can be changed to energy as in nuclear reactions and energy can be changed back into matter, but the totality is conserved. This means that the total amount of matter and energy in the universe is constant and does not change.

STANDARD 7: FORCE AND MOTION

State

Understand the relationship between force, mass and motion of objects; understand major natural forces (gravitational, electrical, and magnetic)

Elaborate

This standard is all about forces and how they change the motion of objects. This means force must be applied to an object that has mass to cause the object to start moving, slow down, speed up or change direction. The same force applied to a smaller mass will create a greater change in motion of the object. A larger mass requires a greater force to cause the same change in motion.

More than one force from more than one direction can be exerted on an object. Forces occur in pairs. This means that if a force is exerted on an object, that object exerts an equal force back. However, the effect of the forces may be different.

Forces permeate the universe through all its constantly moving components such as stars, galaxies, and planets. Forces affect the motion of everything in the universe and they act over long distances, but they also weaken dramatically with increasing distance.

The three major natural forces are gravitational, electrical, and magnetic. Gravitational force is exerted by all objects with mass and is the weakest force because a lot of mass is required before its effect is noticed. It is the primary force that governs the motion of bodies such as stars, planets and galaxies in the universe and is an attractive or pulling force. Electrical force is strong and generated by charged objects. Magnetic force is also strong and related to electrical forces. Both electrical and magnetic forces attract or repel; they can push or pull.

The key concepts in this standard are

- Forces change the motion of objects.
- The applied force and an object's mass determine the amount of change in motion.
- Forces can affect an object's motion over distance.
- Three natural forces are gravitational, electrical, and magnetic.

Key Concepts	Examples
Forces Change the Motion of Objects	• A baseball player has a ball in his hand. He brings his arm back and quickly brings it forward, releasing the ball. The pitcher threw the ball. In other words, he applied a force to change the motion of the ball. • A student is pushing a carton across the floor. He is exerting a force that is moving the carton. Friction force between the floor and carton is making it hard to push because friction force is pushing against the student's force. • Two teams challenge each other in a tug-of-war. Both teams pull on opposite ends of the rope; they exert opposing forces on the rope. The rope will move in the direction of the greater force. • Newton's Laws of Motion include the concept of an action force and a reaction force; forces occur in pairs. If a football player kicks a football, the football kicks him back. In other words, the player exerts a force on the football and the football exerts a force on the player's foot. The player can see the effect on the football because it goes flying and he can feel the force of the football on his foot. Imagine if the football were a big rock; he would really feel the force exerted by the rock.
Force and Mass Determine the Amount of Change in Motion	• Two strong men pull a car and it rolls fast. The same two men pull a big trailer truck and it barely moves. The same amount of force was exerted by the two men on both vehicles, but the car moved faster because the mass was much less. Greater object mass means more force is needed to increase to the same speed. • A professional football player can kick a football over 70 yards, but a 6th grade student can only kick it 35 yards. The professional player can exert more force on the ball and make it go faster and fly farther. Greater force produces greater change in motion.
Forces Can Affect Motion Over Distance	• A ball is thrown straight up. The ball goes up, slows down, and then starts falling down faster and faster. Gravitational force exerted by the Earth is changing the motion of the ball once it is thrown. • The Earth flies straight through space at 60,000 miles per hour, but the gravitational force of the sun pulls on the Earth constantly so that it changes direction all the time and

Key Concepts	Examples
	flies around the sun. The sun's gravity affects the Earth from a far distance of 93,000,000 miles away.. • All orbiting satellites in the universe such as planets, moons, and manmade satellites are moving. All have central bodies that are exerting gravitational forces to make them change direction. Mankind launches communication satellites that orbit the Earth, the central body. The Earth's gravitational force pulls on the satellite hundreds of miles above the Earth. • Everything in the universe is moving and being affected by gravitational forces that are everywhere. A galaxy can be pulled apart by gravitational forces exerted by other galaxies. • If the two opposite poles of a magnet are brought close to each other, the attraction can be felt before the magnets touch. The repulsion can also be felt before two positive poles are brought very close. The magnetic force acts even with space between magnets.
Major Natural Forces: Gravitational, Electrical, and Magnetic	• Gravitational force is exerted by any object with mass. Each human body has mass and exerts a pull of gravity to anything else with mass, but it is so weak that it is not noticed and very difficult to measure. The Earth with a much greater mass exerts a greater gravitational pull than one person can. The sun with over 300,000 times more mass than the Earth has the greatest gravitational force of the solar system. • Electrical and magnetic forces are strong forces. Magnets can be small yet can pull iron objects from a distance. A magnet can keep a paper clip from falling and this means that the magnetic force of the small magnet is greater than the gravitational pull of the Earth. Electrical forces are exerted by positive or negative charges in the atom. • Electrical and magnetic forces can attract or repel. The two negative poles of a magnetic repel. Positively and negatively charged electrical particles attract each other. Gravitational force only attracts masses toward each other. Objects on Earth are only pulled toward Earth. They are not repelled by the Earth and fly into space.

STANDARD 8: EARTH AND SPACE SCIENCE

State
Understand the Earth and its processes, the solar system, and the universe and its content

Elaborate
Chemical (matter) and physical (energy) processes combine to form many of the Earth's cycles, such as the water cycle, the carbon cycle, the rock cycle, plate tectonics, etc. These cycles interact within the lithosphere, hydrosphere, and atmosphere to produce Earthquakes, volcanic activity, winds, waves, water, and ice that help to shape the Earth. The relative positions of the Earth, moon, and sun also help to shape the Earth as they cause changes in the seasons and changes in the climate and weather locally and globally. By understanding these processes and cycles and their interactions, mankind can learn how to live effectively and safely as a part of our dynamic planet.

The Earth is a part of a larger collection of planets, moons, asteroids, and comets that revolve around a solitary star—the sun. This group of objects makes up the solar system. This solar system is but one of many solar systems and stars that collectively make up the Milky Way galaxy. Innumerable galaxies and other objects exist well beyond our galaxy, extending outside our technological reaches. The current knowledge of the origins of the solar system, universe, and stellar processes are a result of scientific observations utilizing the latest technologies.

Essential ideas in this standard are

- The Earth and its processes, forces that shape the Earth.
- The solar system—its origin and evolution.
- The universe and its content.
  1. Comparing the different theories concerning the formation of the universe.
  2. Describing the physical and nuclear dynamics of a star.

The foundation for the high school Earth Science course is laid in 8th grade and 9th grade Physical Science.

Key Concepts	Examples
The Earth and its Processes—Forces that Shape the Earth	• The Earth generally functions as a closed system. The matter contained within this planet and atmosphere generally remains constant and is circulated through various cycles within the Earth's system (the lithosphere, hydrosphere, atmosphere, and biosphere). Energy is also circulated through many of these same cycles. • The Earth receives energy from both internal and external sources. The Earth's external energy source is the sun. It is the predominant energy source for our planet and supplies the energy necessary to support live and to drive our atmosphere and oceans. The sun's radiation heats our planet's surface, which in turn, reradiates energy at a

Key Concepts	Examples
	longer wavelength (infrared) that is more conducive to heating the gases and water vapor of our atmosphere, driving our weather. • The Earth also has an internal energy source—the Earth's core. A remnant source of heat from the early days of Earth's creation, it is a result of gravitational energy and radioactive isotopes. This energy is transferred from the core toward the surface through radiation, conduction, and convection, eventually driving the crustal plates of the planet. • Cycles allow energy and matter to be transported throughout the Earth's system. These cycles are in constant motion, forming a dynamic equilibrium between the matter of the Earth and its energy balance. For example, in plate tectonics, as plates are destroyed in subduction zones, new plates are being formed at divergent boundaries. In the process, energy from both the interior of the Earth, as well as energy related to the subduction process, is transformed into kinetic energy to move the plates as well as energy to drive volcanic activity. In another example, as soon as uplift occurs as in mountain-building, weathering and erosion attempt to level the uplifted area by filling in lower areas with eroded material. • In the atmosphere, the water cycle allows for both the transfer of matter (water) and energy (latent heat of condensation and evaporation) through the atmosphere as it attempts to maintain a balance within the water cycle and the energy flow within the atmosphere. Storms and other violent weather are the result of water and energy imbalances. • Another example includes the formation of ocean and wind currents. These form as water and air attempt to reach equal densities, pressure, and temperatures. As matter flows in an attempt to equalize any differences, winds and currents are created. The greater the differences, the stronger the winds and currents until an equilibrium is reached; then the currents and winds subside. • Finally, all of these processes that shape the Earth have a direct impact on the biosphere—all life on Earth. Understanding how these processes work can help us to live more effectively, harmoniously, and safely on our planet

Key Concepts	Examples
The Solar System—Its origin and evolution	• Currently, the most popular theory is the nebular hypothesis (or the protoplanet nebular theory). It states that the solar system formed about 4.6 billion years ago from swirling clouds of cold gas and dust, having a diameter of over 10 billion km. As gravity pulled the material toward the center, the material condensed, producing great heat and triggering a massive nuclear explosion. Thus, the sun was born. In the process, about 10 % of the material was blown off, forming a disk of left-over stellar material. Gravitational, frictional, and electromagnetic forces attracted the material into clumps called protoplanets that swirled like eddies, eventually producing our planets. The nuclear fusion that started the solar process continues today in our sun. • *(Note: geocentric and heliocentric models are motion models, not origin models. See Earth Science (Grade 8) and Physical Science (Grade 9).*
The Universe and its Content 1. Comparing the different theories concerning the formation of the universe 2. Describing the physical and nuclear dynamics of a star	• Examine some of the current theories concerning the formation of the universe. At this time, the most popular theory is the Big Bang Theory. It states that all the space and matter of the universe was once condensed into a single extremely dense superheated mass between 10 and 15 billion years ago. This material was explosively hurled into space, eventually cooling down and allowing atoms (electrons (-) finally attached to protons (+)) to form, eventually forming the objects (stars, planets, etc.) of the universe. The theory also states that matter from the original Big Bang is continuing to move outward, away from the original source. Evidence for this can be found in the red Doppler shift of objects traveling away from that central point and from each other. Cosmic background radiation has also been detected that appears to be a remnant of that original explosion. • Previous theories included the steady state theory which states that there is no beginning or end to the universe; as the universe expands, its density remains the same because new matter is being created at the same rate that it expands. This theory was discounted by most astronomers since the discovery of background radiation in 1964. • The oscillating theory states the universe expands then contracts upon itself. In other words, there had been a "Big Bang" prior to the current one of which we are a part. This theory, however, does not explain the origin of the universe.

Key Concepts	Examples
	• (Students learned the basic life cycle of a star in 8th grade Earth Science.) This goes one step further, looking at the processes involved as a star progresses through its life cycle. (See also Standard 6—Matter, Standard 7—Forces, and Grade 9 Physical Science for background.) • The physical processes involved in the life cycle of a star include the Laws of Conservation of Matter and Energy. Although a star goes through various changes in its life cycle, all its matter and energy is conserved. Matter is transformed from the lightest of the elements in the early stages of a star's life cycle to heavier elements at its death. Different forms of energy play a role in a star's life cycle at different stages. Gravity initially will pull particles together to amass a huge volume of material. Friction and gravity play a role in condensing the stellar material and heating it to temperatures at which nuclear fusion may occur. During the main course of a star's life cycle, a balance between the gravitational pull inward and the force of nuclear fusion outward is maintained. As the star ages, there is an imbalance between the outward force of fusion, as the star utilizes the last of its nuclear fuel, and the inward pull of gravity due to the immense mass of the star. At this point the star's death is imminent. • The role of nuclear fusion within a star is two-fold: 1) Tremendous amounts of energy (all forms) are produced and emitted by the star, and 2) Matter is transformed from its lightest elements to heavier ones. For example, hydrogen is fused into helium, then helium into carbon and oxygen, as in the sun; or into other heavier elements, such as iron, copper, uranium, etc. in more massive stars.

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3. CURRICULUM, ASSESSMENT, AND INSTRUCTION

STANDARDS-BASED ASSESSMENT

In a standards-based system, assessments are critical because they represent the targets for instruction and they focus attention on what is needed for all students to meet standards. Assessment should not be confused with evaluation. Anne Davies (2000, 1) makes the distinction clear: "When we assess, we are gathering information about student learning that informs our teaching and helps students learn more. We may teach differently, based on what we find as we assess. When we evaluate, we decide whether or not students have learned what they needed to learn and how well they have learned it. Evaluation is a process of reviewing the evidence and determining its value."

In the standards-based education process, assessment is critical to learning because it provides necessary feedback during the learning so students know how to get better or improve their work as they are doing the work. It is important for students to know ahead of time what criteria will be used to judge their work and what the descriptors of quality look like so that they can share the responsibility for their own learning. The process of setting and using criteria for judging work should involve students and their teacher. Collaborating and agreeing on what the "standard" should contain makes clear to all involved what the work must include and look like. When students are involved in this process, there tends to be commitment to producing quality work. The logical next step to this process is to share the "judging" or evaluative role with students and encourage student self-assessment.

In standards-based education, assessment is critical to teaching because it provides important feedback to teachers so that they can make adjustments to instruction to help students learn. Hawaii's standards-based assessment system consists of two parts—classroom assessment and the statewide assessment. Classroom assessments should provide information on where students are with respect to the standard or set goals for the lesson or unit. If some students did not produce the quality of work the teacher was looking for, what needed to be changed in the lesson? Reflection on the results of teaching is an essential piece for improving the teaching-learning process. Professional development to help teachers refine their reflections should emphasize that

1. Teachers can help each other think about what went on in instruction—analysis of the instructional strategy used and resultant student learning should be the basis for teachers' collaboration on their craft. Reviewing the instructional sequence, analyzing student work, and sharing ideas about the sequence of lessons to improve achievement helps teachers reflect on and improve their own teaching.
2. Assessment is an integral part of instruction. Assessment looks just like instruction; it can't be separated from instruction. Teachers have difficulty with this concept since

they expect to see an assessment task that is different from an instructional task. When they can't see the difference, the first reaction is generally one of confusion. When they realize that the only thing that separates assessment from instruction is the purpose for which the task is being used, it's a major "Ah-ha!"

3. Assessment results provide clues to appropriate interventions for students needing further assistance. If learning did not occur as planned, the teacher can use assessment results to consider the following questions: What might the interventions look like? When could the interventions occur (after school, during school, on Saturdays, etc.)? Who can provide the interventions (tutor, classroom teacher, parent, volunteer, etc.)? If someone other than the teacher is providing these interventions, what background must he/she have, what tools should he/she use, and what role does the teacher play?

Assessment is a complex, systematic procedure for collecting and interpreting data. In developing a standards-based instructional unit, the planning model places assessment as the second activity, immediately after the relevant standards are identified. The standards reform movement asks teachers to keep the end in mind. Assessments communicate expectations, and operationally identify what is important.

In many cases, assessment and evaluation are erroneously used interchangeably. Assessments measure student learning. Evaluations place a value judgment on that learning (e.g., a letter grade). This section will not place an emphasis on evaluation.

CLASSROOM ASSESSMENT

Assessments give clues to the way students are thinking and how they approach difficult problems. They give a measure of progress being made. Assessments can take the form of a collection of student work, a written piece of work, a project, an interview, an observation, a performance, and presentations (ASCD, 2000).

The role of assessment has expanded to include making instructional decisions. Research and professional science organizations endorse the use of multiple and varied assessment methods. These generate the information needed by a teacher to determine what the students are thinking, how they are reasoning, and what the next instructional steps should be.

Student learning improves when assessment is a regular part of classroom practice. As teachers give a variety of assessments throughout a unit, they should give feedback to students on how they can improve their work. Communicating expectations with students prior to the task can promote quality work on the assessment. Teachers should choose assessments to integrate with instruction to improve student learning. The ultimate instruction occurs when it can not be distinguished from assessment.

It is important to schedule professional development time and resources to help teachers learn how to analyze both typical and unconventional student work. Analyzing student work can help teachers visualize the depth of students' thinking and pinpoint sources of error or misunderstanding. It also provides information for teachers to reflect on the effectiveness of the teaching and curriculum.

LARGE-SCALE ASSESSMENT

The National Assessment of Educational Progress (NAEP): The National Assessment of Educational Progress (NAEP) is the only national assessment of what America's students know and can do in various subject areas. Science is assessed every four years at grades 4 and 8. The first assessment was conducted in 1996. The NAEP Science framework specifies that students are assessed in the following areas:

- Knowledge of facts;
- An ability to integrate this knowledge into larger constructs; and
- The capacity to use the tools, procedures, and reasoning processes of science to develop an increased understanding of the natural world.

Subscales are reported for the three major fields of science: Earth, Physical and Life sciences.

Finally, the NAEP also measures three characteristic elements of knowing and doing science: Conceptual Understanding, Scientific Investigation, and Practical Reasoning. Each item measures one of the elements of knowing and doing science within one of the fields of science. For example, the student may be asked to conduct an investigation in the context of the Earth sciences.

Plans are underway to meet the assessment requirements under the No Child Left Behind Act of 2001. The Hawaii Department of Education has identified statewide assessment items for all students in grades 5, 7, and 11.

Both the NAEP and the developing HCPS III State Assessment in Science vary the assessment tasks. In addition to the objective questions, a percentage of questions are open-ended, constructed-response, and hands-on performance. Because of the nature of inquiry, performance tasks (as well as authentic tasks) are a natural fit. Brown and Shavelson (1996) elaborate on classroom assessment of performance tasks.

Released test items may be found at the following websites:

- from NAEP: http://nces.ed.gov/nationsreportcard/science/
- from WestED (A Hawaii version of WestED's assessment tool, PASS is being developed): http://www.wested.org/cs/wew/view/rs/612
- from PALS (Performance Standards Links in Science): http://pals.sri.com/

The Hawaii State Assessment (HSA): The standards-based components of the statewide assessment provide data on how Hawaii's students are performing in terms of set criteria—the standards. Classroom formative assessments provide more comprehensive evidence of student performance with respect to each standard. Classroom assessment data can provide more compelling information about what students know and are able to do than the "one-day snapshot" of evidence in the statewide assessment.

The statewide assessment is conducted annually in grades 5 through 8 and grade 11; it consists of multiple-choice, short-constructed response, and extended-response tasks as well as a performance task. All eight HCPS III science content standards are assessed with the HSA Science administered in the fall in grades 5, 7 and 11.

PURPOSES FOR ASSESSMENT

Monitoring Student Progress

Teachers monitor students' progress to understand and document students' growth in relation to the standards and to provide students with relevant and useful feedback about their work and progress. If students are to successfully meet the HCPS III science standards, assessment monitoring practices need to change. The changes need to shift

- Toward judging the progress of each student's attainment of the standards and away from assessing students' knowledge of specific facts and isolated skills.
- Toward communicating with students about their performance in a continuous, comprehensive manner and away from simply indicating whether or not answers are correct.
- Toward using multiple and complex assessment tools (such as performance tasks, projects, writing assignments, oral demonstrations, and portfolios) and away from sole reliance on answers to brief questions on quizzes and chapter tests.
- Toward students learning to assess their own progress and away from teachers and external agencies as the sole judges of progress.

Making Instructional Decisions

Teachers are able to make appropriate instructional decisions when they have a good understanding of what their students know and can do. Evidence of learning is used in three ways: 1) to examine the effects of the tasks, discourse, and learning environment on students' scientific knowledge, skills, and dispositions; 2) to make instruction more responsive to students' needs; and 3) to ensure that every student is successful in meeting the appropriate standards. If students are to successfully meet the HCPS III science standards, assessment practices to support instructional decisions need to change. These changes require moving

- Toward integrating assessment with instruction (to provide data for moment-by-moment instructional decisions) and away from depending on scheduled testing (generally useful only for delayed instructional decisions).

- Toward using evidence from a variety of assessment formats and contexts for determining the effectiveness of instruction and away from relying on only one source of information.
- Toward using evidence of every student's progress toward long-range goals in instructional planning and away from planning for content coverage with little regard for students' progress.

Evaluating Student Achievement

Evaluation is the process of determining worth or assigning a value to something, based on careful examination and judgment. If students are to successfully meet the HCPS III science standards, how student achievement is evaluated must change

- Toward comparing students' performance with performance criteria and away from comparing student with student.
- Toward assessing students' growth in relation to meeting the standards and away from assessing student knowledge of specific facts and isolated skills.
- Toward verifying student achievement based on balanced, multiple sources of information and away from relying on only a few, narrowly-conceived sources of evidence about student learning.
- Toward profiles of achievement based on publicly-stated criteria and away from single letter grades based on variable or nonpublic criteria.

Evaluating Programs

A program evaluation uses student performance data with other evidence to judge the quality and success of the program. In addition to the evaluation of students' learning, program evaluations include information about other important elements, such as goals, curriculum materials, instructional methods, a student's opportunity to learn, and responsibilities of teachers and administrators.

Reporting Progress

Assessments provide evidence about what a student knows and is able to do in terms of the standards. As teachers strive to help their students achieve challenging standards, they need information to tell parents how their child is progressing. Multiple sources of evidence (e.g., observation checklists, student work samples, student commentary and quarterly assessments) collected during the course of a year yield a more comprehensive, ongoing picture of student learning and academic progress towards achieving the standards.

Criteria for Assessing Student Work

A comprehensive, standards-based assessment system offers examples of student work (exemplars) which define acceptable and unacceptable levels of performance in real and meaningful ways. The activities, products and/or performances, criteria, descriptors, and exemplars are sources of evidence to judge student progress and achievement of the standards. A single source of evidence does not represent achievement of the standard. Multiple sources of evidence collected over time, within and across units of study, are needed to judge the success of meeting any one standard.

In a standards-based system, student products and performances are appraised with criteria that are linked to standards. Criteria specify the scope or characteristics of standards for judging student performance. Criteria should be written in clear and specific language easily understood by students and their parents and communicated early and often with them.

Criteria for student learning in a standards-based system should not be confused with expectations for products and/or performances (e.g., 300- to 500-word essay).

STANDARDS-BASED CURRICULUM

A curriculum includes the learning experiences and sequence of units that help students achieve standards. The sequence is not linear or fixed, but rather is spiraled and recursive. Wiggins and McTighe (1998, 153) describe what that means:

> The spiral image guides the teacher in making the student's experience continually developmental while also enabling the student *from the outset* to encounter what is essential. An explanatory logic is deductive; a spiral logic is inductive. . . . The issue is one of timing, not exclusion: Formal explanations come *after* inquiry, not before (or in place of) inquiry.

The standards acknowledge the spiraling nature of the curriculum; they should not be confused with or used as a curriculum. The standards are fixed by the Board of Education, but the determination of a school's curriculum is left to teachers. Hansche (1998, 22) describes the relationship between standards and curriculum as follows:

> Think of a curriculum as a bridge, or conduit, between the broad vision of what is important in lay terms and what teachers should teach in their classrooms. The curriculum is simply an elaborated or "technical" version of the content standards. Content standards and curricula are related tools; they do not contain different content to be learned, and they are not in conflict. The sets of content standards are the models, and the curricula are the blueprints for building those models. If they are created in this way, they automatically align.

Since the standards are the foundation upon which the curriculum is built and/or serve as the basis for selection of appropriate curricula, instructional personnel must understand the content of the standards well enough to be critical consumers of the myriad of commercial materials and products advertised as "best at helping students meet state standards." Teachers must also be able to map their curriculum for the year in such a way as to ensure that students have multiple opportunities to demonstrate learning and achievement towards meeting or exceeding standards.

At the elementary level, articulation across grade levels is essential to ensure that curricula implemented at each grade supports and enhances student achievement and that safety nets are built to ensure that all children meet or exceed standards. At the secondary level, science departments should engage in a "course path analysis" to ensure that no matter what sequence of courses students take, they will have the opportunities necessary for demonstrating that they have met or exceeded the expectations for the range of standards within the benchmark cluster.

Finally, within a complex of schools, there needs to be articulation pre-kindergarten through grade 12 and beyond to ensure that the expectations of each receiving school are communicated with each sending school and that students' needs are met at each grade level or that services are identified so that "no child is left behind." It is through this complex-wide articulation that each level can become aware of what curricular tools are being used and that conversations are initiated and maintained on professional improvement topics, such as the tools which seem to best help improve student achievement towards meeting standards.

STANDARDS-BASED INSTRUCTION

Instruction in a standards-based system is designed to help all children achieve standards. The expectation that all students can learn challenging and rigorous content presents a challenge to teachers who must vary instruction in different ways and over different periods of time. Adjusting instruction requires assessments that give information about where students are academically, the use of varied instructional strategies, measurement of student progress by collecting evidence of learning in relation to the standards, judgments about that progress, and reports of that progress to students, parents and other instructional personnel.

Planning for instruction requires backward mapping from the standards and tasks to instruction. The process requires the teacher to: 1) Identify standards the students will learn; 2) Determine acceptable evidence and criteria; 3) Determine learning experiences that will enable students to learn what they need to know and do; 4) Teach and collect evidence of student learning; 5) Assess student work to inform instruction or use data to provide feedback; and 6) Evaluate student work and make judgments about learning results and communicate those findings.

The first three steps of the process listed above are the planning stages of the process. Steps four and five are the instructional planning that are critical for ensuring standards implementation and student achievement towards meeting the standards. However, the fourth and fifth steps are the most important for instruction. The practice and feedback provided to students enables them to improve their work, thereby increasing their chances of having a quality product or performance. The sixth step contains assessment, grading policy and information to evaluate student performance.

Powerful instruction occurs when

- Teachers believe that what they've planned will result in *all* students learning and achieving challenging standards. This belief and attitude that all students can learn and meet the challenging content of the standards outweighs the best planning for instruction that may have taken place. If the teacher doesn't hold this fundamental belief, that *all* children can learn, then, like the self-fulfilling prophecy, not all children will learn. A related challenge for teachers is to foster the belief in students and their parents that all students can learn the challenging content of the standards.
- Accommodations are made for differences in styles of learning, relevant prior knowledge, and learning pace. Children are all different—they come with different experiences and knowledge, they have different needs, they learn at different rates, and they come with different interests. In a standards-driven system, teachers need to differentiate instruction in order to accommodate the needs of all students.
- The GLOs and related science process standards are emphasized and incorporated throughout the instructional process. Instruction needs to focus on conceptual understanding and the development of critical thinking processes that research has shown support the development of scientific proficiency and further enable students to apply what they have learned to new situations and problems. Helping students to become self-directed learners who produce quality work and can effectively communicate ideas and use technology for multiple purposes prepares them for a highly technical future which requires creative thinking, quick access to resources, and self-reliance.
- The learning environment supports and enables student collaboration, "doing" science; and free exchange of ideas exemplified by conversation, debate, logical arguments, justifications, predictions, etc.
- Instructional strategies used are research-based, thoughtfully chosen with students and outcomes in mind, and effectively carried out with the additional purpose of assessing results of strategies to continually improve instructional delivery and student learning.
- Instructional tasks are rich, relevant, aim for "deep" learning, and result in student work that contains evidence of the quality described for meeting and exceeding expectations. Rich tasks should address multiple standards and may provide the context for integrating multiple content areas and disciplines. Tasks should be crafted and sequenced to form rich instructional units that are purposeful and result in culminating activities where students can showcase their learning with meaningful audiences.

What we teach and *how* we teach must be carefully considered in science education. "If only I had more time to teach science," is a common complaint of science teachers. In our elementary schools, students receive about 35 to 50 hours of science instruction each year. Secondary science courses average about 130 hours a year. If we teach too fast, students cannot fully comprehend, and if we teach too slowly, teachers feel they are not covering enough.

What is so important that we must teach to our students? *How* can we teach it so students would surely learn it? It is time to make changes in what and how we teach.

The ideas, concepts, facts, vocabulary, spelling of science must be learned by our students. But which ideas, concepts, facts, vocabulary or spelling? Are teachers to teach as many concepts and new words as possible in a year? If students do not have some basic science understandings, we educators have failed. The HCPS III Science standards identify these important and basic science content understandings.

The skills of science must be learned by our students. Some of these skills include: scientific investigating, problem solving, critical thinking, as well as more specific skills like measuring, collecting quantitative data, organizing data, charting, graphing, generalizing, applying ideas, hypothesizing, experimenting, controlling variables, and evaluating. If students cannot behave like scientists (at their age level), we science educators have failed.

The attitudes and values of science must be learned by our students. Some desirable ones are: the spirit of inquiry; the need for communication, sharing and collaboration; intellectual honesty, the scientific habits of mind; and more specifically, curiosity, skepticism, openness to new ideas, tolerance for ambiguity, questioning, and the need for evidence, diligence, and rigor. If our students do not possess these qualities, we have failed. These values are both overt and implicit in all strands of the HCPS III Science Standards.

How best do we teach ideas, skills, attitudes, and values within the 35 to 130 hours recommended for science instruction? A child leaves the twelfth grade having received about 650+ hours of science instruction in grades kindergarten to the twelfth grade. As students progress through our educational system, they learn ideas from each of the disciplines of science, are introduced to scientific tools, investigate methods, and form some attitudes and values about science. How can we be sure the ideas, skills and values lead to scientific literacy for our citizenry?

The rapid and complex changes in our post-industrial society make it necessary for all of us to be scientifically literate so that we become actively involved in shaping our own promising future. For adolescents to make the transition from students to adult citizens, they need to understand the interdependence of science, mathematics, and technology. They need to know how to actively apply core concepts (e.g., observation, measurement, hypothesis generation and testing) in science to understand and influence the constant changes occurring within and around them.

At least three major arguments illustrate the need for change in science education.

1. The influence of America in the economic scene appears to be declining. The affluence and international status of the United States was a result of our technological superiority, which is dependent on a scientifically literate workforce. Educational institutions are charged with inadequately preparing students and contributing to this trend.

2. Improved science education can have an impact on human consciousness. Citizens who are scientifically literate, understand key concepts/principles of science and technology, and are able to apply this knowledge in everyday life are in a position to make significant contributions to our county—especially in an age when science and technology permeate our lives. Without science literacy, citizens are disempowered to promote positive changes.
3. Data indicate that many students are simply not taking advanced science classes, and those who do are scoring below other technological nations.

Science must be accepted as a basic subject that is taught in an understandable and meaningful way to all students. Science education must change and that one-dimensional, fragmented and isolated efforts will not work. These changes must be comprehensive in scope and systemic in execution. As science education evolves, efforts must address many dimensions simultaneously.

National organizations all stress the importance of

- Scientific literacy for *all* students (e.g., AAAS, 1990).
- Active, hands-on learning experiences (e.g., NRC, 1996).
- Depth, not breadth: in-depth studies of fewer topics (e.g., Rutherford and Algren, 1990).
- Cooperative and collaborative activities. (e.g., Wiederhold, 1997)
- Integrated and interdisciplinary activities (e.g., Hickman, et. al., 1987).
- Alternative assessments and use of multiple kinds of assessment techniques for teachers and students; e.g., performance-based assessment, portfolio, journals, video samples, structured interviews (ASCD, 2000).
- Developing mathematics and science as a way of thinking, reasoning, and problem solving relevant everyday living (NAS, 2000).
- Applications of science, mathematics, and technology to real-life situations. It is clear that students must have a strong content knowledge and develop scientific habits of mind. AAAS (1993) notes that "students will develop and use skills necessary for full participation in a world shaped by science and technology." Students must be inclined to:
  - Be scientifically honest and curious about how the world works. Be open to new ideas, yet skeptical about accepting ideas too readily.
  - Apply mathematical ideas and skills in making reasonable and meaningful computations to solve problems.
  - Use common tools for dealing with household and other everyday technologies, for making measurements, for processing information and ideas with fidelity and clarity, and for receiving ideas thoughtfully.
  - Decide what evidence to pay attention to and recognize weaknesses in arguments.

Constructivism. Many science education reforms see the learners through constructivist views. Constructivism is a dynamic, interactive model of how humans learn. Constructivists believe that all students can become competent learners capable of refining, reorganizing, and elaborating their existing concepts by integrating these concepts with information gained from dialogues and interaction with peers, manipulation of objects, and systematic observations of events. For example, when students learn about photosynthesis, they connect their emerging understanding to what they already know about “food” and how they think plants make food.

Existing evidence indicates that not only do average students benefit from a constructivist learning environment, but also that at-risk students learn better through direct experiences, cooperative activities, and high levels of interaction (Brooks, 1993). Classrooms dominated by monotonous and repetitive tasks—as opposed to varied ones—where students don’t have the opportunity to make decisions, verbalize, test, modify, and even abandon their pre-existing ideas and adopt new ones breed low-achieving, at-risk students who are locked out of science careers and the understanding that comprises science literacy. Under these conditions, students learn to dislike science.

Technology. Teachers who offer varied activities often use technology to engage students interactively to make personal meaning of scientific concepts. In fact, one of the greatest contributions of educational technology has been the enhancement of science education. Within this new vision, students tackle more challenging problems; connect their work to the world outside their classroom, take greater ownership for their own learning; and work in a variety of styles that reflect diversity in gender, ethnicity, or individual personality.

Technology can allow students to understand ideas through manipulation of systems or conditions that cannot be found in nature. Technological tools and communication networks can connect students to interesting problems in science, link students to other learners, and connect teachers as collaborators with scientists or other teachers.

Telecommunications. Telecommunications offers tangible benefits and resources to teachers by providing international databases of professional development information to network users on the Internet. For example, the Great Lakes Collaborative Star Schools project makes it viable for educators to obtain information on the internet.

In addition to its role as a pedagogical tool, technology can help address many other issues in science education. It allows students and teachers to share information and to network, bring quality science instruction to students in remote regions or in educationally impoverished areas of the country, and provide equitable access and opportunities for learning to students who may be limited by barriers of language, disability, or low expectations.

INSTRUCTIONAL MATERIALS FOR SCIENCE

To achieve the goals of the standards, teachers and students will require access to instructional materials that are accurate in science content, clear in their presentation of scientific understandings and processes, age-appropriate for the children who will use them, suitable for the local community, and consistent with the HCPS III science standards. In addition, because of its instructional implications, instructional materials should correlate with the benchmark maps in science.

Instructional materials for K-12 science include textbooks, kits, software, and other resource materials. Instructional materials serve two major purposes. First, they are a primary source of scientific learning in the classroom. Second, they have a critical role in the education of teachers because professional development training is often structured around instructional materials.

The central issue in the selection of instructional materials is that they reflect the learning goals of the HCPS III. This is not a simple task because there is a broad array of materials that is produced by publishers. The instructional materials review process is intended to assist schools in determining appropriateness.

The process used to select science materials is critical to ensure that students and teachers are provided with a solid foundation for improving achievement. Given this relationship of the quality of instructional materials to student achievement, it is important to pay sufficient attention to the selection of quality materials. Deciding which curriculum material to use is one of the most important professional judgments that educators can make. The decision influences instruction for years to come and, ultimately, how well students learn.

The following pages provide templates of suggested standards-based criteria for use in evaluating instructional materials. The criteria are organized by content strand and process standards. A summary sheet displays total points for criteria on one page and can be used for comparing multiple sets of materials.

Elementary Science Instructional Materials Review Form

CRITERIA		RATING	
PEDAGOGY			
I. DOES THE MATERIAL ADDRESS THE IMPORTANT GOALS OF ELEMENTARY SCIENCE TEACHING AND LEARNING?			
1. Does the material focus on concrete experiences by the children with science phenomena?	**Yes**	**No**	**N/A**
2. Does the material enable children to investigate important science concepts in depth over an extended period of time (especially important for core materials)?	**Yes**	**No**	**N/A**
3. Does the material contribute to the development of scientific reasoning and problem solving skills?	**Yes**	**No**	**N/A**
4. Are assessment strategies aligned with the goals for instruction?	**Yes**	**No**	**N/A**
5. Will the suggested assessment strategies provide an effective means of assessing student learning?	**Yes**	**No**	**N/A**
II. DOES THE MATERIAL FOCUS ON INQUIRY AND ACTIVITY AS THE BASIS OF LEARNING EXPERIENCES?			
1. Does the material engage students in the processes of science?	**Yes**	**No**	**N/A**
2. Does the material provide opportunities for students to make and record their own observations?	**Yes**	**No**	**N/A**
3. Does the material provide opportunities to gather and defend their own evidence?	**Yes**	**No**	**N/A**
III. ARE THE MODES OF INSTRUCTION DEVELOPMENTALLY APPROPRIATE?			
1. Does the material present a logical sequence of related activities that will help students build conceptual understanding over several lessons?	**Yes**	**No**	**N/A**
2. Are opportunities included to assess children's prior knowledge and experiences?	**Yes**	**No**	**N/A**
3. Do the suggested student activities develop critical thinking and problem solving skills?	**Yes**	**No**	**N/A**
SCIENCE CONTENT AND PRESENTATION			
I. COVERAGE OF HCPS III STANDARDS FOR SCIENCE			
2. Does the material adequately cover the following the Standards?			
• Standard 1 –	**Yes**	**No**	**N/A**
• Standard 2 –	**Yes**	**No**	**N/A**
• Standard 3 –	**Yes**	**No**	**N/A**
• Standard 4 –	**Yes**	**No**	**N/A**
• Standard 5 –	**Yes**	**No**	**N/A**
• Standard 6 –	**Yes**	**No**	**N/A**
• Standard 7 –	**Yes**	**No**	**N/A**
• Standard 8 –	**Yes**	**No**	**N/A**
II. SCIENCE CONTENT			
1. Is the science content incorporated in the materials accurately represented?	**Yes**	**No**	**N/A**
2. Is the science content consistent with current scientific knowledge?	**Yes**	**No**	**N/A**
3. Do the suggested investigations lead to an understanding of basic principles?	**Yes**	**No**	**N/A**

Elementary Science Instructional Materials Review Form

CRITERIA		RATING	
III. SCIENCE PRESENTATION			
1. Is the writing style interesting and engaging, while respecting scientific language?	**Yes**	**No**	**N/A**
2. Is vocabulary used to facilitate understanding rather than as an end in itself?	**Yes**	**No**	**N/A**
ORGANIZATION AND FORMAT, MATERIALS, AND EQUITY			
I. ORGANIZATION AND FORMAT			
1. **Teacher Materials:** Does the background material for the teacher provide sufficient information on the scientific content?	**Yes**	**No**	**N/A**
2. **Teacher Materials:** Does the background material for the teacher provide sufficient information on common student misconceptions?	**Yes**	**No**	**N/A**
3. **Teacher Materials:** Are the directions on implementing activities clear?	**Yes**	**No**	**N/A**
4. **Student Materials:** Are the written materials for the students well written, age-appropriate, and compelling in content?	**Yes**	**No**	**N/A**
II. HANDS-ON MATERIALS, EQUIPMENT, AND SUPPLIES			
1. **Teacher Materials:** Is a master source list of materials provided?	**Yes**	**No**	**N/A**
2. **Student Materials:** Are the materials recommended for use appropriate for the designated age levels?	**Yes**	**No**	**N/A**
3. **Student Materials:** Are instructions on manipulating laboratory equipment and materials clear and adequate?	**Yes**	**No**	**N/A**
4. **Student Materials:** Are appropriate safety precautions included, where needed?	**Yes**	**No**	**N/A**
III. EQUITY ISSUES			
1. Is the material free of cultural, racial, ethnic, gender, and age bias?	**Yes**	**No**	**N/A**

Strengths:

____

____

Weaknesses:

____

____

Gaps in alignment with Standards and supplements needed:

____

____

Additional Comments:

____

____

Overall, I would rate this material as:

Excellent	Satisfactory	Fair	Poor

Middle School and High School Science
Instructional Materials Review Form

CRITERIA		RATING		
	PEDAGOGY			
I.	**DOES THE MATERIAL ADDRESS THE IMPORTANT GOALS OF MIDDLE SCHOOL AND HIGH SCHOOL SCIENCE TEACHING AND LEARNING?**			
1.	Does the material focus on engaging students in concrete experiences with science phenomena?	**Yes**	**No**	**N/A**
2.	Does the material enable students to investigate important science concepts in depth over an extended period of time (especially important for core materials)?	**Yes**	**No**	**N/A**
3.	Does the material contribute to the development of scientific reasoning and problem solving skills?	**Yes**	**No**	**N/A**
4.	Are assessment strategies aligned with the goals for instruction?	**Yes**	**No**	**N/A**
5.	Will the suggested assessment strategies provide an effective means of assessing student learning?	**Yes**	**No**	**N/A**
II.	**DOES THE MATERIAL FOCUS ON INQUIRY AND ACTIVITY AS THE BASIS OF LEARNING EXPERIENCES?**			
1.	Does the material engage students in the processes of science?	**Yes**	**No**	**N/A**
2.	Does the material engage students in planning and conducting scientific investigation?	**Yes**	**No**	**N/A**
3.	Does the material provide students with opportunities to gather data and defend their own evidence?	**Yes**	**No**	**N/A**
III.	**ARE THE MODES OF INSTRUCTION DEVELOPMENTALLY APPROPRIATE?**			
1.	Does the material present a logical sequence of related activities that will help students build conceptual understanding over several lessons?	**Yes**	**No**	**N/A**
2.	Does the suggested instructional sequence take into account students' prior knowledge and experiences?	**Yes**	**No**	**N/A**
3.	Do the suggested student activities develop critical thinking and problem solving skills?	**Yes**	**No**	**N/A**
	SCIENCE CONTENT AND PRESENTATION			
I.	**COVERAGE OF HAWAII ACADEMIC STANDARDS FOR SCIENCE**			
1.	Does the material adequately cover the following grades 6-8?			
	• Standard 1 –	**Yes**	**No**	**N/A**
	• Standard 2 –	**Yes**	**No**	**N/A**
	• Standard 3 –	**Yes**	**No**	**N/A**
	• Standard 4 –	**Yes**	**No**	**N/A**
	• Standard 5 –	**Yes**	**No**	**N/A**
	• Standard 6 –	**Yes**	**No**	**N/A**
	• Standard 7 –	**Yes**	**No**	**N/A**
	• Standard 8 –	**Yes**	**No**	**N/A**

Middle School and High School Science
Instructional Materials Review Form

CRITERIA		RATING		
2.	Does the material adequately cover the high school standards (courses)?			
	• Standard 1 –	**Yes**	**No**	**N/A**
	• Standard 2 –	**Yes**	**No**	**N/A**
	• Standard 3 –	**Yes**	**No**	**N/A**
	• Standard 4 –	**Yes**	**No**	**N/A**
	• Standard 5 –	**Yes**	**No**	**N/A**
	• Standard 6 –	**Yes**	**No**	**N/A**
	• Standard 7 –	**Yes**	**No**	**N/A**
	• Standard 8 –	**Yes**	**No**	**N/A**
II.	**SCIENCE CONTENT**			
1.	Is the science content incorporated in the materials accurately represented?	**Yes**	**No**	**N/A**
2.	Do the suggested investigations lead to an understanding of basic concepts and principles of science?	**Yes**	**No**	**N/A**
3.	Is the science content consistent with current scientific knowledge?	**Yes**	**No**	**N/A**
III.	**SCIENCE PRESENTATION**			
1.	Is the writing style interesting and engaging, while respecting scientific language?	**Yes**	**No**	**N/A**
2.	Is vocabulary used to facilitate understanding rather than as an end in itself?	**Yes**	**No**	**N/A**
	ORGANIZATION AND FORMAT, MATERIALS, AND EQUITY			
I.	**ORGANIZATION AND FORMAT**			
1.	**Teacher Materials:** Does the background material provide sufficient information for the teacher on the scientific content?	**Yes**	**No**	**N/A**
2.	**Teacher Materials:** Does the background material provide sufficient information on common student misconceptions?	**Yes**	**No**	**N/A**
3.	**Teacher Materials:** Are the directions for conducting laboratory activities and investigations clear?	**Yes**	**No**	**N/A**
4.	**Student Materials:** Are the print materials for students well written, age-appropriate, and compelling in content?	**Yes**	**No**	**N/A**
5.	**Student Materials:** Is the overall readability of the materials appropriate for middle school and high school students?	**Yes**	**No**	**N/A**
6.	**Textbooks:** Are major concepts, principles, and ideas adequately developed?	**Yes**	**No**	**N/A**
II.	**HANDS-ON MATERIALS, EQUIPMENT, AND SUPPLIES**			
1.	Are instructions on manipulating laboratory equipment and materials clear and adequate?	**Yes**	**No**	**N/A**
2.	Is a list of materials included for each activity?	**Yes**	**No**	**N/A**
3.	Are appropriate safety precautions included?	**Yes**	**No**	**N/A**
III.	**EQUITY ISSUES**			
1.	Is the material free of cultural, racial, ethnic, gender, and age bias?	**Yes**	**No**	**N/A**
2.	Are appropriate strategies included to address the diversity of middle school and high school students' needs, experiences, and backgrounds?	**Yes**	**No**	**N/A**

Middle School and High School Science
Instructional Materials Review Form

Strengths:

Weaknesses:

Gaps in alignment with Standards and supplements needed:

Additional Comments:

Overall, I would rate this material as:

Excellent	Satisfactory	Fair	Poor

A PROCESS FOR SELECTING INSTRUCTIONAL MATERIALS

It is critical for an entire faculty or science department to be involved in the process for deciding which science programs to purchase for use in their school. A process for selecting instructional programs based on standards is described below.

1) Gather copies of the different instructional programs the school is considering. The faculty should attempt to narrow the choices to no more than three programs.
2) Identify a priority strand to focus on (e.g., Inquiry/The Scientific Process; Life and Environmental Sciences; and Physical, Earth, and Space Sciences). Priority can be based on:
    a) Familiarity with the standards in the strand,
    b) The need to address standards in the instructional program, and/or
    c) Areas in which the school's test data (when available) indicate poor student achievement.
3) Focus on a standard from the identified strand as well as the related grade-level cluster benchmark(s) and performance indicator(s).
4) At this point, teachers may focus on one instructional program across all grade levels. If there is more than one teacher at each grade level, teachers in a grade level may decide to focus on different instructional programs.
5) Analyze the instructional program(s) to locate a task (and the instruction for the task) that addresses the strand, standard, benchmark(s), and performance indicator(s) selected.
6) Provide instruction and administer the task. Collect student work for the task.
7) Analyze student work in terms of:
    a) How well the instructional program helped students produce work that contains selected performance indicator(s),
    b) The quality of the work students produce (meets or does not meet the standard), and
    c) The quality of instruction—something was unclear in the program which impacted instruction.
8) Repeat the process (if necessary) for a different set of instructional programs.
9) Perform a holistic review of the materials that go beyond the content standards. Some considerations:
    a) Connections to other disciplines are overtly made throughout the instructional program.
    b) The approach of the instructional program is problem- or project-based.
    c) The instructional program allows for a variety of communication opportunities (oral presentations, written essays, research) and students are encouraged to justify their thinking.
    d) Open-ended problems and/or problems that allow multiple solution paths are an integral part of the instructional program.

The scientific content of the materials selected should reflect state science standards. The program should include cohesive units, multi-day lessons, and worthwhile tasks that allow students sufficient time to explore and investigate in-depth scientific ideas. Materials should develop understanding and abilities in science and should clearly illustrate connections within science and among other disciplines.

Instructional materials should give students opportunities to be active learners. Materials should ask students to communicate orally and in writing. Technology and manipulatives should be used to explore scientific ideas, model scientific situations, analyze data, calculate numerical results, and solve problems. Quality instructional materials elicit, engage, and challenge students' thinking and provide opportunities for all students to learn all levels of science. Assessment should be an integral part of the instructional program. Multiple means of assessment should be used throughout the program to assess conceptual understandings and procedural knowledge.

There is no one set of instructional materials that will be sufficient to meet classroom instructional needs and the standards. It is essential that teachers understand the science standards and become critical consumers. Instructional materials alone cannot ensure that learning will take place.

INTEGRATION

If the goal is to produce scientifically literate citizens who can apply scientific thinking in real-life problem solving situations, then integration of subject matter is essential. Our day-to-day activities and learning experiences are not separated into subject areas or academic disciplines. Ideally, then, a student's experiences should reflect this. Learning is supported, and science curriculum is made more meaningful when connections among the disciplines are emphasized.

RESEARCH AND BEST PRACTICES

Subject integration helps a student make sense of and understand the meaning of new information. Brain research has shown that true learning, defined here as long-term memory, depends on the extent to which information makes sense and has meaning (Sousa, 1995). Without these connections, a student's learning experiences merely add up to a collection of miscellaneous, random topics and unrelated facts.

Integration of subject areas should occur naturally. This occurs when interdependency among information becomes obvious and the integrity of all areas is maintained. For example, it would be impossible to analyze the results of a scientific investigation without understanding the mathematics needed for data analysis. Science provides the context for mathematics to apply data analysis skills. Connections extending across subject areas establish a mental framework that can be applied for future problem solving. This approach to curriculum design helps a student see commonalities among diverse topics and reinforces meaning and understanding.

Integration can stimulate student interest and motivation by connecting to an area of interest. Examples of this may be connecting art and botany, physical education and physics, or music and physical science. Bransford (1999) elaborates on the relationship between learning through brain research, experience, and schooling.

Experimentation has been conducted over the past few decades in the area of curriculum integration, sometimes successfully, sometimes not. Mason (1996) provides a summary of the potential and problems with curriculum integration. The less effective programs tended to sample bits of content from different fields without giving students enough substantive content in any one subject. Other projects were not well constructed in terms of scope and sequence.

Science continues to vie with other fields for time in a limited school day, so educators, researchers, and scientists have been taking a fresh look at how to integrate science with other curricular subjects in ways that avoid these pitfalls. (For purposes of this discussion, integrated programs are those that connect with fields outside of science, as contrasted to interdisciplinary programs that coordinate the disciplines within science.) It must be noted that researchers caution that curriculum integration must be implemented carefully so as not to oversimplify or water down science content.

Some researchers contend that integrated learning activities are more viable and attractive at the elementary level because they require fewer scheduling changes and can be done by one teacher. Even so, middle schools and high schools can integrate instruction effectively if the are willing to be flexible about scheduling, planning, and classroom organization. Barman (1997) notes that when students interact with scientists, the impact on the students' attitude toward science is positive. When curriculum materials for mathematics and science are connected to the workplace, student interest and learning become meaningful and motivational. (Britton, et. al., 1999)

Curriculum integration does not always mean fully merged courses. Other successful approaches include integrating units designed cooperatively and taught in parallel or by a team of teachers, clustering of similar disciplines, and coordinating topics among otherwise separate departments.

The vision is for students to apply their new understandings to questions they have about why things happen in their world, and discuss social implications. Still, there are several challenges to be overcome in integrating instructional programs. One big challenge is providing adequate teacher training. Another is achieving a consensus among disciplinary specialists about goals, content, and pedagogy. Yet another is compensating for the lack of appropriate materials, although that situation is improving as schools, researchers, and professional organizations continue to work on developing quality programs.

IMPLICATIONS FOR THE CLASSROOM

Models exist for integrating science with mathematics, language arts, social studies, history, physical education and fine arts, among others. Mathematics and science are natural partners with similar goals of building process and problem solving skills. Math serves as a critical tool for studying science. Science provides real-life situations in which students can apply the abstractions and tools of math. For example, they can measure and compare the distances objects travel, graph water temperatures, or calculate the percentage of red-haired children in the class. When engaged in scientific inquiry, students analyze empirical data, which often require tables, charts and graphs. Probability and statistics are used in studying ecology, populations and genetics. Measurements of mass, volume, time and distance are also needed for many investigations.

Science can be integrated effectively at all grade levels with mathematics, language arts, social studies, physical education, and the fine arts. Language arts skills (reading, writing, and oral communication) should be a strong component of all the disciplines. Reading, writing, and oral communication are integral skills in science teaching and learning. Science, for its part, offers engrossing subject matter for children to read and write about in language arts classes. In an integrated model, students might read biographies of great scientists or write descriptions of science field trips.

Science teachers intrigued by the study of issues connecting science, technology, and society might find enthusiastic allies in the Social Studies department. The study of such issues as whether the federal government should fund a superconducting super collider provides provocative learning opportunities in both subjects.

The history of science and technology contains fertile and challenging content for integrated instruction in science and history. Such topics as the development of great scientific ideas in world culture help students ground the concepts of science and see how ideas change over history.

Other creative couplings abound. Having students make leaf rubbings pairs science and art. A project in which students build stringed instruments and alter their pitch brings together science and music. Contemporary issues in biology, such as how a retrovirus works, link closely with health. Some schools are integrating several subjects through thematic learning. One model project on rivers suggests activities for science, language arts, math, social studies, technical education, and more.

There are integration models, which are designed and implemented by an individual classroom teacher or by a collaborative, team effort. Thematic units may be taught individually or by a multidisciplinary team of teachers who coordinate topics among otherwise separate departments. The school’s culture often determines the most practical method for subject integration.

Sample Unit Integrating Selected Standards from Science, Art, Language Arts, Educational Technology and Mathematics

Hawai‘i Alive™ is a middle school enrichment program being developed by the Geophysical Institute, University of Alaska Fairbanks, in conjunction with Alu Like. The program takes HCPS III and National Science Standards relating to science as inquiry, structure of the Earth system, Earth history, and forces that shape the Earth. Rather than use examples from the mainland United States, the project uses Hawaii volcanoes as a focus.

The first unit aims to connect students with the host culture (i.e., Hawaiian culture). Students invite *na kupuna* (family members, friends, community members) to their classroom, then listen to, and document, the legends they hear about their island and volcanoes. Students interview *na kupuna* who know *mo‘olelo* (or story) about island creation.

Then, students develop a classroom *ka‘ao* (fairy tale/fictitious story). *Hawa‘i Alive*™ provides sample *mo‘olelo* from various Hawaiian Islands and from around the world, such as “Pele Escapes to Molokai,” “Hina, Maui, and The Great Mo‘o Kuna,” and “Italy and Ancient Rome.” The next lesson has students creating an *ohe kapala* (design on a bamboo stamp often used to remind people about their past, present, or future.) The intent of the *ohe kapala* is to decorate their own clothing and to present a class Mahalo for *na kupuna*.

The transition to “science” begins in the next lesson, “*Mo‘olelo* or Science Theory?” Students learn the difference between a legend and a science theory. Both provide ideas that explain how something works. The *mo‘olelo* or *ka’ao* cannot be tested by repeated experiments under controlled conditions, unlike hypothesis under a theory.

Hawai‘i Alive™ includes an interactive CD-ROM. Live recordings of appropriate and relevant Hawaiian Chants are accessible, Earth processes are modeled, and selected science-related texts are available in English and Hawaiian. Those features are found in all science units: Planet Earth, Active Earth, Earth’s Crust, and Volcanoes.

LITERACY AND SCIENCE SKILLS

Communication is a vital part of science and science education. Instructional programs should allow all students to: 1) order and unify their scientific thinking through communication; 2) articulate their scientific thinking comprehensibly and with clarity to peers, teachers and others; 3) analyze and assess the scientific thinking and strategies of others; and 4) use the language of science to convey their scientific ideas precisely.

Reading and writing in science are an integral part of standards-based science curricula. Reading and writing activities can help students analyze, clarify, interpret, and articulate their scientific ideas, making science more meaningful and motivating. Research suggests that the most logical place for instruction on reading and writing strategies is in the content areas rather than in separate reading classes.

Writing provides opportunities for students to elucidate their own understanding of science and perfect their communication skills. Competency in writing can only be realized through active practice and solving science problems is a natural way to achieve this.

Students who are provided with opportunities, continued support, and a lot of encouragement for speaking, writing, reading, and listening in science classes acquire two benefits: they communicate to learn science, and they learn to communicate scientifically.

THEMATIC PROGRAM AREAS

There is an increasing need to understand and be able to use science in everyday life and in the workplace. Science is a useful tool for thematic areas such as Hawaiian Studies, Environmental Education, and Service Learning. Thematic programs can incorporate science in the following ways:

- *Science for life.* Knowing science can be personally satisfying and empowering. The facets of everyday life are increasingly scientific and technological.
- *Science as a part of cultural heritage.* Science is one of the greatest cultural and intellectual achievements of mankind, and students should develop an appreciation for and understanding of that achievement.
- *Science for the workplace.* The level of scientific thinking and problem solving required in the workplace has increased dramatically, especially in professional areas ranging from health care to graphic design.
- *Science for the scientific and technical community.* All careers require a foundation of scientific knowledge. Those in highly scientific or technical field require more science.

SPECIFIC INTEGRATION MODELS

Problem-based learning/Problem-centered learning

Problem-based learning—using real-life problems—serves as a powerful motivational tool. It extends connections across other disciplines and helps students establish a mental framework for the content that can be recalled for future problem solving.

Many of Hawaii's schools are currently implementing the following problem-based/problem-centered curricula:

- The *Full Option Science System (FOSS)*, developed at the Lawrence Hall of Science , University of California at Berkley, is an elementary science inquiry program.
- *Science Technology and Society for Children,* is the Pre-K to 8 science program that has a hands-on component and literature.

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4. BIBLIOGRAPHY AND GLOSSARY

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GLOSSARY

anatomical evidence—evidence gathered from body structure and its composition.

Big Bang Theory—theory that our universe began with the start of an expansion from a highly condensed point of matter long ago.

biological abnormalities—abnormalities rooted in the life processes.

biotic/abiotic—biotic refers to features of the biosphere that are living or were once living. Abiotic refers to the non-living, physical features of the biosphere. Examples of abiotic features include sunlight, air, water, soil, temperature, and climate.

carrying capacity—the largest number of individuals of a specific species that an ecosystem can support over time.

celestial—of or relating to that which exists outside of the Earth (as contrasted with terrestrial).

chemical reaction—chemicals interacting with each other to form something new.

communication technology—technology that deals with the speed and transfer of information and the assurance that what is sent is also received.

configuration of atoms and molecules—the three-dimensional positions, and energy levels unique to particular atoms (electron cloud model) and molecules.

consumer—in the biological sense, an organism that can not produce its own food (energy-rich molecules) and must eat other organisms for food.

cultivated plants and domestic animals—refer to plants and animals raised, bred, and cared for by humans.

"cycles of matter and energy"—covers the important nutrient cycles, how living things contribute and take from their environment, and how energy flows through living systems, primarily through the processes of photosynthesis and cellular respiration.

Darwin's Theory of Evolution (Biological evolution)—developed from Charles Darwin's hypothesis that organisms inherited traits. Those traits that gave organisms advantages in competition and survival were more likely to survive, reproduce, and pass on their traits to the next generation [natural selection]. Over time, as evidence was collected, Darwin's hypothesis became the Theory of Evolution by Natural Selection, which is accepted by most scientists today.

degree of relatedness—the extent to which two or more organisms are similar genotypically.

Earth materials—the geochemicals that make up the Earth. It includes elements and compounds, rocks and minerals, renewable and non-renewable resources.

Earth's subsystems—interacting parts within the Earth and having unique properties. Examples include: Geochemical Cycles, Atmospheric Systems, Oceanic Systems, and Ecosystems.

ecosystem—all the living things in a given area and their non-living environment.

electric force—the attractive or repulsive force exerted by all charged objects on each other.

electromagnetic waves vs. electromagnetic radiation vs. electromagnetic spectrum—wave that is both electric and magnetic and carries energy from vibrating electric charges in atoms; a broad range of wavelengths of electromagnetic waves, from the shortest gamma rays to the longest radio wave, including visible light; a narrow band of the electromagnetic spectrum that has the characteristics defined by its wavelengths.

element—in the chemical sense, a basic chemical substance in which all the atoms are the same, and different from the atoms of any other substance. It may be material that is natural or synthetic and that cannot be broken down into simpler materials by ordinary means. It has unique properties. Generally, elements are classified as a metal, non-metal, or metalloid.

empirical evidence (empirical data)—data collected from a controlled, scientific experiment.

energy levels of atoms/molecules—forces and internal structure holding electrons to atoms and the atoms of a molecule together. Each atom and molecule has unique energy levels, which contribute to its properties and reactivity.

energy transfer—occurs every time a change takes place in objects. For example, the energy from wind which strikes the coconut leaves, causing it to move (energy transfer from wind to leaves), and make a rustling sound (energy transfer from leaf to your ears.)

energy transformation—energy can have different forms. Examples include: Thermal, chemical, radiant, nuclear, and electrical. Energy is neither created or destroyed (law of conservation of energy), but changes form. When energy changes from one form to another, the action is termed, "energy transformation."

evolution vs. creation—two approaches to help explain the origin of life; the former based on Darwin's Theory of Evolution and the latter on divine intervention.

First Law of Thermodynamics—the basic nature of energy—that it is neither created nor destroyed, but changes from one form to another.

force—a push or a pull. According to Newton's Second Law of Motion, F = ma (an object acted upon by a force will accelerate in the direction of the force). Thus, force equals the mass of the object multiplied by its acceleration.

geo-chemical (rock) cycles—the process of change that rocks goes through as they are formed and reformed into various types.

gravitational force—force between two objects due to gravity. This force depends on the mass of the objects and the distance between them. The force of gravity causes all objects near Earth's surface to fall with an acceleration of 9.8 m/s^2.

Habits of Mind—the shared attitudes, values, and science skills that directly influence a person's outlook on knowledge, learning, ways of thinking and carrying oneself to promote lifelong learning; also known as the "rules" for knowing.

hypothesis—a tentative answer to a research question, based on what is known by the researcher, and what has been observed.

inference—a conclusion formed by reasoning what was observed; an assumption.

investigation, simple vs. scientific—investigation using the main concepts from Scientific Inquiry but not adhering to strict research protocols versus a more rigorous application of Scientific Inquiry that adheres to scientific protocols, including the study design, data collection, mathematical analysis, comparison against what is known and sound communication.

Laws of Conservation of Energy—energy can change its form but it is neither created nor destroyed.

laws of heredity—refers to the passing of traits from parent to offspring. The traits are passed on through genes on a chromosome in the sex cells.

magnetic force—a push or pull of an object without being touched as it passes through a magnetic field

model—a design, representation, set plan, description or analogy for an idea or object.

nature of matter—the essence, traits, or properties of matter.

Nature of Scientific Knowledge—observation → hypothesis → fact → concept → Law → Theory.

natural vs. designed systems—refers to different parts working as a whole in the natural world (as a waterfall in the mountain) vs. a system that has been manipulated and/or altered by humans (as the waterfall at Ala Moana Shopping Center).

natural selection—the process by which, according to Darwin's Theory, living things that are best adapted to their environment survive and multiply to dominate over those less well adapted.

niche—a unique part of an ecosystem for an organism and the ways this organism survives, by obtaining food, shelter, and avoiding danger; how it finds a mate, reproduces and cares for its young.

nuclear reaction—a process of releasing energy stored in the nucleus of an atom.

"**Organisms and the environment**" refers to the different types of living things (primarily plants and animals in the lower elementary grades) and their environmental requirements—the things they need to survive.

Oscillating Universe Theory—theory which predicts that an expanding universe would eventually slow down and collapse, followed by another expansion *ad infinitum.*

physical vs. chemical Properties—matter has characteristic properties which can be used to identify what it is. Physical properties describe the "matter" or substance in question without changing it into a new substance. For example, its state (solid, liquid, gas, plasma) and density are two such properties. A chemical property describes a change that occurs only when one substance reacts with another. It depends on what elements are in that substance and how they are arranged.

problem solving process—a process of devising and implementing a strategy for finding a solution to a scientific problem.

producer—an organism that makes energy-rich molecules from an external energy source, such as the sun (through photosynthesis), or inorganic molecules (through chemosynthesis). These energy-rich molecules serve as food to fuel life processes.

refraction—the bending a wave as it moves from one medium into another medium.

rotation vs. revolution—rotation refers to the Earth spinning on its north/south axis, once in approximately 24 hours, causing day and night to occur. Revolution refers to Earth's elliptical orbit around the Sun, which takes approximately 365 days (one year).

scale—a progressive classification (e.g., by size, mass, or importance).

selective breeding—a process for selecting a male and a female having one or more desirable traits with the intent of breeding offspring having the desirable trait(s).

simple machine—a device that has only one movement, to make work easier. Examples are: pulley, lever, inclined plane, and wheel and axle.

Steady State Theory—the theory that accounts for decrease in density of the universe as it expanded by the continuous creation of matter to maintain a static universe.

structure and function—the arrangement of body parts and how they perform (work).

system—a whole consisting of components that mutually interact and interrelate.

technology—the totality of the means used to make life easier, i.e., tools, processes and innovations, to improve the quality of life.

themes—major ideas that give organization and focus to a group of interrelated concepts.

theory—an overarching explanation that has been well substantiated. Theories are endpoints of science.

Theory of Plate Tectonics—evolved from Alfred Wegener's hypothesis of continental drift, and Harry Hess' theory of seafloor spreading. The Theory of Plate Tectonics accounts for evidence that sections of the seafloor and continents move in relation to each other. Considered as an Earth System, the crust (lithosphere) and part of the upper mantle are broken into plates, which move on a plastic-like mantle (asthenosphere).

trait—observable characteristics in an organism (as relates to genetics).

unbalanced force—when two forces act on each other and one of them is greater than the other, resulting in some kind of motion of an object.

"unity, diversity, and interrelationships"—looks at similarities and differences.

water cycle—the movement of water between the atmosphere and hydrosphere. Driven by the sun's energy, liquid water in the hydrosphere turns into a gas (evaporation) and enters the atmosphere. When the water vapor gets cooled enough, it changes back to a liquid (condensation). As the liquid drops grow, they fall to Earth as rain (precipitation), which completes the cycle by returning water to the hydrosphere.

weather vs. climate—weather refers to the state of the atmosphere at a specific place and time. Climate is the pattern of weather occurring in an area over a period of many years.

work—in the physical science sense, work equals Force times distance (W = FxD).

6. APPENDICES

Appendix A: SCIENCE PROCESS SKILLS

Appendix B: SCIENCE PROCESS SKILLS BY GRADE LEVEL

Appendix C: EXAMPLES OF HCPS III PROCESS MODEL

Appendix D: HABITS OF MIND

Appendix E: SCIENCE SAFETY

Appendix F: FORM 411, STUDENT ACCIDENT REPORT FORM

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APPENDIX A: SCIENCE PROCESS SKILLS

Science Process Skills refer to those skills associated with standards and benchmarks in inquiry and problem solving. HCPS III has embedded the science process skills into Standard 1: Scientific Investigation. As students complete the entire inquiry process at all grade levels they discover, invent, and investigate using the following skills: observing; questioning; inferring and predicting using background information; making and testing hypotheses; identifying and controlling variables in the experimental design; collecting, recording, organizing, and interpreting data; concluding and communicating results.

Process skills are necessary for inquiry and problem solving behaviors. Acquiring and using these skills enables students to conduct scientific investigations and solve problems with a minimal amount of guidance. When appropriately applied, the process skills will enhance the quality of science concept understanding. These process skills also facilitate student achievement and proficiency in the Standards. The nine process skills covered in this appendix are:

1) Observing
2) Questioning, Inferring and Predicting
3) Making, Selecting, and Testing Hypotheses
4) Identifying and Controlling Variables
5) Collecting, Recording, Organizing, and Interpreting Data
    - 5a. Graphing
    - 5b. Using Equipment and Apparatus
    - 5c. Classifying
    - 5d. Measuring
    - 5e. Model Building
6) Using Scientific Vocabulary
7) Communicating
8) Using Space-Time Relationships
9) Process Integration

Each process skill has a number of objectives, which should be mastered by the student. Benchmarks, consistent with the HCPS III Content Standards, are given for each process skill. The student would be expected to meet the benchmark at the level expected for a particular age. This “degree of mastery” of these benchmarks, and subsequent development of each process skill, depends not only on the abilities of the student, but also upon the abilities of our teachers. Teachers are responsible for providing adequate opportunities for the student to meet the benchmarks of each process skill.

Inherent in all skills are the attitudes and habits of mind (see Appendix D.) These should not be overlooked. While it is recognized that reading and writing skills are also important parts of science, these skills are not treated separately. They are integrated as part of the enabling objectives for each process skill.

The following sections elaborate on the nine process skills listed above at grades K-5, at the end of middle school or grade 8, and at the end of high school or grade 12.

1) OBSERVING

Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)

By the end of kindergarten, students should be able to:
- Use senses to make observations about the world around them.
- Identify objects and their properties (color, shape, texture, size, sound, quantity, etc.) using their five senses.
- Identify likenesses and differences in a variety of objects.
- Observe and describe changes in the properties of objects.

By the end of grade 1, students should be able to:
- Use appropriate language when describing an object or making an observation (e.g., Is the object larger in length, width and weight?)
- State objects in quantitative terms whenever possible.
- State objects in qualitative terms whenever possible.

By the end of grade 2, students should be able to:
- Identify the difference between statements of observation and opinion.

By the end of grade 3, students should be able to:
- Use the appropriate senses to collect data to answer a question.

By the end of grade 4, students should be able to:
- Distinguish between an observation and an inference.

By the end of grade 5, students should be able to:
- Use observations to collect data in a scientific investigation.

By the end of grade 8, students should be able to:
- Describe objects qualitatively and quantitatively.
- Distinguish between relevant and irrelevant information in the description of an observation.
- Identify the unknown by comparing it to properties and/or characteristics of what is known.
- Use clear and accurate observations to explain science concepts.

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

- Use emerging technology to enhance the depth and precision of observations.
- Increase the accuracy and processing rate of observations in the collection of data.
- Select and use sense enhancers appropriate to the information desired and subject being observed.
- Describe how observations may be affected by human physiology, emotions, perspective or frame of reference.

2) QUESTIONING, INFERRING AND PREDICTING

Questioning occurs as scientists make observations, read about theories, or wonder about the natural world. Questions can focus, guide, and frame how one tries to answer them. Defining or thinking about the question must occur before an inference.

Inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.

Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.

By the end of kindergarten, students should be able to:

- Ask questions when they observe the world around them.

By the end of grade 1, students should be able to:

- Collect data to answer their questions.

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

- Make a prediction based on observation.

By the end of grade 3, students should be able to:

- Pose relevant questions based on observations.
- Collect and analyze data to answer the question(s).

By the end of grade 4, students should be able to:

- Distinguish between an observation and an inference.

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

- Construct one or more inferences from observations.
- Identify those observations which support an inference.

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

- Recognize when inferences need to be revised based on additional and more recent observations.

- Formulate a prediction based on a given set of observations.
- Conduct a test for predictions that have been made.
- Interpolate and extrapolate information from data.

By the end of grade 12, students should be able to:
- Construct or identify a test for a given inference.
- Categorize statements as logical inferences, facts, or opinions
- Make an if-then statement of two inferences between two related events.
- Determine and conduct additional observations and/or data collection, required to test an inference.
- Show the relationship between/distinguish between direct evidence and indirect evidence leading to an inference of an event or interaction.

3) MAKING, SELECTING, AND TESTING HYPOTHESES

Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.

By the end of kindergarten, students should be able to:
- Identify or make a guess about the cause of an event.

By the end of grade 1, students should be able to:
- Make guesses and give reasons or data to support their guess.

By the end of grade 2, students should be able to:
- Conduct a simple investigation to test a prediction.

By the end of grade 3, students should be able to:
- Develop a hypothesis that relates to an observation.

By the end of grade 4, students should be able to:
- Distinguish between statements that are testable hypotheses and those that are not.

By the end of grade 5, students should be able to:
- Construct a hypothesis from a set of observations and inferences.
- Devise and conduct a test or tests for the formulated hypothesis.
- Choose an appropriate type of apparatus to be used to test a given hypothesis.

By the end of grade 8, students should be able to:
- Identify the degree of precision of measurement necessary for testing a simple hypothesis.
- Suggest or identify a test, which would support one hypothesis and weaken a competing hypothesis.
- Check that a hypothesis matches the existing information.

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

- Distinguish between a statement of opinion or belief and a hypothesis.
- Construct several experimental designs to test a given hypothesis and select the most appropriate procedure.
- Identify and analyze an "inappropriate" procedure for testing a hypothesis.
- Describe or identify a test for a revised hypothesis knowing the original incorrect hypothesis and data.

4) IDENTIFYING AND CONTROLLING VARIABLES

Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.

The school Science Education Program should provide students with many investigative/ experimental experiences in order to help develop skills in identifying and controlling variables.

By the end of kindergarten, students should be able to:

- Make observations about variables that affect a result (e.g. sun = hot)

By the end of grade 1, students should be able to:

- Identify things or events that can change an outcome**.**

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

- Replicate a simple investigation by changing one part of the procedure (variable) at a time to get a different outcome.

By the end of grade 3, students should be able to:

- Collect and analyze data to answer a question
- Identify variables that could affect an outcome.

By the end of grade 4, students should be able to:

- Identify variables in an experimental procedure.
- Identify the variables that must stay the same if the experiment is repeated.

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

- Name variables that have affected or may affect the outcome of an investigation.
- Identify and name which variable should be controlled and manipulated in an investigation.

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

- Identify and name the manipulated and responding (independent and dependent) variables in an investigation.

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

- Construct a test for a hypothesis, inference or problem in which variables are identified.
- State the relationship between the responding (dependent) variable and the manipulated (independent) variable in an investigation.

5) COLLECTING, RECORDING, ORGANIZING, AND INTERPRETING DATA

Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.

The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.

By the end of kindergarten, students should be able to:

- Collect data using the 5 senses.

By the end of grade 1, students should be able to:

- Collect, record, and organize data using simple tools, equipment, techniques.
- Explain results using simple data organizers.

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

- Communicate results of observations and simple investigations.

By the end of grade 3, students should be able to:

- Make graphic organizers to analyze systems and/or the results of investigations.
- Identify data to be collected to answer questions about the investigation.

By the end of grade 4, students should be able to:

- Identify data to be collected in an experimental procedure and communicate it in written or verbal form.
- Analyze data from a table or chart to make inferences or draw conclusions.

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

- Sequence observed changes in materials and systems both verbally and in writing.
- Organize collected data in tables, graphs, histograms, and/or matrices, to display an/or infer trends.
- Research and use accurate and technical information.
- Use data collected to formulate and defend conclusions.

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

- Make a written report of an investigation, including: Background Information, Problem, Hypothesis, Materials and Methods, Results, Analysis, and Conclusion.
- Identify and use the appropriate tools, equipment, and techniques to collect, display and analyze data.
- Represent and communicate data in multiple formats (verbal, written).

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

- Reorganize graphical representation of data to improve analysis.
- Extrapolate and interpolate to arrive at information not specifically presented in data.
- Identify significant pieces of data and determine connection between hypothesis and conclusion.
- Form, defend, and support logical conclusions based only on the data collected.
- Identify relationships between two variables in a given table.

5a) GRAPHING

Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.

The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.

By the end of kindergarten, students should be able to:

- Sort living and non-living things according to stated attributes.

By the end of grade 1, students should be able to:

- Construct and interpret simple graphs.

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

- Construct and accurately label data organizers to show data collected in a simple investigation.

By the end of grade 3, students should be able to:

- Identify different graphs and use them to organize data.
- Interpret and answer questions about data represented in graphs.

By the end of grade 4, students should be able to:

- Describe relationships of components illustrated in various graphs.

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

- Select appropriate graph(s) to depict the data collected.
- Construct, label, and interpret simple line graphs, bar graphs and circle graphs.

By the end of grade 8 all expectations for graphing should be met:

- Plot a set of points on a graph for a given set of data.

- Construct a line graph, including the construction and labeling of axes, marking off units, plotting points and drawing the line (or curve of best fit) for the graph.
- Locate a specific piece of information on a line graph and/or bar graph.
- Make inferences and logical conclusions for a given graph.
- Make a prediction from a given line graph which shows a linear relationship between two variables.

5b) USING EQUIPMENT AND APPARATUS

The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.

The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.

By the end of kindergarten, students should be able to:
- Maintain a safe and healthy classroom environment at all times.

By the end of grade 1, students should be able to:
- Properly retrieve, store, and maintain science equipment and supplies.

By the end of grade 2, students should be able to:
- Recognize the names and functions of various instruments used in class.

By the end of grade 3, students should be able to:
- Follow conventional procedures for effective use of equipment and apparatus.

By the end of grade 4, students should be able to:
- Use appropriate instruments for making a particular measurement or doing a particular experiment.

By the end of grade 5, students should be able to:
- Adapt or modify standard science procedures or equipment as needed, keeping safety in mind at all times.

By the end of grade 8, students should be able to:
- Recognize the appropriateness, limitations, and safety concerns of certain laboratory equipment.
- Identify the names and function of various instruments and equipment used in the classroom.

By the end of grade 12, students should be able to:
- Describe the names and functions of various instruments and equipment used in the classroom.
- Identify reasons for extensive use of precision tools in scientific research.

- Locate and safely use equipment needed for adequate inquiry or problem solving.
- Identify specialized measurement tools, laboratory hardware and software, sense extensors, electronic devices, and other technology used by various scientific disciplines.

5c) CLASSIFYING

The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.

The Science Education Program should determine to what extent classification skills can be carried out. The school Science Education Program should promote the classification skills by providing as many developmental experiences as necessary.

By the end of kindergarten, students should be able to:
- Classify or sort objects or events by their properties.
- Use given or student-generated criteria to sort objects.

By the end of grade 1, students should be able to:
- Classify the same group of objects in several different ways.
- Use student-generated criteria to sort objects.

By the end of grade 2, students should be able to:
- Organize and analyze the classification of objects (living and non-living) in a matrix.

By the end of grade 3, students should be able to:
- Decide ways in which a group of objects are similar or different, and then identify another group of objects that are similar or different in the same way.

By the end of grade 4, students should be able to:
- Create and analyze the classification of objects (living and non-living) in a matrix.

By the end of grade 5, students should be able to:
- Classify one or more given subsystems within a corresponding system (i.e., circulatory, digestive, and respiratory systems are subsystems of the human body).

By the end of grade 8, students should be able to:
- Divide objects into groups according to a hierarchical system by listing and identifying how many objects would be in a total set, given the properties of the objects in subsets and how many objects would be in each subset.

- Identify the property which was used to divide a set of objects into groups, when objects vary in several values of several properties and again when objects are regrouped.
- Demonstrate the ability to reason in terms of the union and intersection of sets.

By the end of grade 12, students should be able to:
- Use conventional systems and terms for labeling or naming objects, materials, categories, etc.
- Locate and use print and non-print materials related to classification skills.
- Devise codes or systems for personal organization, storage and retrieval of information.
- Modify classification schemes as needed to accommodate new or complex information.

5d) MEASURING

Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child.

The school Science Education Program should promote the measuring skills by providing as many developmental experiences as necessary.

By the end of kindergarten, students should be able to:
- Compare properties of two objects or events.
- Order a group of objects from most to least or vice versa using a property of those objects or systems.

By the end of grade 1, students should be able to:
- Measure an object using nonstandard and standard measurements.

By the end of grade 2, students should be able to:
- Use the appropriate instrument for making a particular measurement.

By the end of grade 3, students should be able to:
- Measure length, capacity, and weight in U.S. customary and metric units.
- Select the appropriate units for making a particular measurement.
- Measure some property of an object using arbitrary units (e.g. volume can be measured by using milliliters or fluid ounces.)

By the end of grade 4, students should be able to:
- Select and apply appropriate U.S. customary and metric units/tools to measure to the degree of accuracy needed.
- Make a simple scale diagram.

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

- Select and correctly use the appropriate metric device to measure distance, mass, volume, temperature or other physical quantities
- Explain the limitations and/or degree of precision of common home and scientific laboratory devices.
- Estimate and calculate relative measurements of time, length, mass, volume, and temperature.

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

- Select a measurement that is more precise than another measurement.
- Identify the accuracy of derived values, given the accuracy of the measured variable.
- Differentiate between direct and indirect measurements (e.g. density is an indirect measurement.)
- Measure objects by making relative comparisons (e.g. ratio and proportions.)
- Apply their understanding of metric, non-standard and English units of measure to accurately collect data in a scientific investigation.
- Demonstrate an understanding of metric prefixes through numeral value and scientific notation.

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

- Use a variety of measurement instruments needed in inquiry.
- Select and use appropriate units and procedures for measuring properties and quantitatively documenting observations.
- Make logical estimates based on available measurement information.
- Distinguish between estimates and predictions where estimates are relatively rough approximations while predictions are based on accurate, systematic processing of valid data, mathematical projections, and other evidence.
- Distinguish between multi-component measures, such as vectors, and single component measures.
- Select and use appropriate scientific notations for accurately recording measurements.
- Demonstrate understanding of some relatively subject-specific standardized unit of measurements. Some examples include: time, energy, power, force, electrical potential, charge, temperature and bits.

5e) MODEL BUILDING

Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g. chart, diagram diorama, scale model, dramatization, etc.). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.

By the end of kindergarten, students should be able to:

- Explain an idea or observation in a picture or through a dramatization.

By the end of grade 1, students should be able to:

- Identify characteristics of models (a model represents an object or process and helps to explain how it functions.)
- Create simple models (e.g. dioramas).
- Create simple charts and graphics with appropriate labels.

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

- Create graphics and models to demonstrate their knowledge.

By the end of grade 3, students should be able to:

- Create graphics and/or models to explain their understanding of science concepts (i.e. structures and functions in organisms, sound vibrations).
- Use a model of a simple machine.

By the end of grade 4, students should be able to:

- Represent a scientific model pictorially.
- Create a simple model of a scientific concept, such as an electric circuit.

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

- Identify advantages of models and simulations.
- Use models and/or simulations to represent and investigate scientific concepts.
- Construct models or create simulations to explain scientific concepts.
- Create a simple scale drawing of an object or event.
- Identify two models, which could explain the same phenomenon.

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

- Support and explain scientific data using scale and mathematical models.
- Distinguish between a scientific model and the observation from which the model was derived.
- Test a given model or one's own model experimentally.
- Identify whether or not a given model is satisfactory, given the results of the tests.

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

- Decode scientific information represented in models.
- Distinguish between the various scientific uses of the term "model," based on the context in which it is used.
  - ~ Mental models being frames of reference or cognitive schemes: the sets of definitions, principles, and criteria by which we mentally organize information.
  - ~ Procedural models being sets of conventionalized principles, strategies, and instruments used for inquiry or problem solution.
  - ~ Constructed models being displays of graphics, objects or dynamic representations of ideas about reality.
  - ~ Theoretical models being interpretative schemes or constructs: sets of ideas based on assumptions, which explain observations by identifying factors and hypothesizing relationships.

- Alter or expand mental models to accommodate newly validated scientific information.
- Select and follow procedural models, which are appropriate purposes of inquiries.
- Distinguish between theoretical construct and the reality of observations the theory attempts to explain.
- Define relationships between scientific law and theory.
- Shape theory according to experiment.

6) USING SCIENTIFIC VOCABULARY

The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity.

The school Science Education Program should encourage students to use appropriate scientific vocabulary.

By the end of grades K, 1, 2, and 3, students should be able to:
- Use measurement terms and symbols accurately for their level (e.g. weather symbols, symbol for degrees, periodic table symbols).
- Recognize and use scientific terms appropriate for their grade level.

By the end of grades 5, 8, and 12, students should be able to:
- Recognize the need for standardization of scientific terms, symbols, and measurement units.
- Understand that definitions of scientific terms may be refined/enhanced.
- Use accurate scientific names for organisms and objects, appropriate for their grade level.
- Use scientific terms accurately (e.g. hypothesis and prediction).
- Use scientific terms specifically for the concept involved (e.g. *mass* instead of *weight* and *density* instead of *weight*).
- Locate and use resources for defining and clarifying scientific vocabulary.

7) COMMUNICATING

Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. This is done through activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.

The school Science Education Program should provide students with many opportunities to communicate ideas with others.

By the end of kindergarten, students should be able to:
- Ask questions about the world around them based on observations and using the appropriate senses.

By the end of grade 1, students should be able to:

- Explain the results of an investigation to an audience using simple data organizers (e.g. charts, graphs, pictures).

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

- Listen attentively to reports given by others.
- Ask questions to help clarify and/or expand on ideas.

By the end of grade 3, students should be able to:

- Communicate feelings and values orally and in writing.
- Communicate concepts and data through various formats (i.e. graphs, drawings, or displays.)
- Pose relevant questions that will lead to a hypothesis.

By the end of grade 4, students should be able to:

- Share ideas through discussions and/or reporting in large as well as small groups.
- Listen objectively to distinguish between fact and opinion, observation and inference.

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

- Participate effectively in group inquiries or problem solutions (e.g. contribute ideas and work cooperatively.)
- Communicate and defend conclusions based on evidence (through written or oral reports.)
- Ask questions to clarify their own perception of another person’s feelings or intentions.

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

- Use mathematical concepts and symbols in data analysis to support explanations and conclusions.
- Identify factors, which contribute to accuracy and relevance in communication between individuals.
- Communicate the significant components of the experimental design and results of a scientific investigation

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

- Communicate the components of a scientific investigation, using appropriate format, for the intended purpose.
- Defend and support conclusions, explanations, and arguments based on logic, scientific knowledge, and evidence from data.
- Engage in and explain the importance of peer review in science.
- Explain how scientific explanations must meet a set of established criteria to be considered valid.

8) USING SPACE-TIME RELATIONSHIPS

Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time.

The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.

By the end of kindergarten, students should be able to:
- Identify a two-dimensional object.
- Identify the shapes of various objects in their environment.
- Order a set of events in terms of the time order in which three events occurred.

By the end of grade 1, students should be able to:
- Identify a three-dimensional object.
- Distinguish between figures that have symmetry and those that do not.
- Use positional and directional words such as *left* or *right*, *above* or *below*, *in front of* or *behind* to describe or identify the position of an object relative to another object.
- Construct and use simple maps to represent space relationships.

By the end of grade 2, students should be able to:
- Identify the position of an object relative to several other objects at the same time.

By the end of grade 3, students should be able to:
- Tell whether an object in a series has moved up, down, forward, backward, or left, right.
- Describe the changes in the position of an object in reference to itself or another object.

By the end of grade 4, students should be able to:
- Demonstrate an understanding of points, lines, planes, spaces and angles.
- Describe how a scene would look when viewed from a position other than its present position.
- Identify from a picture drawn in perspective the object that is closer to or farther away from a given point.

By the end of grade 5, students should be able to:
- Read a distance scale on a map and give the distance from one point to another.
- Measure time in units appropriate for the activity—minutes, hour, day, year, season, etc.
- Compare relative speed of objects in motion.

By the end of grade 8, students should be able to:
- Draw a map of a scene to scale.
- Use cardinal (principal) directions when identifying the route between given locations on a map.

- Demonstrate an understanding of the coordinate system.
- Describe how a scene would look like if seen from a position other than one's own.
- Move an object or identify movement in a given angular or linear direction.

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

- Use angular measurements to identify position and to identify the difference between two positions.
- Describe relationships between time measurements and other spatial measurements.

9) PROCESS INTEGRATION

Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem.

The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.

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

- Engage in problem solving appropriate to their level.

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

- Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables.
- Identify the other processes of science and mathematics as applied in the investigation.
- Conduct and report in writing the results of the investigation.

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

- Identify a scientific problem to be investigated, propose or identify a testable hypothesis and devise an appropriate experimental design to collect data to answer the question.
- Identify the process of applying generalizations to the interpretation of information as deduction (deductive logic, deductive reasoning).

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

- Identify the process of generalization from interpretation of information as induction (inductive logic, inductive reasoning).
- Apply generalizations, which are appropriate to the content covered and to deductive inquiry.
- Describe ways in which generalizing relates to other inquiry processes like abstracting, summarizing, associating, and synthesizing

APPENDIX B: SCIENCE PROCESS SKILLS BY GRADE LEVEL

KINDERGARTEN

Skill	*Description of Process Skill*	*Grade Level Expectation*
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of kindergarten, students should be able to:** • Use senses to make observations about the world around them. • Identify objects and their properties (color, shape, texture, size, sound, quantity, etc.) using their five senses. • Identify likenesses and differences in a variety of objects. • Observe and describe changes in the properties of objects.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect or to answer a question. Inferring involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of kindergarten, students should be able to:** • Ask questions when they observe the world around them.
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	**By the end of kindergarten, students should be able to:** • Identify or make a guess about the cause of an event.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/ experimental	**By the end of kindergarten, the student should be able to:** • Make observations about variables that affect a result (e.g., sun = hot).

Skill	*Description of Process Skill*	*Grade Level Expectation*
	experiences in order to help develop skills in identifying and controlling variables.	
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.	**By the end of kindergarten, the student should be able to:** • Make observations about variables that affect a result (e.g., sun = hot).
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.	**By the end of kindergarten, students should be able to:** • Collect data using the 5 senses.
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	**By the end of kindergarten, students should be able to:** • Sort living and non-living things according to stated attributes
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.	**By the end of kindergarten, students should be able to:** • Maintain a safe and healthy classroom environment at all times

Skill	*Description of Process Skill*	*Grade Level Expectation*
	The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into groups or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The school Science Education Program should promote the classification skills by providing as many developmental experiences as necessary.	**By the end of kindergarten, students should be able to:** • Classify or sort objects or events by their properties. • Use given or student-generated criteria to sort objects.
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of kindergarten, students should be able to:** • Compare properties of two objects or events. • Order a group of objects from most to least or vice versa using a property of those objects or systems.
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization, etc.). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	**By the end of kindergarten, students should be able to:** • Explain an idea or observation in a picture or through a dramatization.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with	**By the end of kindergarten, students should be able to:** • Use measurement terms and symbols accurately for their level

Skill	*Description of Process Skill*	*Grade Level Expectation*
	efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	(e.g., weather symbols, symbol for degrees, periodic table symbols). • Recognize and use scientific terms appropriate for their grade level.
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	**By the end of kindergarten, students should be able to:** • Ask questions about the world around them based on observations and using the appropriate senses.
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time. The school Science Education Program should build an understanding of these concepts by providing students the necessary developmental learning experiences.	**By the end of kindergarten, students should be able to:** • Identify a two-dimensional object. • Identify the shapes of various objects in their environment. • Order a set of events in terms of the time order in which three events occurred.
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e. knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	**By the end of kindergarten, students should be able to:** • Engage in problem solving appropriate to their level.

GRADE 1

Skill	***Description of Process Skill***	***Grade Level Expectation***
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of grade 1, students should be able to:** • Use appropriate language when describing an object or making an observation (e.g., Is the object larger in length, width, and weight?) • State objects in quantitative terms whenever possible. • State objects in qualitative terms whenever possible.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of grade 1, students should be able to:** • Collect data to answer their questions.
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	**By the end of grade 1, students should be able to:** • Make guesses and give reasons or data to support their guess.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.	**By the end of grade 1, the student should be able to:** • Identify things or events that can change an outcome.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.	**By the end of grade 1, students should be able to:** • Collect, record, and organize data using simple tools, equipment, techniques. • Explain results using simple data organizers.
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	**By the end of grade 1, students should be able to:** • Construct and interpret simple graphs.
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery involves effective and efficient use. The school Science Education Program should provide our students with many hands-on experiences in the use of science equipment and apparatus.	**By the end of grade 1, students should be able to:** • Properly retrieve, store, and maintain science equipment and supplies.
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into groups or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The school	**By the end of grade 1, students should be able to:** • Classify the same group of objects in several different ways. • Use student-generated criteria to sort objects.

Skill	*Description of Process Skill*	*Grade Level Expectation*
	Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of grade 1, students should be able to:** • Measure an object using nonstandard and standard measurements.
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g. chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	**By the end of grade 1, students should be able to:** • Identify characteristics of models (a model represents an object or process and helps to explain how it functions.) • Create simple models (e.g., dioramas). • Create simple charts and graphics with appropriate labels.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	**By the end of grade 1, students should be able to:** • Use measurement terms and symbols accurately for their level (e.g., weather symbols, symbol for degrees, periodic table symbols). • Recognize and use scientific terms appropriate for their grade level.
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	**By the end of grade 1, students should be able to:** • Explain the results of an investigation to an audience using simple data organizers (e.g. charts, graphs, pictures).

Skill	*Description of Process Skill*	*Grade Level Expectation*
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time. The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.	**By the end of grade 1, students should be able to:** • a three-dimensional object. • Distinguish between figures that have symmetry and those that do not. • Use positional and directional words such as left or right, above or below, in front of or behind to describe or identify the position of an object relative to another object. • Construct and use simple maps to represent space relationships.
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	**By the end of grade 1, students should be able to:** • Engage in problem solving appropriate to their level.

GRADE 2

Skill	*Description of Process Skill*	*Grade Level Expectation*
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of grade 2, students should be able to:** • Identify the difference between statements of observation and opinion.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of grade 2, students should be able to:** • Make a prediction based on observation.
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	**By the end of grade 2, students should be able to:** • Conduct a simple investigation to test a prediction.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.	**By the end of grade 2, the student should be able to:** • Replicate a simple investigation by changing one part of the procedure (variable) at a time to get a different outcome.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.	**By the end of grade 2, students should be able to:** • Communicate results of observations and simple investigations.
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	**By the end of grade 2, students should be able to:** • Construct and accurately label data organizers to show data collected in a simple investigation.
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use. The school Science Education Program should provide our students with many hands-on experiences in the use of science equipment and apparatus.	**By the end of grade 2, students should be able to:** • Recognize the names and functions of various instruments used in class.
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The school	**By the end of grade 2, students should be able to:** • Organize and analyze the classification of objects (living and non-living) in a matrix.

Skill	*Description of Process Skill*	*Grade Level Expectation*
	Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of grade 2, students should be able to:** • Use the appropriate instrument for making a particular measurement.
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	**By the end of grade 2, students should be able to:** • Create graphics and models to demonstrate their knowledge.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	**By the end of grade 2, students should be able to:** • Use measurement terms and symbols accurately for their level (e.g., weather symbols, symbol for degrees, periodic table symbols). • Recognize and use scientific terms appropriate for their grade level.
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	**By the end of grade 2, students should be able to:** • Listen attentively to reports given by others. • Ask questions to help clarify and/or expand on ideas.

Skill	***Description of Process Skill***	***Grade Level Expectation***
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling, and time. The school Science Education Program should build understanding of these concepts by providing students with the necessary developmental learning experiences.	**By the end of grade 2, students should be able to:** • Identify the position of an object relative to several other objects at the same time.
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	**By the end of grade 2, students should be able to:** • Engage in problem solving appropriate to their level.

GRADE 3

Skill	***Description of Process Skill***	***Grade Level Expectation***
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of grade 3, students should be able to:** • Use the appropriate senses to collect data to answer a question.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of grade 3, students should be able to:** • Pose relevant questions based on observations. • Collect and analyze data to answer the question(s).
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	**By the end of grade 3, students should be able to:** • Develop a hypothesis that relates to an observation.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.	**By the end of grade 3, the student should be able to:** • Collect and analyze data to answer a question. • Identify variables that could affect an outcome.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.	**By the end of grade 3, students should be able to:** • Make graphic organizers to analyze systems and/or the results of investigations. • Identify data to be collected to answer questions about the investigation.
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	**By the end of grade 3, students should be able to:** • Identify different graphs and use them to organize data. • Interpret and answer questions about data represented in graphs.
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use. The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	**By the end of grade 3, students should be able to:** • Follow conventional procedures for effective use of equipment and apparatus.
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into groups or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The school	**By the end of grade 3, students should be able to:** • Decide ways in which a group of objects are similar or different, and then identify another group of objects that are similar or different in the same way.

Skill	*Description of Process Skill*	*Grade Level Expectation*
	Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of grade 3, students should be able to:** • Measure length, capacity, and weight in U.S. customary and metric units. • Select the appropriate units for making a particular measurement. • Measure some property of an object using arbitrary units (e.g., volume can be measured by using milliliters or fluid ounces.)
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	**By the end of grade 3, students should be able to:** • Create graphics and/or models to explain their understanding of science concepts (e.g., structures and functions in organisms, sound vibrations). • Use a model of a simple machine.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	**By the end of grade 3, students should be able to:** • Use measurement terms and symbols accurately for their level (e.g., weather symbols, symbol for degrees, periodic table symbols). • Recognize and use scientific terms appropriate for their grade level.
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	**By the end of grade 3, students should be able to:** • Communicate feelings and values orally and in writing. • Communicate concepts and data through various formats (i.e., graphs, drawings, or displays). • Pose relevant questions that will lead to a hypothesis.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling, and time. The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.	**By the end of grade 3, students should be able to:** • Tell whether an object in a series has moved up, down, forward, backward, or left, right. • Describe the changes in the position of an object in reference to itself or another object.
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	**In grade 3, students should be developing skills to:** • Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables. • Identify the other processes of science and mathematics as applied in the investigation. • Conduct and report in writing the results of the investigation.

GRADE 4

Skill	*Description of Process Skill*	*Grade Level Expectation*
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of grade 4, students should be able to:** • Distinguish between an observation and an inference.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of grade 4, students should be able to:** • Distinguish between an observation and an inference.
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	**By the end of grade 4, students should be able to:** • Distinguish between statements that are testable hypotheses and those that are not.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.	**By the end of grade 4, the student should be able to:** • Identify variables in an experimental procedure. • Identify the variables that must stay the same if the experiment is repeated.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.	**By the end of grade 4, students should be able to:** • Identify data to be collected in an experimental procedure and communicate it in written or verbal form. • Analyze data from a table or chart to make inferences or draw conclusions.
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill	**By the end of grade 4, students should be able to:** • Describe relationships of components illustrated in various graphs.
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use. The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	**By the end of grade 4, students should be able to:** • Use appropriate instruments for making a particular measurement or doing a particular experiment.
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The	**By the end of grade 4, students should be able to:** • Create and analyze the classification of objects (living and non-living) in a matrix.

Skill	*Description of Process Skill*	*Grade Level Expectation*
	school Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of grade 4, students should be able to:** • Select and apply appropriate U.S. customary and metric units/tools to measure to the degree of accuracy needed. • Make a simple scale diagram.
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	**By the end of grade 4, students should be able to:** • Represent a scientific model pictorially. • Create a simple model of a scientific concept, such as an electric circuit.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	**By the end of grade 4, students should be able to:** • Recognize the need for standardization of scientific terms, symbols, and measurement units. • Understand that definitions of scientific terms may be refined/enhanced. • Use accurate scientific names for organisms and objects, appropriate for their grade level. • Use scientific terms accurately (e.g., *hypothesis* and *prediction*). • Use scientific terms specifically for the concept involved (e.g. *mass* instead of *weight* and *density* instead of *weight*). • Locate and use resources for defining and clarifying scientific vocabulary • .

Skill	*Description of Process Skill*	*Grade Level Expectation*
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	**By the end of grade 4, students should be able to:** • Share ideas through discussions and/or reporting in large as well as small groups. • Listen objectively to distinguish between fact and opinion, observation and inference.
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time. The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.	**By the end of grade 4, students should be able to:** • Demonstrate an understanding of points, lines, planes, spaces and angles. • Describe how a scene would look when viewed from a position other than its present position. • Identify from a picture drawn in perspective the object that is closer to or farther away from a given point.
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	**In grade 4 students should be developing skills to:** • Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables. • Identify the other processes of science and mathematics as applied in the investigation. • Conduct and report in writing the results of the investigation.

GRADE 5

Skill	*Description of Process Skill*	*Grade Level Expectation*
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of grade 5, students should be able to:** • Use observations to collect data in a scientific investigation.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of grade 5, students should be able to:** • Construct one or more inferences from observations. • Identify observations which support an inference.
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened	**By the end of grade 5, students should be able to:** • Construct a hypothesis from a set of observations and inferences. • Devise and conduct a test or tests for the formulated hypothesis. • Choose an appropriate type of apparatus to be used to test a given hypothesis.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with investigative/experimental experiences to develop skills in identifying and controlling variables	**By the end of grade 5, the student should be able to:** • Name variables that have affected or may affect the outcome of an investigation. • Identify and name which variable should be controlled and manipulated in an investigation.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.	**By the end of grade 5, students should be able to:** • Sequence observed changes in materials and systems both verbally and in writing. • Organize collected data in tables, graphs, histograms, and/or matrices, to display and/or infer trends. • Research and use accurate and technical information. • Use data collected to formulate and defend conclusions.
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	**By the end of grade 5, students should be able to:** • Select appropriate graph(s) to depict the data collected. • Construct, label, and interpret simple line graphs, bar graphs, and circle graphs.
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use. The School Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	**By the end of grade 5, students should be able to:** • Adapt or modify standard science procedures or equipment as needed, keeping safety in mind at all times.
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The	**By the end of grade 5, students should be able to:** • Classify one or more given subsystems within a corresponding system (i.e., circulatory, digestive, and respiratory systems are subsystems of the human body).

Skill	*Description of Process Skill*	*Grade Level Expectation*
	school Science Education Program should promote classification skills by providing as many developmental experiences as necessary	
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of grade 5, students should be able to:**. • Select and correctly use the appropriate metric device to measure distance, mass, volume, temperature or other physical quantities. • Explain the limitations and/or degree of precision of common home and scientific laboratory devices. • Estimate and calculate relative measurements of time, length, mass, volume, and temperature.
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	**By the end of grade 5, students should be able to:** • Identify advantages of models and simulations. • Use models and/or simulations to represent and investigate scientific concepts. • Construct models or create simulations to explain scientific concepts. • Create a simple scale drawing of an object or event. • Identify two models, which could explain the same phenomenon.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately and with efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	**By the end of grade 5, students should be able to:** • Recognize the need for standardization of scientific terms, symbols, and measurement units. • Understand that definitions of scientific terms may be refined/enhanced. • Use accurate scientific names for organisms and objects, appropriate for their grade level. • Use scientific terms accurately (e.g., *hypothesis* and *prediction*). • Use scientific terms specifically for the concept involved (e.g., *mass* instead of *weight* and *density* instead of *weight*). • Locate and use resources for defining and clarifying scientific vocabulary.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	**By the end of grade 5, students should be able to:** • Participate effectively in group inquiries or problem solutions (e.g. contribute ideas and work cooperatively). • Communicate and defend conclusions based on evidence (through written or oral reports). • Ask questions to clarify their own perception of another person's feelings or intentions.
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time. The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.	**By the end of grade 5, students should be able to:** • Read a distance scale on a map, and give the distance from one point to another. • Measure time in units appropriate for the activity—minutes, hour, day, year, season, etc. • Compare relative speed of objects in motion.
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	**By the end of grade 5, students should be able to:** • Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables. • Identify the other processes of science and mathematics as applied in the investigation. • Conduct and report in writing the results of the investigation.

MIDDLE SCHOOL (GRADES 6, 7, 8)

Skill	*Description of Process Skill*	*Grade Level Expectation*
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of grade 8, students should be able to:** • Describe objects qualitatively and quantitatively. • Distinguish between relevant and irrelevant information in the description of an observation. • Identify the unknown by comparing it to properties and/or characteristics of what is known. • Use clear and accurate observations to explain science concepts.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of grade 8, students should be able to:** • Recognize when inferences need to be revised based on additional and more recent observations. • Formulate a prediction based on a given set of observations. • Conduct a test for predictions that have been made. • Interpolate and extrapolate information from data.
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	**By the end of grade 8, students should be able to**: • Identify the degree of precision of measurement necessary for testing a simple hypothesis. • Suggest or identify a test, which would support one hypothesis and weaken a competing hypothesis. • Check that a hypothesis matches the existing information.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/experimental	**By the end of grade 8, students should be able to:** • Identify and name the manipulated and responding (independent and dependent) variables in an investigation.

Skill	*Description of Process Skill*	*Grade Level Expectation*
	experiences in order to help develop skills in identifying and controlling variables.	
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.	**By the end of grade 8, students should be able to:** • Make a written report of an investigation, including: Background Information, Problem, Hypothesis, Materials and Methods, Results, Analysis, and Conclusion. • Identify and use the appropriate tools, equipment, and techniques to collect, display, and analyze data. • Represent and communicate data in multiple formats (verbal, written).
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill	**By the end of grade 8, students should be able to:** • Plot a set of points on a graph for a given set of data. • Construct a line graph, including the construction and labeling of axes, marking off units, plotting points, and drawing the line (or curve of best fit) for the graph. • Locate a specific piece of information on a line graph and/or bar graph. • Make inferences and logical conclusions for a given graph. • Make a prediction from a given line graph which shows a linear relationship between two variables.
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use. The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	**By the end of grade 8, students should be able to:** • Recognize the appropriateness, limitations, and safety concerns of certain laboratory equipment. • Identify the names and function of various instruments and equipment used in the classroom.
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The	**By the end of grade 8, students should be able to**: • Divide objects into groups according to a hierarchical system by listing and identifying how many objects would be in a total set, given the properties of the objects in subsets and how many

Skill	Description of Process Skill	Grade Level Expectation
	experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The school Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	objects would be in each subset. • Identify the property which was used to divide a set of objects into groups, when objects vary in several values or several properties and again when objects are regrouped. • Demonstrate the ability to reason in terms of the union and intersection of sets.
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of grade 8, students should be able to:** • Select a measurement that is more precise than another measurement. • Identify the accuracy of derived values, given the accuracy of the measured variable. • Differentiate between direct and indirect measurements (e.g. density is an indirect measurement). • Measure objects by making relative comparisons (e.g., ratio and proportion). • Apply their understanding of metric, non-standard and English units of measure to accurately collect data in a scientific investigation. • Demonstrate an understanding of metric prefixes through numeral value and scientific notation.
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g. chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle	**By the end of grade 8, students should be able to:** • Support and explain scientific data using scale and mathematical models. • Distinguish between a scientific model and the observation from which the model was derived. • Test a given model or one's own model experimentally. • Identify whether or not a given model is satisfactory, given the results of the tests.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	**By the end of grade 8, students should be able to:** • Recognize the need for standardization of scientific terms, symbols, and measurement units. • Understand that definitions of scientific terms may be refined/enhanced.

Skill	***Description of Process Skill***	***Grade Level Expectation***
		• Use accurate scientific names for organisms and objects, appropriate for their grade level. • Use scientific terms accurately (e.g., *hypothesis* and *prediction*). • Use scientific terms specifically for the concept involved (e.g., *mass* instead of *weight* and *density* instead of *weight*). • Locate and use resources for defining and clarifying scientific vocabulary.
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	**By the end of grade 8, students should be able to:** • Use mathematical concepts and symbols in data analysis to support explanations and conclusions. • Identify factors which contribute to accuracy and relevance in communication between individuals. • Communicate the significant components of the experimental design and results of a scientific investigation.
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time. The school Science Education Program should build understanding of these concepts by providing students the necessary developmental learning experiences.	**By the end of grade 8, students should be able to:** • Draw a map of a scene to scale. • Use cardinal (principal) directions when identifying the route between given locations on a map. • Demonstrate an understanding of the coordinate system. • Describe how a scene would look like if seen from a position other than one's own. • Move an object or identify movement in a given angular or linear direction
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving	**By the end of grade 8, students should be able to:** • Identify a scientific problem to be investigated, propose or identify a testable hypothesis, and devise an appropriate experimental design to collect data to answer the question. • Identify the process of applying generalizations to the interpretation of information as deduction (deductive logic, deductive reasoning).

Skill	***Description of Process Skill***	***Grade Level Expectation***
	experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	

HIGH SCHOOL (GRADES 9-12)

Skill	*Description of Process Skill*	*Grade Level Expectation*
Observing	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	**By the end of grade 12, students should be able to:** • Use emerging technology to enhance the depth and precision of observations. • Increase the accuracy and processing rate of observations in the collection of data. • Select and use sense enhancers appropriate to the information desired and subject being observed. • Describe how observations may be affected by human physiology, emotions, perspective, or frame of reference.
Questioning, Inferring, and Predicting	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations. Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	**By the end of grade 12, students should be able to:** • Construct or identify a test for a given inference. • Categorize statements as logical inferences, facts, or opinions. • Make an if-then statement of two inferences between two related events. • Determine and conduct additional observations and/or data collection required to test an inference. • Show relationship between/distinguish between direct evidence and indirect evidence leading to an inference of an event or interaction.
Making, Selecting, and Testing Hypotheses	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	**By the end of grade 12, students should be able to:** • Distinguish between a statement of opinion or belief and a hypothesis. • Construct several experimental designs to test a given hypothesis and select the most appropriate procedure. • Identify and analyze an "inappropriate" procedure for testing a hypothesis. • Describe or identify a test for a revised hypothesis knowing the original incorrect hypothesis and data.
Identifying and Controlling Variables	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the	**By the end of grade 12, the student should be able to:** • Construct a test for a hypothesis, inference or problem in which variables are identified. • State the relationship between the responding (dependent)

Skill	*Description of Process Skill*	*Grade Level Expectation*
	investigation and the ability to design ways of controlling them. The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.	variable and the manipulated (independent) variable in an investigation.
Collecting, Recording, Organizing, and Interpreting Data	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table. The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.	**By the end of grade 12, students should be able to:** • Reorganize graphical representation of data to improve analysis. • Extrapolate and interpolate to arrive at information not specifically presented in data. • Identify significant pieces of data and determine connection between hypothesis and conclusion. • Form, defend, and support logical conclusions based only on the data collected. • Identify relationships between two variables in a given table.
Graphing	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph. The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	**By the end of grade 12, students should be able to:** • All expectations for graphing should be met by grade 8.
Using Equipment and Apparatus	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use. The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	**By the end of grade 12, students should be able to:** • Describe the names and functions of various instruments and equipment used in the classroom. • Identify reasons for extensive use of precision tools in scientific research. • Locate and safely use equipment needed for adequate inquiry or problem solving. • Identify specialized measurement tools, laboratory hardware and software, sense extensors, electronic devices and other technology, used by various scientific disciplines.

Skill	*Description of Process Skill*	*Grade Level Expectation*
Classifying	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out. The Science Education Program should determine to what extent classification skills can be carried out. The school Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	**By the end of grade 12, students should be able to:** • Use conventional systems and terms for labeling or naming objects, materials, categories, etc. • Locate and use print and non-print materials related to classification skills. • Devise codes or systems for personal organization, storage, and retrieval of information.
Measuring	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	**By the end of grade 12, students should be able to:** • Use a variety of measurement instruments needed in inquiry. • Select and use appropriate units and procedures for measuring properties and quantitatively documenting observations. • Make logical estimates based on available measurement information. • Distinguish between estimates and predictions where estimates are relatively rough approximations while predictions are based on accurate, systematic processing of valid data, mathematical projections and other evidence. • Distinguish between multi-component measures, such as vectors, and single component measures. • Select and use appropriate scientific notations for accurately recording measurements. • Demonstrate understanding of some relatively subject-specific standardized unit of measurements. Some examples include time, energy, power, force, electrical potential, charge, temperature and bits.
Model Building	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be	**By the end of grade 12, students should be able to:** • Decode scientific information represented in models. • Distinguish between the various scientific uses of the term "model" based on the context in which it is used.

Skill	*Description of Process Skill*	*Grade Level Expectation*
	pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	a. Mental models being frames of reference or cognitive schemes: the sets of definitions, principles, and criteria by which we mentally organize information. b. Procedural models being sets of conventionalized principles, strategies and instruments used for inquiry or problem solution. c. Constructed models being displays of graphics, objects or dynamic representations of ideas about reality. d. Theoretical models being interpretative schemes or constructs: sets of ideas based on assumptions, which explain observations by identifying factors and hypothesizing relationships. • Alter or expand mental models to accommodate newly validated scientific information. • Select and follow procedural models, which are appropriate purposes of inquiries. • Distinguish between theoretical construct and the reality of observations the theory attempts to explain. • Define relationships between scientific law and theory. • Shape theory according to experiment.
Using Scientific Vocabulary	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity. The school Science Education Program should encourage students to use appropriate scientific vocabulary.	**By the end of grade 12, students should be able to:** • Recognize the need for standardization of scientific terms, symbols, and measurement units. • Understand that definitions of scientific terms may be refined/ enhanced. • Use accurate scientific names for organisms and objects, appropriate for their grade level. • Use scientific terms accurately (e.g., *hypothesis* and *prediction*). • Use scientific terms specifically for the concept involved (e.g., *mass* instead of *weight* and *density* instead of *weight*). • Locate and use resources for defining and clarifying scientific vocabulary
Communicating	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking	**By the end of grade 12, students should be able to:** • Communicate the components of a scientific investigation, using appropriate format for the intended purpose.

Skill	***Description of Process Skill***	***Grade Level Expectation***
	questions, sharing, writing, graphing, discussing, and reporting. The school Science Education Program should provide students with many opportunities to communicate ideas with others.	• Defend and support conclusions, explanations, and arguments based on logic, scientific knowledge, and evidence from data. • Engage in and explain the importance of peer review in science. • Explain how scientific explanations must meet a set of established criteria to be considered valid.
Using Space-Time Relationships	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling, and time. The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.	**By the end of grade 12, students should be able to:** • Use angular measurements to identify position and to identify the difference between two positions. • Describe relationships between time measurements and other spatial measurements.
Process Integration	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem. The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	**By the end of grade 12, students should be able to:** • Identify the process of generalization from interpretations of information as induction (inductive logic, inductive reasoning). • Apply generalizations, which are appropriate to the content covered and to deductive inquiry. • Describe ways in which generalizing relates to other inquiry processes like abstracting, summarizing, associating, and synthesizing.

APPENDIX C:
EXAMPLES OF THE HCPS III IMPLEMENTATION PROCESS MODEL

The purpose of Appendix C is to clarify, elaborate, and gives examples of using the HCPS III Implementation Process Model as a means of planning and implementing standards and benchmarks in Science.

The following are included in this section:

- The HCPS III Implementation Process Model Flow Chart.
- The steps of the process model presented as a flow chart.
- The focus and guiding questions for each step.
- A sample unit in which the grade 5 benchmark map benchmarks are "chunked." In this unit, the Critical Thinking Clarity Strategy called SEE (**S**tate the step; **E**laborate, or give details and restate the step in other words; and **E**xample, or give examples of what each step would look like) is used.
- Unit examples for Grade 2, 4, 7, and Biology. Each unit illustrates the steps of process model for each grade level, using one life science standard (Standard 4). Each unit is built upon the grade's benchmark map with the benchmarks "chunked" in the sample unit.

USING THE HCPS III IMPLEMENTATION PROCESS

Standards-Based Unit, Lesson Planning Flow Chart

1. Identify relevant standards and benchmarks

- Which benchmarks are the central focus of the lesson/unit?
- What are the Essential Questions, "Big Ideas," Major Understandings, Universal Concepts, Content, Skills, and GLOs relevant to the benchmarks?

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2. Determine desired outcomes/evidence

- What evidence will show the student has met the standard (how will students be assessed)?

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3. Determine learning experiences

- What do students already know and what can they do (prior knowledge) in relation to the standards/benchmarks and desired outcomes, and what misconceptions do they have? (e.g., KWLH (What I know, What I Want to know, What I learned, How I learned) chart,
- What interventions/strategies/best practices will build the necessary understandings to help students meet proficiency, and what accommodation/differentiation is needed?

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4. Teach and collect evidence (formative assessments) of student learning

- What are "I can…" statements for benchmarks with students?
- What are criteria for desired outcomes with students (e.g., T-charts and rubrics)?
- What can we show and discuss as exemplars of varying degrees of proficiency with students?
- What are the learning activities/lessons/unit plans for these benchmarks?

5. Assess student work to inform instruction (formative assessments) and use data to provide feedback

- How can students conduct self- and peer-assessments of learning products using student generated criteria/rubrics?
- What does the evidence indicate about the students' progress?
- What further instruction, re-teaching, or support is needed?

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6. Evaluate student work (summative assessments); make judgments about learning results and communicate findings

- What do the assessments indicate about the student's level of proficiency?

Grade: 5	Quarter: 2

Big Idea(s)/Major Understanding(s): *Students will understand that…*

- An ecosystem is all the living (producers, consumers, and decomposers) and nonliving (soil, air, water, and sunlight) things that interact with each other in an environment.
- Matter (food, water and air) is changed and recycled in the ecosystem.
- Energy usually enters an ecosystem from the sun, flows through producers (plants) in the form of water and carbon dioxide, and then is turned into glucose, a food (stored energy) for the plant.
- All organisms need energy to live. They are categorized on the basis of how they get this energy. In most ecosystems, producers form the base of the food chain with the sun's energy flowing through consumers and decomposers, which end the food chain as it breaks down the organisms.
- The human body is made of trillions of cells. Cells group to form tissues, tissues build organs, and organs work together to comprise a body system.
- Organs make up the skeletal, muscular, nervous, digestive, respiratory, circulatory and excretory systems that work together to sustain a human's life.
- All organ systems in a human body work together to keep it healthy and alive.
- Offspring inherit some of their physical traits from their parents while behavioral traits are learned.

HCPS III Benchmarks:

- SC.5.3.1: Describe the flow of energy among producers, consumers, and decomposers
- SC.5.3.2: Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter
- SC.5.4.1: Describe the structures of the human body and how they work together to sustain life
- SC.5.5.1: Recognize that some traits of living things are inherited and others are learned

- ❖ *SC.5.1.1: Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments*
- ❖ *SC.5.1.2: Formulate and defend conclusions based on evidence*
- ❖ *SC.5.2.1: Use models and/or simulations to represent and investigate feature of objects, events, and processes in the real world*

❖ *Italicized benchmarks are taught and assessed in more than one quarter.*

1. Identify Relevant Standards/Benchmarks
In other words, teachers collaborate and collectively: • Select the standards and benchmarks students need to focus on. • Identify the big ideas, major understandings, and essential questions that will drive the lessons, unit of study, and/or project (for examples, see science benchmark maps). • Determine what content and skills students should know and be able to do to facilitate student proficiency in the identified standard and benchmarks.
For example, when designing a fifth grade ecology unit, • Cluster (ecology) SC 5.3.2 and SC 5.3.1; (inquiry) SC 5.1.1, 5.1.2, and 5.2.1. • The major understandings are: 1. Living and non-living things interact with each other in an ecosystem. 2. Matter is changed and recycled in the ecosystem. 3. Energy usually enters an ecosystem from the sun, which is used by producers to change water and carbon dioxide into glucose. 4. All organisms need energy to live. • The essential questions are: 1. How are producers, consumers, and decomposers interrelated? 2. How do organisms get the energy they need? • The content students should know are: 3. An ecosystem is the relationship between organisms and their environment. 4. Definitions of producers, consumers, and decomposers. 5. Food chain and food webs. 6. Flow of energy 7. Cycle of matter (oxygen, carbon dioxide, water) 8. Photosynthesis • The skills students will be able to do are: 1. Create a diagram of a food chain in an ecosystem tracing the path of energy. Start with the sun as the source of energy for the producers. 2. Create a model/diagram of a food web within an ecosystem showing multiple pathways of relationships of producers, consumers, and decomposers. 3. Design an inquiry-based, controlled experiment of an ecosystem where there is a difference of only one variable. For example, set up two aquariums with equal amounts of fish where one has aquatic plants and the second one does not to determine what effect the plants have on an aquatic ecosystem.
2. Determine Desired Outcomes/Evidence
In other words, **teachers collaborate and collectively –** • Decide what desired outcomes and a variety of evidence, products or performances will show that the student has met/achieved the benchmark. (i.e., a final culminating assessment vs. smaller chunked assessments) • Establish criteria relevant to the expectations of the benchmark.
For example, in the fifth grade ecology unit, • Students will create a flow chart that shows the flow of energy from the sun, to the producers, to the consumers, to the decomposers, etc. • Students will demonstrate knowledge of content through methods like vocabulary tests, extended responses, oral presentations, models, observations, conversations, etc. • Students will create a food web poster showing multiple pathways of relationships

between producers, consumers, decomposers, and the environment.

- Students will design and carry out a scientific investigation detailing all steps of the inquiry process in a project proposal, laboratory report, and/or project presentation and discussion.

3. Determine Learning Experiences

In other words, teachers collaborate and collectively –

- Determine baseline data on what students already know about the content and their performance level, use baseline data to determine where to start and how to scaffold their learning.
- Incorporate appropriate strategies/best practices, skills, or tools into the unit that are relevant to the targets and help all students meet the standards and benchmarks. This includes differentiated, varied approaches that take into account students' baseline data.

For example, in the fifth grade ecology unit,

- Use KWLH (What I know, What I Want to know, What I learned, How I learned), journal entry, activity/task, observations, pre-test, etc. to determine what students know about:
    1. The cycle of matter and the flow of energy in an ecosystem.
    2. Food webs/chains.
    3. The science investigation process.
    4. Process skills related to this unit (see "Process Skills").
- Plan an instructional unit to include: Direct instruction, hands-on experiences, cooperative/collaborative activities, integrated/interdisciplinary activities, real life application, inquiry-based activities, field experiences, excursions, science fair, model building, inventions, competitions, service learning, etc.

4. Teach and Collect Evidence (Formative Assessments) of Student's Learning
5. Assess Student Work to Inform Instruction and Use Data to Provide Feedback

In other words, teachers collaborate and collectively –

- Work with students to understand the benchmarks and create "I can" statements. These statements should be clearly worded so that students and parents will understand what they should know and be able to do. Use the descriptions to guide instruction, assessment, and evaluation.
- Work with students to determine criteria (t-charts, rubrics, checklist, etc.) for the appropriate desired outcomes.
- Design and implement lessons, i.e., use Anne Davies' Four step process:
    1. Brainstorm criteria.
    2. Sort and categorize criteria.
    3. Make and post a T-chart of criteria and details.
    4. Add, revise, refine.
- Work with students in using the criteria to examine anchor pieces/exemplars (if available) and discuss/comment on the varying proficiency levels.
- Use formative assessments/evidence from learning experiences and decides where additional instruction or support is needed.
- Select and use various types of Formative Assessment:
    1. Observations: lab protocol, lab techniques, safety practices, presentations, peer conferences, group interactions (cooperative and collaborative).
    2. Products: peer and self assessment using criteria/rubrics, journals/reflections,

worksheets.
- Feedback through conversations about learning: peer conferences, teacher-student conferences, self-reflection, justifying peer evaluation.

For example, in the fifth grade ecology unit,
- Deconstruct the benchmark with students into “I can” statements (i.e., “I can explain how a living thing depends on several non-living things.”).
- Explore the main concepts of ecology with students through suggested learning experiences:
  1. vocabulary (direct instruction)
  2. diagrams and/or flow charts (model building)
  3. articles and/or textbook (research/critical thinking)
  4. worksheets (guided practice)
  5. journals/learning logs/reflection logs
  6. inquiry-based activities (cooperative/collaborative)
- Use Anne Davis’ Four step process to determine criteria for the flow chart, food web poster, and the inquiry-based scientific investigation.
- Show and discuss anchor/exemplar pieces. Students should be able to determine whether the pieces are novice, partially proficient, proficient, or advanced.
- Using the rubrics, students self-assess or peer-assess their flow charts, food webs, scientific investigation.
- Students reflect (written, oral conversation) on their progress, needs, and/or questions to the teacher.
- Teacher continues or revises instruction based on student feedback and formative assessments.

6. Evaluate Student Work (Summative Assessments), Make Judgment on Learning Results and Communicate Findings

In other words, teachers collaborate and collectively –
- Determine the proficiency level of the student products.
- Determine if students are novice, partially proficient, proficient, or advanced with regards to benchmarks.
- Collect and use various examples of Summative Assessments: tests, projects, models, lab reports, oral and written presentations
- Use a variety of methods to communicate student achievement of benchmarks to stakeholders

For example, in the fifth grade ecology unit,
- Using the rubrics, classroom observations, and conversations with students, teacher evaluates final student vocabulary test, flow charts, food web posters, scientific investigation lab report and presentations.
- Teacher determines whether or not each student exceeded, met, approached or was well below proficiency in relation to each of the benchmarks. An appropriate level of proficiency is assigned.
- Student led conferences, “bin” or discussion portfolios, and/or report card can be used to communicate student achievement of benchmarks.

Grade: 2	Quarter: 1

Big Idea(s)/Major Understanding(s): *Students will understand that…*

- Organisms go through different stages in their lives: they are born, they grow, they develop into adults, and they reproduce.
- Different kinds of animals have different kinds of life cycles.
- Technologies such as computers, magnifiers, digital equipment, microscopes have enhanced our understanding of organisms.

HCPS III Benchmarks:

- SC.2.4.1: Explain how plants and animals go through life cycles

❖ *SC.2.1.1: Develop predictions based on observations*
❖ *SC.2.1.2: Conduct a simple investigation using a systematic process safely to test a prediction*
❖ *SC.2.2.1: Describe changes that have occurred in society as a result of new technologies*

❖ *Italicized benchmarks are taught and assessed in more than one quarter.*

Topic: Plants vs. Animals
Grade 2

1. Identify Relevant Standards/Benchmarks
Standard 4: Life and Environmental Sciences: Structure and Function in Organisms – Understand the structures and functions of living organisms and how organisms can be compared scientifically **Benchmark 2.4.1:** Explain how plants and animals go through life cycles **Essential Questions:** What is a life cycle? What are the life cycles of plants? Of animals? Possible extension activity: How are plant and animal life cycles similar and different? **Purpose:** To cover the essential concepts of plant and animal life cycles
2. Determine Acceptable Evidence and Criteria (Desired Outcomes/Evidence)
Desired Outcomes: • Flow chart depicting a life cycle: organisms are born, grow, change, and die. • Diagrams with captions describing the life cycle of a plant. (i.e., germination, growth, reproduction, death.) • Diagrams with captions describing the life cycle of different types of animals. (i.e., birth, growth, reproduction, death.) • Students meet proficiency if they can explain how plants and animals go through life cycles, advanced proficiency if they can classify plants and animals by descriptors of their life cycles. • Possible extension activity: Venn diagram showing similarities and differences between plant and animal life cycles.
3. Determine Learning Experiences
• Clarification of benchmark (I Can statements) • Student generation of criteria for desired outcomes • Life cycle flow chart • Plant life cycle diagram • Animal life cycle diagrams • Class discussion • Possible extension activity: Graphic organizer—Venn diagram

4. Teach and Collect Evidence of Student Learning **5. Assess Student Work to Inform Instruction and Use Data to Provide Feedback**	
Lesson Procedures	Formative Assessments
1. Students contribute to a class KWLH (What I know, What I want to know, What I learned, How I learned), of life cycles of plants and animals.	➢ Class discussion, KWLH chart
2. Deconstruct the benchmark with students into kid friendly "I can…" statement. (i.e., "I can draw and explain the life cycle of different kinds of plants. I can draw and explain the life cycle of different kinds of animals.")	➢ Class discussion
3. Discuss why it's important to know about life cycles? How does it relate to their lives? Can students list real life examples?	➢ Class discussion
4. Brainstorm criteria for the flow charts and captioned diagrams. Extension activity: Brainstorm criteria for the Venn diagrams with students.	➢ Class discussion, e.g., using Anne Davies' Four Step Process
5. If available, show and discuss exemplar pieces. Students should determine which are: novice, partially proficient, proficient, and advanced.	➢ Class discussion, list reasons for classifications on post-it notes or along the side of each exemplar
6. Students discuss own experiences with life cycles (i.e., planting seeds, observing birth-growth-death, etc.).	➢ Class discussion, pair/share or small group
7. Students draw pictures of plant and animal life cycles based on prior knowledge / experiences. Students add captions describing the stages of a life cycle.	➢ Student drawings, teacher observations and/or conversations
8. Review similarities and differences between plant and animal life cycles through resources such as: textbooks, non-fiction or fiction books, DVDs/videos, hands-on or direct observation (i.e., in-class inquiry investigations), guest speakers, worksheets.	➢ Class discussion, guided practice or worksheets, webs/flow charts, learning logs/reflection
9. Guided scientific investigation where students will predict, observe, and analyze the life cycles of plants (i.e.,	➢ Class discussion, guided practice, teacher observation, peer and teacher conversations/feedback

fruit/vegetable/flower seeds, plant parts, etc.) and animals (i.e., butterflies, meal worms, tadpoles, brine shrimp, etc.).	
10. Students revise their initial drawings/ captions based on class discussions and guided scientific investigation.	➢ Teacher observation
11. In pairs or small groups, students discuss observations of plant and animal life cycles. Pairs or small groups share the main concepts of their discussion with the entire class.	➢ Peer conversations/feedback
12. Students make final revisions to their drawings/captions based on class-generated criteria, class discussions, scientific investigation, peer feedback.	➢ Teacher observation, teacher/peer feedback
13. Possible extension activity: Given diagrams with descriptors, students create a Venn diagram to show the similarities and differences between plant and animal life cycles.	➢ Teacher observation, teacher/peer feedback

- Using student-generated criteria/rubrics, students self-assess and/or peer assess their flow charts, diagrams, Venn diagrams.
- Students communicate needs or questions.
- Using formative assessments as a guide, re-teach concepts that students have not learned.
- Offer oral and/or written descriptive feedback to students so that they know what concepts require further study.

6. Evaluate Student Work, Make Judgment on Learning Results and Communicate Findings

- Flow chart: assess based on student-generated criteria/rubric.
- Individual student drawings and captions of plant and animal life cycles: assess based on student-generated criteria/rubric.
- Possible extension activity: Assess Venn diagram based on the explanation of life cycles and classification of plant or animal cycles based on given descriptors.

Grade: 4	Quarter: 2
Big Idea(s)/Major Understanding(s): *Students will understand that…* • A cell is the smallest living part of an organism. • In a food chain, every organism can be classified as a producer (plants), a consumer (herbivores, carnivores, omnivores), or a decomposer (fungi, bacteria, mold, mildew, yeast). • Food chains and food webs are affected by introduced species. Technology (e.g., grafting plants, eradication methods like poisons and traps, greenhouses for propagation, soil and water conservation practices) enables the preservation of Hawaii's native plants and animals.	
HCPS III Benchmarks: • SC.4.3.1: Explain how simple food chains and food webs can be traced back to plants • SC.4.4.1: Identify the basic differences between plant cells and animal cells • SC.4.5.2: Describe the roles of various organisms in the same environment ❖ *SC.4.1.1: Describe a testable hypothesis and an experimental procedure* ❖ *SC.4.1.2: Differentiate between an observation and an inference* ❖ *SC.4.2.1: Describe how the use of technology has influenced the economy, demography, and environment of Hawaii*	

❖ *Italicized benchmarks are taught and assessed in more than one quarter.*

Topic: Plants vs. Animals
Grade 4

1. Identify Relevant Standards/Benchmarks

Standard 4:
Life and Environmental Sciences: Structure and Function in Organisms – Understand the structures and functions of living organisms and how organisms can be compared scientifically
Benchmark 4.4.1:
Identify the basic differences between plant cells and animal cells
Essential Question: How are plant and animals similar and different?
Purpose: To help students identify the basic differences between plant cells and animal cells.

2. Determine Acceptable Evidence and Criteria (Desired Outcomes/Evidence)

Desired Outcomes:
- Exploration drawings of onion skin/elodea cells and animal tissue cells
- Group research on the structure and function of the parts of a plant and animal cell.
- Group oral presentation using a visual organizer depicting the similarities and differences of a typical plant and animal cell.
- Optional lab activity: Project design and presentation of the laboratory report of an inquiry based investigation project on comparing plant and animal cell structures.

3. Determine Learning Experiences

- Prior knowledge drawings
- Viewing and drawing of onion/elodea and animal tissue cells using a microscope
- Research similarities and differences between animal and plant cells
- Cell drawings/presentations
- Class Discussion

4. Teach and Collect Evidence of Student Learning
5. Assess Student Work to Inform Instruction and Use Data to Provide Feedback

Lesson Procedures	Formative Assessments
1. Assist students in developing their skills for clarifying an idea or concept. Students use the clarifying strategy to clarify their understanding of the benchmark: o Define or state the standard o Elaborate on what the benchmark means (In other words …) o Give an example of what the benchmark means o Illustrate what the benchmark means	➢ Students complete and turn in the clarity strategy showing their understanding of the benchmark. ➢ Class-generated rubric
2. Facilitate student understanding and involvement for creating visual organizers.	➢ Class-generated rubric

3. Students collaborate with each other to generate rubrics which will be used for the assessment of projects.	➢ Students reflect upon what they know, what they learn/observe, and what they need to know about plant and animal cells, student drawings
4. Exploration activity: • From what they already know, students draw what they think is the smallest part of a plant that can be seen through a microscope.	➢ Use of drawing/written observations rubric, teacher observations
• Compare what they have drawn to what is actually seen through a microscope as they view and draw cells of an onion skin or the elodea plant.	➢ Student drawings/labels
• As students draw the parts of a plant cell as seen through their observations, they predict and label the different parts they see and the functions they serve. • Students repeat the same procedure in exploring an animal cell. Viewing of animal tissue or cheek cells may be explored under the microscope.	➢ Use of drawing/written observations rubric, teacher observations
• Students generate a list of questions as they wonder through their explorations. (E.g., Do all plant cells have the same structures? Do all animal cells have the same structures?) Students may investigate this by comparing other animal and plant tissues, making detailed observations and drawings of each for comparison. (This may evolve into an inquiry based science investigation project.)	➢ List of questions
5. Research group activity focusing on the similarities and differences of a plant and animal cell. Students draw a typical plant and animal cell, labeling the parts of each along with their function. They create a visual to show the similarities and differences of the plant and animal cell. Each group presents their project to an audience.	➢ Facilitate student participation in developing assessment skills using criteria and rubrics. Students take an active part in peer and self assessment processes in drafting revisions and modifications. ➢ Students use rubrics to do commentaries in assessing their peers and themselves as part of the revision process.

6. Discussion of student findings focusing on the parts of plants and animals (structure and function).	➢ Students present project proposals as part of their formative assessment strategies leading up to final project presentations.
• Using student-generated criteria / rubrics, students self-assess and/or peer assess their flow charts, diagrams, Venn diagrams. • Students communicate needs or questions. • Using formative assessments as a guide, re-teach concepts that students have not learned. • Offer oral and/or written descriptive feedback to students so that they know what concepts require further study.	
6. Evaluate Student Work, Make Judgment on Learning Results and Communicate Findings	
Summative Assessments: • Reflections on explorations, what I learned and what I still need to know about cell structure and function. • Research on cell structure and function • Visual organizer of similarities and differences of plant and animal cell structures. • Group presentations of projects • Reflections and observations of group dynamics with respect to responsibility and teamwork. • Laboratory report (for optional investigation projects): Inquiry project design, data collection and analysis, and conclusion and implications.	

Grade: 7	Quarter: 2

Big Idea(s)/Major Understanding(s): *Students will understand that…*

- All living things are composed of cells which are the basic unit of living things.
- All cells are produced from other cells.
- Different cells have unique structures and functions.
- Cells are identified and/or organized by their functions, and their ability to work together to do a job.
- Living things are classified into groups that form a hierarchy from general to specific.
- Different organisms in each classification group share similar characteristics.

HCPS III Benchmarks:

- SC.7.4.1: Describe the cell theory
- SC.7.4.2: Describe the basic structure and function of various types of cells
- SC.7.4.3: Describe levels of organization in organisms
- SC.7.4.4: Classify organisms according to their degree of relatedness

❖ *SC.7.1.1: Design and safely conduct a scientific investigation to answer a question or test a hypothesis*
❖ *SC.7.1.2: Explain the importance of replicable trials*
❖ *SC.7.1.3: Explain the need to revise conclusions and explanations based on new scientific evidence*
❖ *SC.7.2.1: Explain the use of reliable print and, electronic sources to provide scientific information and evidence*

❖*Italicized benchmarks are taught and assessed in more than one quarter.*

Topic: Plants vs. Animals
Life Science, Grade 7

1. Identify Relevant Standards/Benchmarks
Standard 4: Life and Environmental Sciences: Structure and Function in Organisms – Understand the structures and functions of living organisms and how organisms can be compared scientifically **Benchmark SC 7.4.1:** Describe the cell theory **Benchmark SC 7.4.2:** Describe the basic structure and function of various types of cells **Benchmark SC 7.4.3:** Describe the levels of organization in organism **Benchmark SC 7.4.4:** Classify organisms according to their degree of relatedness **Essential Question:** What is a Cell? How are cells alike? How are they different? What do they do? **Purpose:** To build a foundation of understanding on cells, including similarities and differences between cells, their structure, how they work, why they are important
2. Determine Acceptable Evidence and Criteria (Desired Outcomes/Evidence)
Desired Outcomes: • Organizers for concepts and info, i.e. diagrams, Venn, cluster maps, sequencing charts, cycle maps, "What's the Big Idea?", etc. • Journal, learning logs, e.g., KWLH (What I know, What I want to know, What I learned, How I learned), Internet-based web-quest and journal of research • One word web for content vocabulary • Study guides and note taking; e.g., "1/3, 2/3" strategy • Models, illustrations/drawings, posters, brochures, presentation boards • Lab and/or Research reports; i.e., scientific investigations including background information on cells, their structure, and function • "Real Life" applications and/or "Hands-on" experiences; e.g., design a game to help other students review cellular structure and function • Paper and pencil tests, writing response to prompts
3. Determine Learning Experiences
• Clarification of benchmarks ("I Can" statements) • Student generation and clarification of criteria for desired outcomes • KWLH notebook on cells • Cell drawings • Group work • Class, group discussion • Graphic Organizer – Venn diagram • Cell Models and Inquiry • If time allows, field study and experience • Web research

4. Teach and Collect Evidence of Student Learning **5. Assess Student Work to Inform Instruction and Use Data to Provide Feedback**	
Lesson Procedures	Formative Assessments
1. Clarify benchmarks by deconstructing standards with students. Use the **SEEI**	➢ Clarify/Deconstruct benchmarks, student "I can" statements and

model to help clarify benchmarks: • **S**tate or define the standard in own words • **E**laborate on what the benchmark means; • Give an **E**xample of what the benchmark means • **I**llustrate what is required in benchmark 2. Write “I can” statements with students. (It should be clearly worded so students and parents will understand what they should know and be able to do.) 3. Individually in notebook, students record KWLH about cells. 4. Students draw two cells (plant, animal) based on prior knowledge. 5. Students do research to collect information on cells using various methods such as: • **Collaborative/Cooperative Learning**: Example: Students given post-it notes with either cell structure or function written on it, student attempt to find partner, students can use resources such as books, charts, to confirm they are correctly matched with each other, partners share with the rest of the class by writing on overhead provided by teacher. All students take notes. • **Class/group discussion**- Using cooperative strategy “round table” teacher presents question–What do plant cells look like? Students respond as a group by writing their responses on one folder paper. Paper is passed around the table and each student writes something until time up. Group share information with the class and teacher writes information on chart paper. After all have shared, each group will use textbooks, charts, internet, etc. to confirm if information on chart paper is accurate or inaccurate. Groups convene, share their information and teacher circles	criteria/rubric checklist, SEEI conversation, class discussion, journal ➢ KWLH chart, 3 column chart that helps capture the before, during and after components of content learning. Cell Drawing, pre ➢ **SQ4R, survey** info on cells, turn big ideas, concepts in **questions**, generate answers to questions, **recite** to self, summarizing in own words what learned, **relate** new information to self that are personally meaningful in some way. ➢ **1/3, 2/3 note taking strategy** notes

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accurate information and crosses out inaccurate ones.

Visuals, media- students have diagram, worksheet, and questions to complete as view video. Teacher pauses video when appropriate to engage in discussion, questions, comments from students. Students record information.
Web based research

6. Students revise cell drawing and accompany revision with comments in KWLH chart.
7. Students demonstrate achievement of benchmarks by applying understanding in presentations and applications; e.g.,:

Power point presentation on cells including concept maps, Venn diagrams, and drawings
Real life applications such as creating a game for cell structure and function review

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Using student-generated criteria / rubrics, students self-assess and/or peer assess their flow charts, diagrams, Venn diagrams.
Students communicate needs or questions.
Using formative assessments as a guide, re-teach concepts that students have not learned.
Offer oral and/or written descriptive feedback to students so that they know what concepts require further study.

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<tr><td colspan="2">6. Evaluate Student Work, Make Judgment on Learning Results and Communicate Findings</td></tr>
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Using student generated criteria/rubrics, students self/peer assess their work required by teacher. (See section 3. Determine Learning Experiences)
Students use feedback to make corrections, clarify, redo, revise
Teachers use feedback to modify or make necessary instructional adjustments, such as re-teaching, using alternative instructional approaches, offer opportunities for additional practice, to assist and facilitate student success in reaching proficiency level
KWLH chart: assess using rubric student /teacher generated
Formal paper and pencil test (multiple choice, fill in blanks, matching, true/false) and short response questions) on major understandings

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Course: Biology — Quarter: 2

Big Idea(s)/Major Understanding(s): *Students will understand that…*

- Cells are the basic structural and functional units of life.

HCPS III Benchmarks:

- SC.BS.4.1: Describe different cell parts and their functions
- SC.BS.4.2: Explain how cells are specialized into different tissues and organs
- SC.BS.4.3: Differentiate between the processes of mitosis and meiosis
- SC.BS.4.5: Describe the components and functions of a variety of macromolecules active in biological systems

SC.BS.1.1-SC.BS.1.5 and SC.BS.1.7-SC.BS.1.9: (Scientific Investigation): These scientific process benchmarks should be embedded throughout the course to facilitate learning major understandings. Emphasis of particular benchmarks will vary with learning activities and teaching strategies each quarter.

- ❖ *SC.BS.1.1: Describe how a testable hypothesis may need to be revised to guide a scientific investigation*
- ❖ *SC.BS.1.2: Design and safely implement an experiment, including the appropriate use of tools and techniques to organize, analyze, and validate data*
- ❖ *SC.BS.1.3: Defend and support conclusions, explanations, and arguments based on logic, scientific knowledge, and evidence from data*
- ❖ *SC.BS.1.4: Determine the connection(s) among hypotheses, scientific evidence, and conclusions*
- ❖ *SC.BS.1.5: Communicate the components of a scientific investigation, using appropriate techniques*
- ❖ *SC.BS.1.7: Revise, as needed, conclusions and explanations based on new evidence*
- ❖ *SC.BS.1.8: Describe the importance of ethics and integrity in scientific investigation*
- ❖ *SC.BS.1.9: Explain how scientific explanations must meet a set of established criteria to be considered valid*

- ❖ *SC.BS.2.1: Explain how scientific advancements and emerging technology have influenced society*
- ❖ *SC.BS.4.4: Describe how homeostatic balance occurs in cells and organisms*

❖ *Italicized benchmarks are taught and assessed in more than one quarter.*

Topic: Plants vs. Animals
Biology

<table>
<tr><th colspan="2">1. Identify Relevant Standards/Benchmarks</th></tr>
<tr><td colspan="2">Standard 4:
Life and Environmental Sciences: Structure and Function in Organisms – Understand the structures and functions of living organisms and how organisms can be compared scientifically
Benchmark SC.BS.4.1: Describe different cell parts and their functions
Benchmark SC.BS.4.2: Explain how cells are specialized into different tissues and organs
Essential Question: What structural and functional similarities and differences characterize plants and animals?
Purpose: To review structural/functional similarities/differences between animals and plants on a cellular level, and compare plants and animals on the tissue, organ, and organ system levels.</td></tr>
<tr><th colspan="2">2. Determine Acceptable Evidence and Criteria (Desired Outcomes/Evidence)</th></tr>
<tr><td colspan="2">Desired Outcomes:
• Venn Diagram showing similarities and differences between plant and animal cells—students meet proficiency if they can illustrate at least three similarities and three differences, exceeds if five or more similarities and differences
• 3D model of an animal cell or plant cell—design a rubric to illustrate exceed, meet, approach and well below proficiency
• Comparison table listing cell parts, cell types, tissue types, organ types and system types in plants vs. animals—students meet proficiency if they fill in table with at least two examples in each cell, exceeds if at least four examples are correctly listed in each cell</td></tr>
<tr><th colspan="2">3. Determine Learning Experiences</th></tr>
<tr><td colspan="2">• Clarification of benchmarks (“I Can” statements)
• Student generation of criteria for desired outcomes
• Cell diagrams
• Class discussion
• Graphic Organizer—Venn diagram
• 3-D Cell Models
• Animal/Plant Comparison table</td></tr>
<tr><th colspan="2">4. Teach and Collect Evidence of Student Learning
5. Assess Student Work to Inform Instruction and Use Data to Provide Feedback</th></tr>
<tr><td>Lesson Procedures</td><td>Formative Assessments</td></tr>
<tr><td>1. Deconstruct the benchmarks with students into kid friendly “I can…” statements (i.e. “I can list the eight major organelles of a plant cell, draw what they look like and where they are found in the cell, and describe the function of each one.”)</td><td>Class discussion</td></tr>
<tr><td>2. Brainstorm and generate criteria for the 3-D models, Venn diagrams and comparison table with students.</td><td>Class discussion</td></tr>
</table>

3. If available, show and discuss exemplar pieces. Students should determine which examples are: novice, partially proficient, proficient, and advanced. 4. Students contribute to a class KWLH (What I know, What I want to know, What I learned, How I learned) chart of similarities and differences between plant and animal cells 5. Students draw a picture of a plant cell and animal cell based on prior knowledge 6. Review similarities and differences between animal and plant cells as a class and have students "edit" their drawings 7. Students create a Venn diagram to show the similarities and differences between plant and animal cells based on previous class discussion 8. Teacher lectures on functions of cell organelles 9. In groups of four, students design a 3D cell (assign each group either plant or animal) out of food items. During the next class period, students build cell, label all parts 10. Using the 3D model, students study the parts and functions of each part 11. Students complete a worksheet showing how each organelle is linked in function with other organelles (e.g., after proteins are made at the ribosomes found on the rough endoplasmic reticulum, they are sent to the Golgi body where they are packaged into sacs and then sent to the cell membrane to be exported from the cell) 12. Students fill in a table using textbooks and Internet with examples of the following for both plants and animals: cell organelles, cell types, tissues, organs, systems	Class discussion KWLH chart, class discussion Student drawings Class discussion, student drawings Model designs, observations of students as they design and build their 3D models, conversations Informal Quiz: after students study cell parts and functions of their models, orally quiz each student on at least two cell parts to assess whether they can describe the cell parts and their functions
• Using student-generated criteria or rubrics, students self-assess and/or peer assess their flow charts, diagrams, Venn diagrams. • Students communicate needs or questions.	

•	Using formative assessments as a guide, re-teach concepts that students have not learned.
•	Offer oral and/or written descriptive feedback to students so that they know what concepts require further study.
6.	**Evaluate Student Work, Make Judgment on Learning Results and Communicate Findings**
•	3D Cell Model: assess based on rubric
•	Venn Diagram: assess based on number of similarities and number of differences
•	Plant/Animal Specialization Table: assess based on number of examples given in each cell of the table

APPENDIX D: HABITS OF MIND

Habits of Mind refers to skill goals discussed and clarified in the publication, *Benchmarks for Science Literacy* (1993, 2008), from the American Association for the Advancement of Science (AAAS). These skills were formerly included in HCPS II, Domain 1 standards and benchmarks. Because these standards and benchmarks are embedded in and permeate the HCPS III Science standards and benchmarks; they are further described here for the following reasons:

- They address the cognitive skills needed in scientific problem solving.
- They should be learned in the context of HCPS III standards and benchmarks in the same way that the scientific inquiry process is best learned in the context of the HCPS III content, understandings, and skills.
- The skills and thinking associated with Habits of Mind are significant and relevant to what it means to be literate in science.

Students' ability and inclination to solve problems effectively depend on their having certain knowledge, skills, and attitudes that are highly prized in the scientific community because they are essential to the scientific way of thinking, knowing, and doing. These knowledge, skills, and attitudes, described as Habits of Mind, relate directly to a person's way of thinking and acting and applying knowledge and learning.

Habits of Mind, A Way of Thinking and Acting: Students develop and apply the values, attitudes, and commitment characteristic of an inquiring mind.

This means that students value honesty as an important characteristic in life and in conducting experiments; value critical-mindedness as an important way of evaluating information; value the need for evidence to support statements of beliefs and explanations; value objectivity as criteria necessary for problem solving; value the quality of open–mindedness as a means of evaluating ideas without preconceived ideas or assumptions; realize that a questioning attitude is necessary to validate, contradict, clarify, or expand on an idea or statement; believe in oneself and are self-directed; and value science as a way of thinking and knowing.

The following table shares what these values, attitudes, and commitments would look like at the grade level clusters K-3, 4-5, 6-8, and 9-12, including suggested links to the GLOs.

HABITS OF MIND: A WAY OF THINKING AND ACTING

General Learner Outcomes	Habits of Mind	K – 3	4 – 5	6 – 8	9 - 12
❖ Self-directed Learner ❖ Community Contributor ❖ Effective Communicator ❖ Effective & Ethical User of Technology	**Honesty**	• Report observations accurately	• Report all observations accurately and precisely • Acknowledge work done by others	• Report observations even when they contradict a hypothesis • Acknowledge references, contributions, and work done by others	• Report findings accurately without alterations and draw conclusions from unaltered findings • Acknowledge references, contributions, and work done by others
❖ Self-directed Learner ❖ Complex Thinker ❖ Quality Producer ❖ Effective Communicator ❖ Effective & Ethical User of Technology	**Critical-Mindedness**	• Ask many questions starting with *What*, *Where*, *Why*, *Whom*, and *How*, to gather information about their "wonderings"	• Validate and evaluate multiple sources of information (texts, periodicals, web sites, and people) to support research	• Evaluate empirical evidence to develop reasonable conclusions and explanations and compare them to current scientific knowledge	• Evaluate the logic and validity of evidence, conclusions, and explanations against current scientific knowledge
❖ Self-directed Learner ❖ Community Contributor ❖ Complex Thinker ❖ Quality Producer ❖ Effective Communicator	**Objectivity**	• Examine many perspectives of a question, situation, or problem	• Examine many perspectives of a question, situation, or problem and consider many possible solutions	• Examine several possible options when investigating a problem. • Distinguish between facts and speculations/ inferences	• Evaluate various perspectives and their implications before drawing conclusions

General Learner Outcomes	Habits of Mind	K – 3	4 – 5	6 – 8	9 - 12
❖ Self-directed Learner ❖ Community Contributor ❖ Complex Thinker	**Open-Mindedness**	• Examine ideas presented by others	• Acknowledge that ideas, conclusions, and expectations may change	• Evaluate all evidence that support or contradict the hypothesis	• When appropriate, modify ideas, explanations, and hypotheses, based on empirical data or evidence
❖ Self-directed Learner ❖ Community Contributor ❖ Complex Thinker ❖ Quality Producer ❖ Effective Communicator	**Questioning**	• Ask “wondering” questions	• Ask questions to clarify and expand an idea or statement	• Ask questions to understand the multiple perspectives and interpretations of a problem, situation, or solution	• Ask questions to clarify or validate purpose, perspective, assumptions, interpretations, and implications of a problem, situation, or solution
❖ Self-directed Learner ❖ Quality Producer ❖ Effective Communicator ❖ Effective & Ethical User of Technology	**Self-Directed**	• Share new experiences and knowledge learned from individual investigations	• Plan and carry out tasks as an individual and as a member of a group	• Locate, identify, and use a wide variety of appropriate information to draw conclusions in a research project	• Use research techniques and a variety of resources to complete a report on a project of one’s choice
❖ Community Contributor ❖ Complex Thinker ❖ Effective & Ethical User of Technology	**Value Science**	• Ask questions and describe the “wonderings” about the world around us	• Ask questions and give examples of how science explains what is happening in the world around us	• Ask questions and explain findings and answers scientifically	• Ask questions, explain, and elaborate how science is a way of thinking and knowing the world around us

Habits of Mind: Application of Knowledge and Learning: Students use concepts and themes such as system, change, scale, and model to help them understand and explain the natural world.

In other words, students understand the natural world more meaningfully when they use concepts and themes to make the connections between objects, events, and experiences.

For example, in studying the unifying concept of system, as in ecosystem, students make connections between the physical and biological factors that affect mango yield. Mango yield is dependent on temperature, wind, water, and length of day and pollinators. Another example is students using an aquarium or tank as a model to replicate the movement and currents of fluids (i.e. ocean water) based on temperature and density and extending their observations to developing hypotheses, investigations, or inventions in that environment. Connections to unifying concepts and themes can also be tied to technology via computer models, computer generated scenarios, and the use of technology in depicting the physical natural world around us.

The following table shares what these values, attitudes, and commitments would look like at the grade level clusters K-3, 4-5, 6-8, and 9-12, including suggested links to HCPS III.

HABITS OF MIND: APPLICATION OF KNOWLEDGE AND LEARNING

HCPS III Connections	Concepts & Themes	K – 3	4 – 5	6 – 8	9 - 12
Standard 3 – Organisms & the Environment Standard 4 – Structure & Function in Organisms Standard 5 - Diversity, Genetics & Evolution Standard 6 – Nature of Matter & Energy Standard 8 – Earth & Space Science	**System**	Identify the components of a system that interact to perform a function (examples of systems are human body, clock, solar system, or car)	Observe and describe how parts influence one another in a system	Explain how a given system works	Explain the function of a given system and its relationship to other systems in the natural world
Connections at the benchmark level	**Change**	Observe and describe changes that occur	Identify patterns of change in things (such as steady, repetitive, or irregular change) using data as evidence	Identify patterns of change and the implications on a system	Explain the effect of large and small disturbances on systems in the natural world
Standard 8 – Earth & Space Science	**Scale**	Describe changes in size, weight, time, color, or movement of things and note which of their other qualities remains the same	Use a known set of measurement standard to relate objects to scale	Translate very large or very small numbers to scale using ratio and proportion (e.g., distance, time, blueprints, timeline, solar systems)	Report how large changes in scale typically change the way things work in physical, biological, or social systems

HABITS OF MIND: APPLICATION OF KNOWLEDGE AND LEARNING

HCPS III Connections	**Concepts & Themes**	K – 3	4 - 5	6 - 8	9 - 12
Standard 1 – Scientific Investigation Standard 2 – Nature of Science Standard 3 – Organisms & the Environment Standard 4 – Structure & Function in Organisms Standard 5 - Diversity, Genetics & Evolution Standard 6 – Nature of Matter & Energy Standard 7 – Force & Motion Standard 8 – Earth & Space Science	**Model**	Use a model, such as an object or a picture, to describe the feature or function of the original object, device, thing, etc.	Use geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, or stories to represent corresponding features of objects, events, and processes in the real world. Identify ways in which the representations do not match their original counterparts	Identify several different models that could be used to represent the same thing, and evaluate their usefulness, taking into account such things as the model's purpose and complexity	Design or create a model to represent a device, a plan, an equation, or a mental image

APPENDIX E: SCIENCE SAFETY

This section provides teachers information and a sample safety guide. Although by no means complete in all safety considerations, its purpose is to provide a sample safety guide for the classroom to help teachers develop a safe environment for students.

There are two sections to Appendix E:

- Science Safety for Elementary Schools
- Science Safety for Secondary Schools

Safety is the responsibility of all stakeholders in a school. In the classroom, teachers and students must work together to maintain a safe environment that supports and encourages learning. Best practices in science call for students and teachers “doing science” through exploration labs, scientific investigations, and building and using models along with all procedural and safety considerations in place.

Science Safety for Elementary Schools (pages 156–168) gives an overview of safety responsibilities for schools, including administrators, grade level chairs/chairpersons, teachers, and students. This includes physical, chemical, and organism safety considerations, and practices that are grade level appropriate. This section may be used for kindergarten through grade 6.

Safety in the Science Classroom (pages 169–194) gives an overview of safety responsibilities for secondary schools, including administrators, department heads, teachers, and students. This section addresses specific concerns in chemistry, biology, physical science, and other accelerated lab situations where complex chemicals and equipment are used for grades 7 through 12.

SCIENCE SAFETY FOR ELEMENTARY SCHOOLS

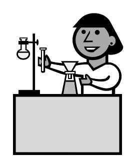
RESPONSIBILITIES OF SCHOOL ADMINISTRATORS

1. Be responsible for the administration and supervision of laboratory safety and practices for the school science programs.
2. Take immediate corrective action to reduce or eliminate safety hazards.
3. Be responsible for administering emergency first aid to sick or injured students.

RESPONSIBILITIES OF GRADE LEVEL CHAIRS/CHAIRPERSON

1. Orient new teachers and substitutes as to teacher responsibilities in science safety.
2. Perform tasks assigned by the principal in administering the safety program for the school.
3. Conduct grade level meetings to discuss science safety-related topics.
4. Supervise the safety program for the grade level.

RESPONSIBILITIES OF TEACHERS OF SCIENCE



Teachers at all times must be concerned with making every reasonable effort to prevent accidents. This requires training in safety practices and constant awareness of student behavior in the classroom. Teachers must be aware of the application of safety practices and must display exemplary behavior regarding accident prevention.

1. Teachers should be familiar with the school procedures in case of an accident or injury. The school's Teacher's Handbook provides guidelines.
   a. The principal and grade level chair should be notified of an accident immediately.
   b. A properly trained person will administer first aid if necessary.
   c. An injury which requires medical care should be treated only by a physician.
   d. Prepare department accident report form (see Form 411, p. 194) immediately after an accident occurs. This will provide essential information regarding liability and will provide potential information to correct the cause of the accident.
2. Teachers should instruct students in laboratory safety procedures at the beginning of the school year. Students should be given specific instructions regarding the safe use of equipment and materials for each laboratory activity. Students must review and sign a safety contract early in the school year. (A sample is provided on page 159.)
3. Teachers should make regular classroom inspections and notify the principal and grade level chair/chairperson of the existence or development of any hazards.
4. Teachers should require students to use personal protective devices such as laboratory aprons, safety eye shields (goggles), covered shoes, and gloves as needed.

5. Teachers should take precautions to shield and place students at safe distances from demonstrations when there is a possibility of chemicals splattering, a chance of a flash flame, or an explosion.
6. Laboratory experiments and exercises which involve potential hazards should be previously tried out by the teacher to determine whether the lesson can be performed safely.
7. Student devices, equipment, and individual projects should be pre-tested before use as a demonstration in the classroom. Even then, extra precaution must be exercised during the actual demonstration.
8. Teachers should be well trained in first aid and be able to render this help when needed. It is recommended that teachers maintain a current first aid certificate.[1]
9. The areas around the first aid kit and other safety devices should be kept open for quick access in case of emergencies. All aisles and exits must be kept clear at all times.
10. Teachers should keep bottles and containers of chemical materials labeled at all times. Unknown chemicals should be disposed of properly. Teachers can call the Solid and Hazardous Waste Management Branch at 586-4226 for disposal information.
11. Teachers should supervise students at all times.
12. Students should be warned of the hazards of conducting home projects involving explosive mixtures, poisons, pathogenic bacteria, and high voltage electricity (including house current).

In general, “reasonable care” may take two forms. A teacher must not do anything that a reasonable person would recognize as being potentially dangerous. Neither may teachers fail to do something that would be necessary to protect the safety of their students. Thus, negligent conduct may take two forms–the performance of an act that puts students in danger or the failure to take an action to protect them.

[1] For further reference, refer to Policy 1710-14.1, “Emergency Care for Sick or Injured Students, Policies and Regulations, Department of Education Code.

RESPONSIBILITIES OF STUDENTS–SAMPLE SAFETY CONTRACT

1. I know the safety procedures and will be careful at all times to ensure the safety of everyone in the laboratory.

2. I will follow instructions and will only perform experiments that my teacher approves.

3. I will clean up spilled materials right away, return equipment and chemicals, and dispose of waste materials into proper receptacles.

4. I will wear appropriate personal protective devices such as aprons, safety glasses, and shoes when instructed by my teacher.

5. I know the location and proper use of the first aid kit, fire extinguisher, and other safety equipment.

6. I will immediately report all accidents and potential hazards to the teacher.

7. I will never taste, smell, or touch any chemical unless instructed by the teacher.

8. I will wash my hands before and after every science activity.

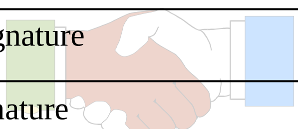
9. If I have allergies, I will inform my teacher and ask to be excused from any activities that might cause a reaction.

10. I will never clown around, play practical jokes or take chances while working in the science laboratory.

Please sign and return the bottom portion of this sheet

I have read this letter and understand what will be expected of my child. I understand the purpose of the safety requirements. If I have any questions, I will contact the teacher for clarification.

____
Student name



____________________________ ______________
Student signature Date

____________________________ ______________
Parent signature Date

____________________ ____________________
Emergency Telephone Number Email Address

My child is allergic to the following:

PHYSICAL SAFETY

Physical environment

Many classrooms are not set up to be science laboratories. Teachers must be aware of the classroom environment to prevent accidents and injuries. First aid kits, fire alarm pull stations, room exits, and other emergency equipment items must be easily accessible. Walkways, spaces between desks and around working areas should be kept free of obstacles and clutter. If students will be using flames, chemicals, or glassware, the work area should be cleared of unnecessary items, the area should have enough space for all students to work safely, and there should be proper ventilation to ensure that flames or chemical fumes will not spread.

Use of equipment

Science activities use many common equipment items that can cause injuries. Teachers should exercise caution when using common items such as rubber bands, balloons, thermometers, rulers, magnets, and timers, as students may be tempted to improperly use these objects. For example, it is common to find students who "shoot" rubber bands at each other, play "swords" with thermometers and rulers, or swallow and choke on balloons. This type of behavior must be monitored to prevent physical injury. Damaged, cracked, or broken items should be disposed of properly and should not be used in classroom activities.

Cleaning up

Teachers must be prepared to properly dispose of broken equipment. Students and teachers should never pick up glass or other sharp objects with bare hands. If a glass item breaks in the classroom, all students should clear the area and a custodian or teacher should clean the area using a dustpan and broom. Glassware and other sharp objects should be properly disposed of and not mixed with normal trash. Computers and other electronic devices may contain dangerous substances and teachers should consult their principal or designee before disposing of these items. Teachers should properly discard items so students will not be able to retrieve them.

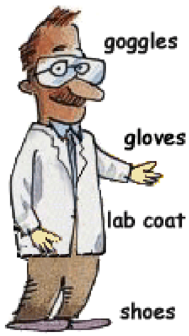
CHEMICAL SAFETY

Choosing the chemicals

Many products found in a home or store can be dangerous. For example, vinegar, an acetic acid, can burn exposed eyes and nose tissue. Care should be taken whenever using chemicals around children. Teachers should always know if the chemical being used is safe for young students to handle.

Using chemicals with children

Teachers must use practical sense when using chemicals with their students. All demonstrations and activities should be pre-tested before exposure to students. Students using potentially dangerous chemicals should always wear goggles and other necessary safety equipment. Teachers should also stress to students that experiments should be performed at home only under parental supervision.



Cleaning up

Children must wash their hands with soap after using any chemicals to avoid getting the chemicals in their mouths, eyes, ears, or noses. Chemicals can also be spilled or splattered on the floor or clothing, so cleaning up after an activity is extremely important.

Chemical storage

All chemicals must be labeled before storing. Chemicals not used within a year should be disposed of using proper disposal techniques. All unknown chemicals should be disposed of as soon as possible. Teachers unsure of how to dispose of a chemical should inform the principal to call the Solid and Hazardous Waste Management Branch at 586-4226 for information and instructions.

Liability

It is important to plan preventive steps that will minimize accidents and reduce both individual and department liability. These steps include effective safety instruction, prudent selection of activities, careful supervision of students, and proper maintenance of the equipment and the classroom. Teachers should investigate their room to identify possible hazards and remedy problems before accidents occur.

FOOD SCIENCE SAFETY

Area preparation

Preparation of the work area and preventive cleaning is extremely important when working with edible products or consumable materials. Students need instruction on proper hand washing and personal sanitary habits. The work area should be wiped clean with a sanitizing solution and all potentially poisonous materials should be removed from the classroom. Students should be instructed to never taste or consume materials unless instructed by the teacher. After the activity is finished, a thorough cleaning may be necessary to prevent insect or fungal infestation.

Materials and equipment

When performing a food science activity, only clean and sanitary equipment should be used. Do not use equipment that has been used in unsanitary conditions as it may still contain harmful residues. Thermometers that contain mercury should not be used as they may break and expose students to the mercury. Teachers should use caution when heating items in the classroom.

Working with food

When working with food items, it is important to be aware of the number and health of students handling the materials. Teachers should facilitate the activity so that students work only with their own materials to prevent contamination from other students. Foods that spoil easily should be used with caution or avoided. Teachers must use extreme caution when using food that has been heated because it can burn students.

- It is important for teachers to keep in mind that some students may be allergic to certain food products. Knowledge of students' allergies is important before any activity is conducted.

ORGANISM SAFETY

Exhibition and maintenance

Students should be taught never to harm or kill organisms in a science classroom. Organisms must be treated properly and humanely. Teachers should have a prepared area to meet the needs of any organisms. Some research or background knowledge may be required to properly care for some organisms. For example, some organisms may require a certain type of food, light, or filtration.

Handling

Organisms can be dangerous to handle without proper instruction. Organisms such as mice, rats, rabbits, and birds can bite students. Insects can contain poison or have harmful bites or stings. Crayfish, crabs, and other organisms can pinch and injure students. Teachers should review proper handling procedures with the students so that they are aware of how to carry and care for the organisms. Teachers must limit the amount of handling each organism endures because over-handling can lead to stress and death.

FIRST AID

Do's in First Aid

1. Do remain calm.

2. Do obtain staff assistance if necessary. Do call 911 when needed.

3. Do handle the person as little as possible. Do not move the person.

On completion of the emergency phase:

4. Do make a complete and accurate report about the incident to the administration. Do clean up the area if needed.

Don't's in First Aid

1. Don't give liquids or medicine to an unconscious person.

2. Don't try to arouse an unconscious person

3. Don't break blisters, or break a person's skin.

4. Don't give medicine or medicine advice.

5. Don't transport an injured student in a private vehicle.

6. Don't send a student home without consulting a parent.

7. Don't treat injuries that happened at home. Send the student to the Health Room.

Safety Symbols:

Poison

Biohazard

Explosive

High Voltage

Flammable

General Safety Warning

Corrosive

Laboratory Equipment:

Beaker

Graduated Cylinder

Dropper (Pipette)

Erlenmeyer Flask

Tongs

Goggles

Florence Flask

Test tube

Petri Dish

Bunsen Burner

Triple Beam Balance

Rubber Stopper

Overflow Cup (Displacement)

Compound Microscope

Dissecting Microscope

Thermometer

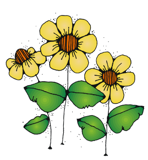
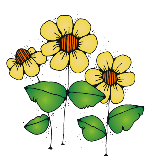
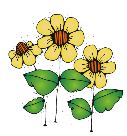
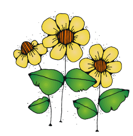
COMMON HOUSEHOLD CHEMICALS:

Common Name	Chemical Name	Chemical Formula
Ammonia	Ammonium hydroxide	NH_40H
Baking Soda	Sodium bicarbonate	$NaHCO_3$
Bleach	Sodium hypochlorite	NAClO
Borax	Sodium tetraborate	$Na_2B_4O_7$
Chalk	Calcium carbonate	$CaCo_3$
Charcoal	Carbon	C
Cream of Tartar	Potassium bitartrate	$KHC_4H_4O_6$
Dry Ice	Carbon dioxide	CO_2
Epsom Salt	Magnesium sulfate	$MgSO_4$
Flowers of Sulfur	Sulfur	S
Grain Alcohol	Ethyl alcohol	C_2H_5OH
Graphite (pencil lead)	Carbon	C
Lye	Potassium hydroxide or Sodium hydroxide	KOH or NaOH
Milk of Magnesia	Magnesium hydroxide	$Mg(OH)_2$
Mothballs	Napthalene	$C_{10}H_8$
Peroxide	Hydrogen peroxide	H_2O_2
Table Salt	Sodium chloride	NaCl
Sand	Silicon dioxide	SiO_2
Table Sugar	Sucrose	$C_{12}H_{22}O_{11}$
Vinegar	Acetic acid	CH_3COOH

COMMON PLANTS

Plants	Dangers
Angels trumpet or Brugmansia	All parts of this and other angel trumpets are narcotic and poisonous.
Autumn crocus or meadow saffron	Intense thirst, burning of throat, vomiting; possible death from respiratory failure.
Bird of paradise	Severe poisoning if ingested.
Black locust	Seeds can cause dullness and depression, vomiting and weak pulse if ingested.
Buttercup	Irritant juices can severely injure the digestive system.
Candelabra cactus	May severely impair visual acuity on contact with the eye.
Castor bean	May lead to convulsions, exhaustion, and death.
Crown flower	Sap can cause severe eye injury.
Daphne	Berries can be fatal.
Elderberry	Using the pithy stems for blowguns has poisoned children. Nausea and digestive upset result.
Elephant ear	Intense pain around lips, mouth and tongue if chewed. If base of tongue swells and blocks air passage, death can result.
Foxglove	Nausea, vomiting, dizziness; affects heart rhythm (source of digitalis). May be fatal.
Golden chain	Severe poisoning. Excitement, lack of coordination, convulsions, and coma. May cause death.
Hyacinth, daffodil, narcissus	Bulbs may cause nausea, vomiting, and diarrhea if ingested. May be fatal.
Jerusalem cherry	Vomiting when ingested; local irritation; slowing action on the heart.
Jimson weed thorn apple	All parts may cause abnormal thirst, delirium, distorted sight, incoherence, and coma. Common cause of poisoning. May be fatal.
Lily of the valley	Roots, leaves, and fruit can stimulate the heart (similar to digitalis).
Mayapple	Contains at least 16 active toxic principles, mostly in the roots. Eating of the apples may cause diarrhea.
Mistletoe	Berries are poisonous; can be fatal.

Plants	Dangers
Nightshade	Intense digestive disturbances and nervous symptoms. All parts, especially the unripe berry, may cause death.
Oak	Chewing on leaves or acorns gradually affects kidneys. Symptoms appear only after several days or weeks.
Philodendron	Skin rash requiring long-term medical care; swelling of mouth and throat if ingested.
Poinsettia	Poisons from only one leaf can kill a child.
Poison hemlock	Resembles a large wild carrot. All parts may be fatal.
Red pepper, chili	Burns skin and moth. Large doses may cause severe poisoning.
Rhododendron	Intense pain, diarrhea, and discomfort.
Rhubarb	Leaf blades-ingestion of large amounts can cause convulsions, coma, and death.
Rosary pea or jequirity bean	Seeds are violently poisonous. A single seed has caused death.
Wisteria	Seeds and pods cause mild to severe digestive upset.
Yellow oleander	All parts of the plant are extremely poisonous; affects the heart; produces severe digestive upset; may be fatal.
Yew	Violent gastrointestinal distress; ingestion also causes quick pulse, fainting, convulsions, and death.


MODEL ROCKETRY FLIGHT STANDARDS

Using model rockets requires practice and preparation. It is important for teachers to test the equipment and choose an appropriate launch site before students launch rockets. Below is a list of guidelines from the Federal Aviation Administration (FAA):

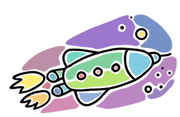
a. Do not use more than four ounces of propellant.
b. Use a slow burning propellant.
c. Rockets must be made of paper, wood, or breakable plastic, containing no substantial metal parts and weighing not more than 16 ounces, including propellant.
d. Rockets must be operated in a manner that does not create a hazard to persons, property, or other aircraft.

Launch Site Dimensions

- Minimum Launch Site Dimensions: Dimension for a circular area is the diameter in feet. For a rectangular area, the dimension is the shortest side in feet.
- In selecting a site, the larger the better.
- Choose a large field away from power lines, tall buildings, tall trees, and low flying aircraft.
- Be aware of wind direction and speed.
- The area must be clear of obstruction AND HAVE NO DRY WEEDS OR HIGHLY FLAMMABLE MATERIALS.

Engine Types	Minimum Launch Site Dimensions	Maximum Altitude
¼ A to ½ A	50 feet	200 feet
A	100	400
B	200	800
C	400	1,600
D	500	1,800

SAFETY RESOURCES



National Science Teachers Association (NSTA)
http://www.nsta.org/

Scilinks
http://www.scilinks.org/default.asp

Flinn Scientific
http://www.flinnsci.com/

SAFETY IN THE SCIENCE CLASSROOM

To play a violin, one needs to know how to handle it properly. To do a meaningful experiment, one must mix and measure just as properly.

Sienko, Plane and Marcus, 1984

Note: This section of the framework is intended to assist the classroom science teacher in providing a safe laboratory environment that does not unduly restrict scientific activity. Information provided is intended to guide the teacher but will not guarantee against accidents. Secondary schools were provided with a CD-ROM entitled, *The Total Science Safety System—Hawaii Version* (JaKel, 2003), which amplifies information given here.

Although all teachers need to be concerned about safety in their classrooms, science teachers have special concerns. Statistics from the National Safety Council note that nationwide, 16% of 32,000 school-related accidents are science-related. Special knowledge and precautions are required when one works with chemicals, glassware, heating devices, electrical equipment, plants, and animals. In the eyes of the courts, ignorance of potential hazards or safe techniques is not an acceptable excuse.

Science teachers may be held liable for a lack of knowledge of safe procedures, as well as for not following them. They must also be aware of the mental and physical limitations of their students. If a teacher is being considered for negligence, the courts also consider the students' abilities and limitations. For example, all students may not have the motor coordination or the experience necessary for carrying out a particular experiment. The increased mainstreaming efforts of handicapped students into regular classes further magnify the issue.

The safety of students and teachers in science classrooms and laboratories requires good planning, constant practice of safety as a habit, and development of an attitude. Each individual must realize that the laboratory is a workplace where one has a safety responsibility to oneself and to one's fellow worker.

Concern for safety precautions must be communicated to and shared by all students. Every classroom demonstration and laboratory activity demands safety considerations. Safety should be taught through understanding and respect for potential hazards that equipment and chemicals may present when improperly handled rather than through fear. Proper supervision and training of students, availability of safety equipment, and constant effort to improve safety practices and procedures make the science laboratory a place where effective learning takes place and accidents are minimized. A science classroom that incorporates safety as a part of its everyday routine can foster an injury-free place.

The responsibility for safety in the science classroom and laboratory belongs to the administrator, the teacher, and the student, each assuming a share. Careful planning and adequate knowledge will allow potential dangers to be dealt with safely.

RESPONSIBILITIES OF SCHOOL ADMINISTRATORS

1. Be responsible for the administration and supervision of laboratory safety and practices for the school science programs.
2. Ensure that all science teachers certify annually that they have received and read this guide.
3. Take immediate corrective action to reduce or eliminate safety hazards.
4. Be responsible for administering emergency first aid to sick or injured students.

RESPONSIBILITIES OF DEPARTMENT CHAIR

1. Orient new teachers and substitutes as to teacher responsibilities for science safety.
2. Perform tasks assigned by the principal in administering the safety program for the school.
3. Conduct departmental or grade level meetings to discuss science safety-related topics.
4. Supervise the safety program for the department or grade level.
5. Devise, with department or grade level cooperation, suggestions for improvement of the science safety program together with recommendations to be submitted to the Educational Specialist for Science for the development of a more comprehensive manual.

RESPONSIBILITIES OF TEACHERS OF SCIENCE

Teachers must constantly be concerned with making every reasonable effort to prevent accidents. This requires training in safety practices and constant awareness of student behavior in the laboratory. Teachers must be aware of the application of safety practices and must display exemplary behavior regarding accident prevention.

1. Teachers should be familiar with the school procedures in case of an accident or injury. The school's Teacher's Handbook provides guidelines.
   a. The principal and department chair should be notified of an accident immediately.
   b. A properly trained person will administer first aid if necessary.
   c. An injury which requires medical care should be treated only by a physician.
   d. Prepare department accident report form (see Form 411, p. 194) immediately after an accident occurs. This will provide essential information regarding liability and will provide potential information to correct the cause of the accident.
2. Teachers should instruct students in laboratory safety procedures at the beginning of the school term. Students should be given specific instructions regarding the safe use of equipment and materials for each laboratory activity. Students should be reminded of the particular safety instructions just prior to conducting that laboratory activity. Students

should be given the list of responsibilities to read and sign early in the school year. This document is called a Student Safety Contract. Flinn Scientific and JaKel (2004) each have contracts that can be used.

3. Teachers should make regular laboratory inspections and notify the principal and department chair of the existence or development of any hazards. The sections of this appendix that detail chemical storage, disposal, and reactivity for inspection criteria may be helpful.
4. Teachers should require students to use personal protective devices such as laboratory aprons, safety eye shields (goggles), covered shoes, and gloves as they perform investigations for which these devices are appropriate. Appropriate personal protective equipment (PPE) is listed in the Material Safety Data Sheet (MSDS) for each chemical.
    a. The school will supply a set of student goggles for each classroom. Anytime chemicals, heat, glassware, or a potential for flying objects exists, teachers will require that students wear laboratory goggles. There are no exceptions to this rule. Students who wear contact lenses should be discouraged from wearing them in the laboratory when working with chemicals. If possible, recommend that they wear regular glasses on lab days. If a student must wear contact lenses, he or she needs to notify the teacher and wear non-vented chemical splash goggles. Goggles need to be sterilized between each student use.
    b. The school will supply and the teachers will require students to wear laboratory aprons anytime chemicals are used or when there is a potential for spilling anything on themselves.
    c. Anytime chemicals, glassware, or heavy equipment is used or when there is a potential for something falling on, cutting, or hurting the foot, teachers will require that students wear covered shoes. That means that the shoe must completely cover the foot. No sandals, slippers, or open toed shoes are allowed. Leather shoes with covered toes are appropriate safety devices when using acids or caustics.
5. Teachers should take precautions to shield and place students at safe distances from demonstrations when there is a possibility of chemicals splattering, a chance of a flash flame, or an explosion.
6. Warning signs should be posted in all areas where poisonous materials, high voltage electricity, pathogenic organisms, or radioactive materials may be located.
7. First responders need to be aware of the location and hazards of the chemicals contained in a chemical storage area in the event of an emergency. These areas need to be labeled using the National Fire Protection Association (NFPA) rating diamond. The NFPA diamond must be affixed to all of the outer and inner doors leading to any chemical storage area. The diamond should indicate the highest NFPA rating for each of the categories as well as any special considerations like oxidizer, no water, corrosive material, etc. The NFPA rating may be found on the MSDS for that chemical. The NFPA diamonds may be purchased from any vendor, including Safety Systems Hawaii.
8. When working with limited quantities of equipment, each student group should be small enough to avoid confusion, which might result in an accident.
9. Laboratory experiments and exercises which involve potential hazards should be previously tried out by the teacher to determine whether the lesson can be performed safely.

10. Student devices, equipment, and individual projects should be pre-tested before use as a demonstration in class. Even then, extra precaution must be exercised during the actual demonstration.
11. Teachers should be well trained in first aid and be able to render this help when needed. It is recommended that teachers maintain a current first aid certificate.[2]
12. All science classrooms must be equipped with the following safety equipment: safety shower, fire blanket, eye wash fountain, fire extinguisher, and first aid kit.
13. The areas around the safety shower, fire blanket, eye wash fountain, fire extinguisher, and first aid kit should be kept open for quick access in case of emergencies. All aisles and exits must be kept clear at all times.
14. All safety equipment (safety shower, fire blanket, eye wash fountain, fire extinguisher, and first aid kit) must be clearly labeled.
15. Teachers should keep bottles and containers of chemical materials labeled at all times. Liquids and solids in unlabeled containers should be discarded if the material can be identified and proper disposal is known.
16. Teachers should supervise students at all times.
17. Students should be warned of the hazards of conducting home projects involving explosive mixtures, poisons, pathogenic bacteria, and high voltage electricity (including house current).
18. Teachers should post by each exit the school's current evacuation map. Teachers need to familiarize students with the procedures and path as designated by this map in the event of an evacuation of the building.

In general, "reasonable care" may take two forms. A teacher must not do anything that a reasonable person would recognize as being potentially dangerous. Neither may teachers fail to do something that would be necessary to protect the safety of their students. Thus, negligent conduct may take two forms—the performance of an act that puts students in danger or the failure to take an action to protect them.

RESPONSIBILITIES OF STUDENTS

This list or rules and responsibilities should be given to students to read and sign at the beginning of the school year. Flinn Scientific and JaKel (2004) each have contracts that can be used.

1. Students should be familiar with safety procedures and take appropriate precautions at all times to insure the safety of every individual in the laboratory.
2. Students should follow instructions explicitly and perform only authorized experiments whenever hazardous conditions exist or potentially dangerous materials are available.
3. Students should practice good housekeeping—clean up spilled materials immediately, return equipment and chemicals to proper places, and dispose of waste materials into proper receptacles.

[2] For further reference, refer to Policy 1710-14.1, "Emergency Care for Sick or Injured Students, Policies and Regulations, Department of Education Code.

4. Students should wear appropriate personal protective devices such as aprons, safety glasses, and covered shoes while performing laboratory activities.
5. Students should know the location and proper use of the safety shower, eye wash fountain, fire extinguisher, fire blanket, and fist aid kit.
6. Students should immediately report all accidents and potential hazards to the teacher.
7. Students should consider every chemical as toxic and take precautions against poisonous fumes, corrosive materials, explosions, and fire. Never taste, smell, or touch any chemical unless instructed by the teacher.
8. Students who are allergic to substances such as formaldehyde, alcohol, latex, or certain plant and animal materials should inform the teacher and ask to be excused from working with them.
9. Students should never clown, play practical jokes, or take chances while working in the science laboratory.

CLASSROOM SAFETY PROCEDURES

Essential to any effective science program are established safety procedures. A set of classroom rules must be compiled and class time devoted to discussing them. This teaching activity must be written into a lesson plan; in a court of law, the lesson plan could be used as evidence that safety procedures were taught. Rules should be reviewed periodically and posted in a prominent place.

Suggested rules and procedures are provided below. These rules and procedures are not all-inclusive nor are procedures considered as “absolutes;” they should be interpreted with prudent caution.

General

- Maintain safe laboratory conditions by practicing good housekeeping.
- Never eat or drink in the laboratory or from laboratory equipment.
- Practical jokes or horseplay is not tolerated.
- Perform only those experiments that are authorized by the teacher.
- When in doubt about any procedure, ask before attempting to carry it out.
- Never sniff chemicals directly from the bottle. Use a wafting motion of the hand to note odors or fumes.
- Never conduct experiments in the laboratory alone.
- When using heat, use heat-safety items to protect yourself.
- Never use broken or chipped glassware. Dispose of it in the proper container. Always notify the teacher when you dispose of glassware.
- Never taste chemicals to determine its identification.
- Follow instructions on safe clothing and hairstyles. Safety glasses, aprons, and covered shoes should be worn. Don’t wear loose jackets, long ties or sandals. Tie back long hair.

Electrical

- Remember that the human body conducts electricity.
- Work areas, including the counters and floors, should be kept dry. Never handle electrical equipment with wet hands or when standing on a damp area.
- Never overload circuits.
- Discharge electrical condensers and Leyden jars before handling them to avoid severe shock.
- Never touch grounded objects, such as water and gas pipes, and an electrical circuit simultaneously.
- Use only three-prong polarized outlets.
- Inspect insulation on electrical wires before use. Never use an electrical wire with worn insulation.

Glassware

- Never “force” glass rods or tubing into rubber stoppers.
- If glassware is to be heated, use only Pyrex or other similar heat-treated type glassware.
- Broken glassware should be disposed of properly. Put into a special container marked, “Broken Glass.”
- Should glassware break, first pick up the large pieces with a whisk broom and dustpan. Very small pieces of glass can be picked up using large pieces of wet cotton. Never use fingers to pick up broken glass, regardless of size.
- Glassware should be cleaned thoroughly after each use.
- Use a safety ring on graduated cylinders to help prevent breakage.
- Do not touch glassware too soon after removing it from a heating source because the glassware can still burn for several minutes.
- The ends of all glass tubing must be squared and fire polished to dull the edges.
- In removing glassware from old stoppers, it is safer to slit open the stopper with a razor blade than to risk breaking the glassware.
- Glassware should not be used for mixing potentially explosive compounds.
- Beakers must not be used as drinking glasses since they may have poisonous residues from prior use.

First Aid and Emergencies

- Establish and periodically review first-aid procedures to be used in the event of an accident.
- Be certain that all students know the location of the exits, fire extinguishers, eyewash stations, safety showers, fire blankets, and first aid kit. OSHA standard identifying signs should be posted near each.
- Instruct students in emergency care for chemical burns, heat burns, chemicals in the eye, exposure to fumes, and skin irritations caused by chemicals.
- Emergency instructions should be posted concerning: fire, explosions, spillage, chemical reactions, and first aid procedures.

Storage Facilities

Proper storage facilities and policies are essential to the safe operation of any science laboratory. In many cases, several science teachers share storage facilities. It is important that policies be established and followed by all who use these facilities. Inadequate and improperly cared for storage areas are a major problem in school safety. Here are some policies that should be followed:

- Limit accessibility to authorized personnel.
- Secure storage areas when not in use.
- Keep only needed quantities of hazardous chemicals.
- Be certain that incompatible chemicals are not stored in close proximity.
- Label all chemicals as to substance, date received, hazards, and suggested precautions.
- Never use reagents when the labels are obliterated or missing.
- Avoid transporting chemicals and equipment when the halls are crowded.
- Do not store chemicals and equipment in the same room.
- Store chemicals alphabetically according to types. See suggested shelf patterns in this document.
- Lock flammables or toxic gases at or above ground level-not in basements.
- Store flammable or toxic gases at or above ground level-not in basements.
- Be certain storage rooms containing flammable, toxic, or combustible chemicals are properly ventilated.
- Do not allow smoking, open flames, or other heating devices in storage areas.
- Do not use the storage area for mixing or transferring chemicals.
- Inventory chemicals periodically (minimum is annually). Discard those chemicals that are out-of-date, have missing labels or are in damaged containers.

Note: The principal should be notified of any hazardous wastes that need to be disposed. Teachers should complete a waste disposal inventory. (An electronic version of this form may be down loaded from the safety and securities website http://fssb.k12.hi.us; click on “Forms” and then on “Hazardous material disposal inventory.”) Submit this completed form to the school administration. The administrator will contact the Safety and Security Office at 586-3457 for hazardous chemical disposal. The safety office wants to do a one-time schoolwide pick up, so the principal must coordinate with all teachers (science, industrial arts, photography, custodians, etc.) to dispose of all waste materials.

Suggested Shelf Storage Pattern–ORGANIC CHEMICALS

Organic #2 Alcohols, Glycols, Amines, Amides, Imines, Imides (Store flammables in a dedicated cabinet.)		**Organic #8** Phenol, Cresols
Organic #3 Hydrocarbons, Oils, Esters, Aldehydes (Store flammables in a dedicated cabinet.)		**Organic #6** Peroxides, Azides, Hydroperoxides
Organic #4 Ethers, Ketones, Ketenes, Halogenated Hydrocarbons, Ethylene Oxide (Store flammable in a dedicated cabinet.)		**Organic #1** Acids, Amino Acids, Anhydrides, Peracids (Store **certain** organic acids in acid cabinet.)
Organic #5 Epoxy Compounds, Isocyanates		**Organic #9** Dyes, Stains, Indicators (Store alcohol-based solutions in flammables cabinet.)
Organic #7 Sulfides, Polysulfides, Etc.	If possible avoid using the floor.	**MISCELLANEOUS**

(Store flammables in a dedicated flammables cabinet) **Organic #2** Alcohols, Glycols, Etc. **Organic #3** Hydrocarbons, Etc. **Organic #4** Ethers, Ketones, Etc. **Organic #9** Alcohol-based Indicators	If possible, avoid using the floor.	**Store severe poisons in Poisons Cabinet**

Suggested Shelf Storage Pattern—INORGANIC CHEMICALS

Inorganic #10 Sulfur, Phosphorus, Arsenic, Phosphorus Pentoxide		**Inorganic #7** Arsenates, Cyanides, Cyanates (Store away from water)
Inorganic #2 Halides, Sulfates, Sulfites, Thiosulfates, Phosphates, Halogens, Acetates		**Inorganic #5** Sulfides, Selenides, Phosphides, Carbides, Nitrides
Inorganic #3 Amides, Nitrates (not Ammonium Nitrate), Nitrites, Azides (Store Ammonium Nitrite away from all other substances-ISOLATE IT!)		**Inorganic #8** Borates, Chromates, Manganates, Permanganates
Inorganic #1 Metals and Hydrides (Store away from any water) (Store flammable solids in flammables cabinet)		**Inorganic #6** Chlorates, Bromates, Iodates, Chlorites, Hypochlorites, Perchlorates, perchloric acid, peroxides, hydrogen peroxide
Inorganic #4 Hydroxides, Oxides, Silicates, Carbonates, Carbon	If possible avoid using the floor.	**MISCELLANEOUS**

STORAGE SUGGESTIONS

1. Avoid floor chemical storage (even temporarily).
2. No top shelf chemical storage.
3. Shelf assemblies firmly secured to walls. Avoid island shelf assemblies.
4. Provide anti-roll-off lips on all shelves.
5. Ideally shelving assemblies should be of wood construction.
6. Avoid metal, adjustable shelf supports and clips. Use fixed, wooden supports.
7. Store acids in dedicated acids cabinet. Store nitric acid in that same cabinet only if isolated from other acids.
8. Store flammables in a dedicated flammables cabinet.
9. Store severe poisons in a dedicated poisons cabinet.

Acid Cabinet
(Acids are best stored in dedicated cabinets.) **Inorganic #9** Acids, except Nitric (Store Nitric Acid away from other acids unless your acid cabinet provides a separate compartment for Nitric Acid.)

Incompatible Chemicals

Many chemicals react violently when they interact, producing toxic fumes or becoming fire hazards. The chemicals in the left hand column below should be stored to prevent contact with the chemicals in the right-hand column.

Chemical	Enemies
Acetic acid	*Chronic acid, nitric acid, ethylene glycol, peroxides, permanganates.*
Acetone	*Concentrated sulfuric and nitric acid.*
Alkali metals	*Oxygen (in the air), water*
Ammonia (anhydrous)	*Mercury, hydrogen fluoride, calcium hypochlorite.*
Bromine, chlorine	*Ammonia, acetylene, butane, hydrogen, sodium carbide, turpentine, finely divided metals.*
Chlorates	*Ammonium salts, strong acids, powdered metals, sulfur, finely divided organic materials*
Copper	*Acetylene and hydrogen peroxide*
Flammable liquids	*Ammonium nitrate, chronic acid, hydrogen peroxide, sodium peroxide, nitric acid, the halogens.*
Hydrocarbons	*Fluorine, chlorine, bromine, chromic acid, sodium peroxide.*
Hydrogen peroxide	*Copper, chromium, iron, flammable liquids, other combustible materials*
Iodine	*Acetylene, ammonia.*
Oxygen	*Oils, grease, hydrogen, flammable liquids, solids, gases*
Potassium permanganate	*Glycerin, ethylene glycol, sulfuric acid.*
Silver	*Acetylene, ammonia compounds, oxalic acid, tartaric acid.*
Sulfuric acid	*Chlorates, perchlorates, permanganates, water*

Dangerous Substances and Reactions

More and more commonly used substances are being recognized as hazardous. In fact, full agreement has not yet been reached as to which substances should be classified as hazardous, especially with regard to carcinogens. The list keeps growing, and science teachers should keep abreast of new developments in this area.

The decision to conduct a particular activity or experiment should not be based on what has been done in the past. Just because an experiment appears in print somewhere does not mean it involves no potential dangers. Evaluate proposed experiments by asking: What are the known or alleged risks involved? Are there other substances that could be substituted? Are there other methods for meeting this objective? Should this experiment be designed as a student activity or as a teacher demonstration? How competent are the students? Are laboratory facilities adequate for conducting this experiment?

The following lists of potentially dangerous substances are not all-inclusive. The lists do present many of the hazardous substances that are likely to be encountered in scientific laboratory and/or fieldwork at the junior high and high school level.

Hazardous Chemicals

Note: Those items marked with an asterisk (*) should be removed from school laboratories. Little justification for their use exists.

Chemical	Dangers
Acetone, benzene, methyl alcohol, and other common organic solvents	*Serious toxic effect if inhaled over an extended period; flammable; may irritate skin, eyes, and lungs.*
Aluminum chloride	*Moderately toxic; painful skin and eye burns.*
Ammonia	*Vapor toxic; skin, eye and lung irritant.*
Ammonium dichromate	*Used to simulate volcanic eruptions in model volcanoes. Toxic; flammable; may react explosively with certain organic compounds. Keep in a tightly closed container and away from open flames. A substitute is strongly recommended for volcanic demonstrations.*
*Antimony and compounds	*Poisonous if swallowed, inhaled, or absorbed through the skin.*
Barium and compounds	*The metal and most barium compounds are poisonous; barium metal reacts with water to produce hydrogen (explosive) and barium hydride (poisonous).*
*Bromine	*Poisonous; short exposure to bromine liquid causes severe skin burns; exposure to high concentrations of vapor can cause death or major damage; skin irritant.*
Calcium carbide	*Active on water; produces highly combustible acetylene when reacting with water.*
*Carbon disulfide	*Highly flammable; liquid poisonous if swallowed; vapor is eye and lung irritant*
Calcium hypochlorite	*Poisonous, corrosive powder; harmful to eyes, skin, and lungs.*
Carbon tetrachloride	*Extremely poisonous; rapidly absorbed by the body in both liquid and vapor form; can cause acute liver damage and kidney failure. Use only when absolutely necessary and with extreme caution in a well ventilated area. Do not use for extinguishing fires or killing insects.*

Chemical	Dangers
*Chlorates and perchlorates	*Explode easily, with heat or shock, when only slightly contaminated. Most are poisonous if swallowed; dust is skin, lung, and eye irritant.*
*Chlorine	*Poisonous; extremely harmful to eyes, lungs, and respiratory tract.*
Copper compounds	*Toxic if swallowed.*
*Cyanides	*Vapor from acid or water contact is very poisonous. Somewhat poisonous by skin contact or swallowing.*
Ethers	*Flammable; open bottles form peroxides which are extremely explosive. Be certain to date bottles.*
*Hydrogen peroxide (10% and higher)	*Strong oxidant—avoid contact with combustible materials. High concentrations can cause eye, lung, and skin burns*
*Hydrogen sulfide	*Poisonous gas; can cause unconsciousness with severe or fatal effects on nervous and respiratory systems.*
Iodine	*Poisonous if swallowed; vapor harmful to eyes and respiratory system. Solid burns the eyes and skin.*
Lead compounds	*Toxic; poisons cumulative*
*Magnesium powder	*Potential fire hazard. Burns are severe and often slow to heal.*
Mercury and its compounds	*Use with extreme care. Can be absorbed into the body by inhalation, ingestion, or through the skin. Poisons are cumulative. Highly volatile. When metallic mercury is dropped, it breaks into many small droplets and is virtually impossible to clean up completely.*
Nitrites	*Metal nitrites are poisonous if swallowed or inhaled. Small amounts can be fatal. Can explode when heated or in contact with organic matter.*
Phosphorous (yellow or white)	*Poisonous if swallowed or if vapor and smoke are inhaled from burning phosphorus. Can cause severe skin burns. Ignites spontaneously in air.*
*Picric acid	*Severe explosion risk when shocked, heated, or subjected to friction. Especially reactive with metals or metallic salts, forming highly sensitive explosive compounds. Highly toxic.*
*Potassium metal	*Severe skin burns; ignites spontaneously in moist air; reacts violently with water.*
Potassium permanganate	*Strongly irritating to skin.*
PTC paper	*Phenylthiocarbamide or phenylthiourea taste papers often used in biology programs. Has not been approved by FDA; rodentacide.*
Sodium metal	*Flammable corrosive solid; reacts violently with water.*
Toluene	*Eye irritant (vapor and liquid); highly flammable; poisonous if swallowed or absorbed through the skin*

Carcinogens

The Occupational Safety and Health Administration (OSHA) has classified the following chemicals as cancer-causing substances. These chemicals should be banned for school use unless they are absolutely essential for special projects, which are conducted under strict personal supervision of a certified teacher who is knowledgeable in the handling and use of such compounds. These compounds are extremely toxic—even at concentrations of one part per billion.

- 4-Nitrobiphenyl (4-NBP)
- Beta-Propiolactone (BPL)
- Alpha-Naphthylamine (1-NA)
- 2-Acetylaminofluorene
- 4,4'-Methylene bis (2-chloroaniline)
- 4-Dimethylaminoazobenzene
- Methyl chloromethyl ether (CMME)
- N-Nitrosodimethylamine (DMN)
- 3,3'-Dichlorobenzidine (and its salts)
- Inorganic arsenic
- Bis-chloromethyl ether (BCME)
- Acrylonitrile
- Beta-naphthylamine (2-NA)
- 1,2-Dibromo-3-chloropropane (DBCP)
- Benzidine
- Vinyl chloride
- 4-Aminodiphenyl
- Asbestos
- Ethyleneimine (EI)
- Benzene

LABORATORY SUBSTITUTES

Original Material	Substitute	Comments
Acetamide	Stearic Acid	In phase change and freezing point depression
Benzoyl peroxide	Lauryl peroxide	When used as a polymer catalyst
Chloroform	1,1,1-trichloroethane	
Carbon tetrachloride	Cyclohexane	In test for halide ions
Carbon tetrachloride	1,1,1,-trichloroethane, 1,1,2-trichlorotrifluoroethane	
Formaldehyde	Peracetic acid	In cleaning of kidney dialysis machines
Formaldehyde	“Formalternate” (Flinn Scientific), Ethanol	For storage of biological specimens
Halogenated solvents	Non-halogenated solvents	In parts washers or other solvent processes
Sodium dichromate	Sodium hypochlorite	
Sulfide ion	Hydroxide ion	In analysis of heavy metals
Toluene	Simple alcohols and ketones	
Wood’s metal	Onion’s Fusible alloy	
Xylene	Simple alcohols and ketones	
Xylene or toluene based liquid scintillation cocktails	Non-hazardous proprietary liquid scintillation cocktails	In radioactive tracer studies

Source: Klein-Banay, C., Maier C., & Ashbrook, P. (1992). *Dtermination, Implementation and Evaluation of Laboratory Waste Minimization Opportunities.*. Urbana-Champaign, IL: Division of Environmental Health and Safety, University of Illinois—Urbana-Champaign.

Radioactive Materials

Certain weak radioisotopes have been approved for classroom use by the federal government. Use of such isotopes does not require a special license or complex safety measures, but certain precautions should be taken. Label such isotopes "RADIOACTIVE" and indicate the level of radioactivity, date of assay, kind, and quantity. Store in a locked cabinet that is marked "RADIOACTIVE MATERIAL." Avoid getting radioisotopes near the eyes, mouth, or open sores. Perform reactions under a fume hood. Wash hands after each experiment and test with a Geiger counter. Check all radioactive specimens brought into the laboratory to be certain that the radiation is not at a dangerous level.

Never use X-ray machines on students for demonstration or other purposes. Operate tubes at the lowest possible current and voltage. Keep time of operation at a minimum. Keep students at least eight feet away from a tube when it is operating.

Poisonous Plants

According to the U.S. Public Health Service, plants poison approximately 12,000 children each year. Some become violently ill; some die. Over 700 species of plants are known to cause death or illness. Teachers and parents are often unaware of the dangers of many plants used in the school and at home—or encountered on field trips. The following is a list of common poisonous plants.

Plants	Dangers
Rosary pea or jequirity bean	*Seeds are violently poisonous. Ingesting a single seed has caused death.*
Elephant ear	*Intense pain around lips, mouth and tongue if chewed. If base of tongue swells and blocks air passage, death can result.*
Crownflower	*Sap can cause severe eye injury.*
Red pepper, chili	*Burns skin and mouth. Large doses may cause severe poisoning.*
Autumn crocus or meadow saffron	*Intense thirst, burning of throat, vomiting; possible death from respiratory failure.*
Foxglove	*Nausea, vomiting, dizziness; affects heart rhythm (source of digitalis). May be fatal.*
Castor bean	*Ingestion may lead to convulsions, exhaustion, and death.*
Bird of paradise	*Severe poisoning if ingested.*
Philodendron	*Skin rash requiring long-term medical care; swelling of mouth and throat if ingested.*
Lily of the valley	*Roots, leaves, and fruit can stimulate the heart (similar to digitalis).*
Yew	*Violent gastrointestinal distress; ingestion also causes quick pulse, fainting, convulsions, and death.*
Yellow oleander	*All parts of the plant are extremely poisonous; affects the heart; produces severe digestive upset; may be fatal.*
Jerusalem cherry	*Vomiting when ingested; local irritation; slowing action on the heart.*

Plants	Dangers
Rhododendron	*Intense pain, diarrhea, and discomfort*
Golden chain	*Severe poisoning. Excitement, uncoordination, convulsions, and coma. May cause death.*
Candelabra cactus	*May severely impair visual acuity on contact with the eye.*
Black locust	*Seeds can cause dullness and depression, vomiting and weak pulse if ingested.*
Hyacinth, daffodil, narcissus	*Bulbs may cause nausea, vomiting, and diarrhea if ingested. May be fatal.*
Poinsettia	*One leaf can kill a child.*
Mistletoe	*Berries are poisonous; can be fatal.*
Rhubarb	*Ingestion of large amounts of leaf blades can cause convulsions, coma, and death.*
Daphne	*Berries can be fatal.*
Wisteria	*Seeds and pods cause mild to severe digestive upset.*
Oak	*Chewing on leaves or acorns gradually affects kidneys. Symptoms appear only after several days or weeks.*
Elderberry	*Using the pithy stems for blowguns has poisoned children. Nausea and digestive upset result.*
Jack-in-the-pulpit	*All parts contain crystals of calcium oxalate that cause intense irritation and burning of the mouth and tongue.*
Mayapple	*Contains at least 16 active toxic principles, mostly in the roots. Eating of the apples may cause diarrhea.*
Buttercup	*Irritant juices can severely injure the digestive system.*
Nightshade	*Intense digestive disturbances and nervous symptoms. All parts, especially the unripe berry, may cause death.*
Poison hemlock	*Resembles a large wild carrot. All parts may be fatal.*
Jimson weed thorn apple	*All parts may cause abnormal thirst, delirium, distorted sight, incoherence, and coma. Common cause of poisoning. May be fatal.*

Identification of Waste

How does a teacher determine if waste is hazardous? Where can the criteria be found? The teacher can consult the Material Safety and Data Sheets (MSDS) under the topic of "Disposal" or the teacher can contact the Hazardous Waste Division at 586-4226.

Hazardous Waste

Hazardous wastes are regulated by the U.S. Environmental Protection Agency under the Resource Conservation and Recovery Act (RCRA). Responsibility for proper management and disposal of such wastes extends to all personnel. Businesses (i.e., schools) that generate the waste are liable for its proper handling and disposal.

Hawaii does not have its own hazardous waste rules; therefore the federal regulations are being implemented. The state agency responsible for monitoring these regulations is the

Hawaii Department of Health, Solid and Hazardous Waste Branch. Regulations governing hazardous waste are defined in 40 Code of Federal Regulations (CFR) Parts 260 to 270. Hazardous wastes fall into two groups: characteristic wastes and listed wastes.

Characteristic wastes, identified in 40 CFR Parts 261.20 to 261.24, are defined as:

- Ignitable—a liquid with a flash point less than 60° C (140° F), or an ignitable compressed gas.
- Corrosive—an aqueous liquid with a pH less than or equal to 2.0 or greater than or equal to 12.5.
- Reactive—a substance that is normally unstable and undergoes violent change without detonating, or reacts violently with water.
- Toxic—a waste that contains one or more of 40 contaminants, listed in Table 1 of 40 CFR Part 261.24, at concentrations defined by the Toxicity Characteristic Leaching Procedure (TCLP).

Listed wastes are defined based on activity or industrial process. They exhibit one or more of the characteristics mentioned above, or have been shown to be harmful to health and the environment. There are four lists including over 400 types of wastes; these can be found in 40 CFR Parts 261.30 to 261.33. Listed within these items are hazardous and acutely hazardous wastes, identified in the tables in 40 CFR Parts 261.31 and parts 261.33, respectively.

The business' (i.e., school's) status as a hazardous waste generator is determined by the wastes generated at the business (i.e., school) and the total quantity of hazardous wastes generated in any one month.

Regulated Hazardous Waste Generator:

A ***Conditionally-Exempt Small Quantity Generator (CESQG)*** of hazardous waste is one that generates no more than 100 kg (about 220 pounds or 25 gallons) of hazardous waste and no more than 1 kg (about 2 pounds) of acutely hazardous waste in any calendar month. A CESQG must:

- Identify all hazardous waste generated;
- Send waste to site permitted to manage hazardous waste or one that is permitted by the state to accept municipal or industrial solid waste; and
- Accumulate no more than 1,000 kg of hazardous waste on business property at any given time.

Also, it is recommended that a CESQG:

- Segregate hazardous and non-hazardous wastes;
- Label waste containers with words "Hazardous Waste";
- Store these wastes in sound compatible containers, keeping them closed.

Many schools will probably fall under the CESQG classification on a regular basis. If a school cleans out a storeroom or generates more than the 220 lbs in any given month, it will be classified as a small quantity generator for the year.

A ***Small Quantity Generator (SGQ)*** of hazardous wastes is one that generates more than 100 kg but less than 1,000 kg (between 220 and 2,200 pounds or about 25 to less than 300 gallons) of such waste, and no more than 1 kg of acutely hazardous waste in any month. A SGQ must:

- Identify all hazardous wastes generated;
- Send waste to a hazardous waste treatment, storage, or disposal (TSD) facility for proper management and disposal;
- Obtain a EPA Identification Number for Hazardous Waste Activities (see Resources, this section);
- Never accumulate more than 6,000 kg of hazardous waste on site;
- Never store waste at the business site for more than 180 days, or 270 days if the waste must be shipped to a TSD facility more than 200 miles away;
- Complete a Uniform Hazardous Waste Manifest form to allow tracking of hazardous waste from generation to TSD facility;
- Complete a Land Disposal Restriction Notification, as required, when sending waste off site for disposal;
- Place waste in sound compatible containers, marked with the words "Hazardous Waste," and the date when accumulation began; and
- Keep Hazardous Waste containers closed, and inspect them weekly for leaks and deterioration.

In addition, a SQG must develop a "Preparedness and Prevention Plan" for the safety of employees [40 CFR part 262.34 (d) (4)]. The plan should address the following:

- Ensure that all employees are familiar with proper waste handling and emergency procedures;
- Minimize the possibility of fire, explosion or any unplanned sudden or non-sudden release of hazardous waste;
- Establish an internal communication of alarm system, and ensure that the following are easily accessible: a telephone to obtain emergency assistance, fire extinguishers, and spill control and decontamination equipment;
- Inform the police, fire department, local hospital, and emergency response agency of the facility layout and types of hazardous waste handled at the site; and
- Designate an Emergency Coordinator who can be contacted 24 hours a day, and post emergency information next to the facility phone.

Questions or concerns about regulatory requirements of SQG's can be directed to the appropriate state or federal agency (see Resources, this section). [Adapted from *Waste Management Services in Hawai`i,* Hawaii Department of Health, September 1992.]

Disposal of Hazardous Substances

What criteria does the Safety Office want teachers to use for disposal guidelines? Are there written disposal guidelines that a teacher can look up and follow? For example, is it safe to put NaCL down the drain but not $BaCl_2$? Schools can check the MSDS sheets or call the hazardous Waste Management Division at 586-4226.

An estimated 30 to 40 million tons of hazardous wastes are generated annually. Much of this waste is being disposed of in ways that are neither legally acceptable nor environmentally safe. Methods for disposing of chemicals vary with the nature of the chemicals and with local regulations. The following are general rules:

1. Never dispose of liquid wastes in wastepaper baskets. The safety of custodial help must always be considered.

2. In general, flush nonflammable water-soluble liquids down the drain with large quantities of water, if acceptable, based on the MSDS sheet or an inquiry to the Hazardous Waste Management Division at 586-4226.

3. Place liquids heavier than water in special containers since they may clog drains if flushed.

4. Flush small quantities of insoluble liquids down the drain if they are nonflammable and nontoxic.

5. Place flammable liquids and insoluble liquids over a liter in special labeled, covered containers.

6. Do not flush mercury or its compounds down the drain. Mercury in solution can be precipitated with a solution of sodium chloride. The precipitant can be discarded with other solid lab waste.

7. To clean up mercury spills, push droplet or mercury together and collect them. Sprinkle powdered sulfur over the area and allow 24 hours for the sulfur and mercury to react. Carefully sweep up the mercury sulfide. Spills on smooth surfaces can be cleaned with a suspension made from 250 milliliters of liquid detergent, 250 milliliters of sulfur, and one liter of water. Mop on surface and let dry overnight. Mop up.

8. Many chemicals and solid wastes can be dumped into landfills. This list includes dry cell batteries, lamp bulbs, scrap metal, paint, rubber, scrap glass, and scrap stone ware.

9. For the safe disposal of extremely dangerous, unlabeled, or contaminated chemicals, consult commercial chemical disposal firms, local colleges or universities, local industries that use or produce such chemicals, the nearest office of EPA or Department of Health.

Waste Minimization in Action: Checklist for Laboratories

HANDLING AND STORING MATERIALS

__ Develop a purchasing strategy for hazardous materials
- √ Designate a single person to be responsible for purchasing and tracking of hazardous materials (e.g. Department Head)
- √ Purchase hazardous materials in small sizes

__ Institute inventory control
- √ Designate a centralized place for raw hazardous materials and for hazardous waste, with spill containment
- √ Label all materials properly and keep covered to prevent spills
- √ Use a first-in/first-out policy for materials
- √ Return expired materials to supplier (sometimes it is a part of the contract)

__ Work on spill and leak prevention
- √ Inspect equipment used for hazardous materials and repair any leaks
- √ Keep a record of spills and note why they happen

BETTER LABORATORY PROCEDURES

__ Segregate wastes
- √ Keep hazardous waste separate from non-hazardous waste
- √ Keep different groups of solvents separate (i.e., halogenated and non-halogenated solvents)

__ Use solvents and other hazardous materials sparingly

__ Monitor chemical reactions closely, and add additional chemicals only as necessary

__ Run “micro-scale” experiments (i.e., smaller scale experiments using less chemicals)

__ Set up a procedure to filter used solvent for reuse where possible

__ Set up procedures for non-regulated lab treatment of waste materials
- √ Neutralize acids and bases
- √ Perform chemical conversion to create non-hazardous substances

MATERIALS SUBSTITUTION

__ Substitute less hazardous chemicals for more hazardous ones
- √ Use laboratory detergent rather than hazardous cleaning baths (i.e., substitute detergents for chromic acid solutions)
- √ Use non-halogenated solvents rather than halogenated solvents (i.e., substitute cyclohexene for carbon tetrachloride)
- √ Use less toxic/hazardous solvents rather than more toxic/hazardous ones

RECYCLING

__ Set up an internal surplus chemical exchange

__ Participate in outside chemical/waste exchange programs (see HIMEX form attached)

__ Distill spent solvents on-site

__ Recycle solvents via a solvent-recycling service

Waste Minimization in Action: References

[Prepared by Hazardous Waste Minimization News of Hawai`i. June 1992.]

American Chemical Society. 1985. Less is Better. Pamphlet.

Armour, Dr. Margaret-Ann. 1990. Hazardous Laboratory Chemicals Disposal Guide. CRC Press, Inc., Boca Raton, FL. (Toll-free phone line: 1-800-272-7737)

Klein-Banay, Cindy, Chuck Maier, and Peter Ashbrook. No date. 101 Ways to Reduce Hazardous Waste in the Lab. Funded by the Illinois Hazardous Waste Research and Information Center.

Minnesota Technical Assistance Program. 1986. Hazardous Waste Fact Sheet for Minnesota Generators – Laboratories.

Municipality of Metropolitan Seattle. 1990. METRO Industrial Waste Program: Waste Management Guidelines for Analytical Laboratories.

Ross and Associates. 1991. Materials developed for Meeting on Hazardous Waste Minimization in Schools and Laboratories. Funded by Hawai`i Department of Health, Solid and Hazardous Waste Branch.

U.S. Environmental Protection Agency. 1990. Guides to Pollution Prevention: Research and Educational Institutions. EPA/625/7-90/010.

U.S. Environmental Protection Agency. 1988. Waste Minimization Opportunity Assessment Manual. EPA/625/7-88/003.

RESOURCES (ON HAZARDOUS WASTE)

[Prepared by Hazardous Waste Minimization News of Hawai`i, June 1992.]

Hawaii Department of Health, Honolulu: Solid and Hazardous Waste Branch
(SHWB), Hazardous Waste Section – ph: 586-4226
(SHWB), Solid Waste Section – ph: 586-4227

EPA Public Information Office, Honolulu – ph: 541-2710

EPA RCRA Information Hotline: (415) 744-2074 (M-F, 1-4 p.m., PST)

RCRA/Superfund Hotline: (800) 424-9346 (M-F, until 7:30 p.m., EST)

EPA's Hazardous Waste Ombudsman Hotline: (800) 368-5888 (M-F, until 5:00 p.m., EST)

EPA RCRDA Docket (to order publications, have EPA publication number ready)
– Ph: (202) 260-9327

Government Institutes, Inc. [to order Code of Federal Regulations (CFRs)]
– Ph: (301) 921-2355

HIMEX LISTING FORM

DATE ______________________________

BUSINESS NAME ____

CONTACT NAME ____

TITLE __________________________________ TYPE OF BUSINESS ____________________________

STREET ADDRESS ____

CITY, STATE ____ ZIP CODE ___________

PHONE ____ FAX ____________________________

MATERIALS AVAILABLE/WANTED (circle one)
MATERIAL CLASSIFICATION (circle one)

1 ACID	7 PLASTIC & RUBBER	13 CONTAINERS & PALLET
2 ALKALIS	8 TEXTILES & LEATHER	14 DURABLE & ELECTRONIC GOODS
3 OTHER INORGANIC CHEMICALS	9 WOOD & PAPER	15 GLASS
4 SOLVENTS	10 METALS & METAL SLUDGES	16 PAINTS & COATINGS
5 OTHER ORGANIC CHEMICALS	11 LABORATORY CHEMICALS	17 MISCELLANEOUS
6 OILS & WAXES	12 CONSTRUCTION MATERIALS	

NAME OF MATERIAL: ____ AMOUNT: ________________

FREQUENCY OF AVAILABILITY: ONE TIME ONLY RECURRING (circle one)
If recurring, how frequent and in what amounts? ____

____

LOCATION OF MATERIAL (City, State): ____
Is material currently classified as a Hazardous Waste? ____

FOR MATERIALS WANTED, list acceptable geographic range:

CHECK ONE: ____ NON-CONFIDENTIAL (your name and phone number will be available with listing)
____ CONFIDENTIAL (we turn inquiries over to you to make contact if you wish)

DIRECTIONS: Write the information as you want it to appear in the catalog (including information that an interested party would want to know i.e., location, condition, composition, packaging, sample availability, pH, toxicity, contaminants, potential uses). Include Material Safety Data Sheet if available.

Please Mail Copy to:
Waste Minimization Coordinator
Department of Health, Solid & Hazardous Waste Branch, Five Waterfront Plaza, Suite 250
500 Ala Moana Boulevard, Honolulu, Hawai`i 96813

Microscale Experiments

Implementing micro-scale experiments, where appropriate, is a laboratory practice that can help reduce the toxicity and quantity of wastes generated through chemical reactions. Lab waste is reduced as a result of reduced volume of chemicals and the local environment benefits.

Although microscale laboratory manuals are available, many existing laboratory experiments can be microscaled using the existing manual. It is not necessary to abandon present lab procedures because a teacher can do this incrementally.

Other benefits include:

- Decreased chemical and equipment cost. Measurement of classroom quantities is done in grams rather than kilograms.
- Decreased storage space. Materials can be stored as a complete set using little space. This reduces setup time for the same experiment in the future.
- Faster cleanup time.
- More laboratory work completed.
- Increased motor skill development. Students have shown to exhibit more care and attention when dealing with micro-volumes.
- Increased finish time and verification opportunities.
- Increased safety. Teacher and students use smaller quantities of potentially hazardous materials.

A corollary to this practice is that the teacher spends less time in preparing for the experiment and in cleaning up. Students can finish the experiment in a shorter amount of time. As a result, multiple trials can be completed and pre-post-lab discussions can be conducted in the same class period.

Selected Materials that Support Microscale Experiments

Reaction Plate—Generally used in place of test tubes.
Beral-Type Pipet—Made of polyethelene, it comes in four types: thin stem, micro tip, extra large bulb, and graduated.
Pasteur Pipet—Used as a dropping bulb; can be cut to size.
Eppendorf Pipet Tip—Affixed to a standard syringe to make an accurate dropping pipet; a needle is therefore not needed.
Culture Flask—Can be used as a solution storage vessel. Stackable on its side, which allows storage of many containers in a small space.

MODEL ROCKETRY FLIGHT STANDARDS

Using model rockets requires practice and preparation. It is important for teachers to test the equipment and choose an appropriate launch site before students launch rockets. Below is a list of guidelines from the Federal Aviation Administration (FAA):

a. Do not use more than four ounces of propellant.
b. Use a slow burning propellant.
c. Rockets must be made of paper, wood, or breakable plastic, containing no substantial metal parts and weighing not more than 16 ounces, including propellant.
d. Rockets must be operated in a manner that does not create a hazard to persons, property, or other aircraft.

Launch Site Dimensions

- Minimum Launch Site Dimensions: Dimension for a circular area is the diameter in feet. For a rectangular area, the dimension is the shortest side in feet.
- In selecting a site, the larger the better.
- Choose a large field away from power lines, tall buildings, tall trees, and low flying aircraft.
- Be aware of wind direction and speed.
- The area must be clear of obstruction AND HAVE NO DRY WEEDS OR HIGHLY FLAMMABLE MATERIALS.

ENGINE TYPES	MINIMUM LAUNCH SITE DIMENSION	MAXIMUM ALTITUDE
¼ A to ½ A	50 feet	200 feet
A	100	400
B	200	800
C	400	1,600
D	500	1,800

References

Federal Aviation Administration (FAA)
Flight Standards District Office
90 Nakolo Pl., Room 215
Honolulu, HI 96819.
Ph: 808-836-0615
FAX: 808-836-8163
National Association of Rocketry (NAR)
The Hobby Industry of America
Toy Manufacturers of America (TMA)
Canadian Association of Rocketry

Safety Resources

National Science Teachers Association (NSTA)
http://www.nsta.org/

Scilinks
http://www.scilinks.org/default.asp

Flinn Scientific
http://www.flinnsci.com/

Rev. 8/90, RS 90-8690 (Rev. of RS 85-7510)

STATE OF HAWAII
DEPARTMENT OF EDUCATION
Office of Business Services
P.O. Box 2360
Honolulu, Hawaii 96804

STUDENT ACCIDENT REPORT
Form No. 411

School ______ School Code # ______ Accident Report # ______

Report Filled Out By ______ Position ______ Date of Report ___/___/___ (Month Day Year)

A. STUDENT INVOLVED

Name ______ (Last) (First) (Initial)

Grade ____ Age ____ Sex ____ Reg. ____ Spe'l ____

Accident Date ___/___/___ (Month Day Year) Time ____ AM__PM__

E. PART OF BODY INJURED

☐ Abdomen ☐ Eye ☐ Knee
☐ Ankle ☐ Face ☐ Leg
☐ Arm ☐ Finger ☐ Teeth
☐ Back ☐ Foot ☐ Wrist
☐ Chest ☐ Hand ☐ Other (Specify)
☐ Elbow ☐ Head ______

B. LOCATION OF ACCIDENT

☐ Agriculture Field ☐ Playground
☐ Athletic Field ☐ Shop
☐ Cafeteria ☐ Stairs/Steps
☐ Classroom ☐ Swimming Pool
☐ Gymnasium ☐ Walkway, Outdoor
☐ Hallway ☐ Other (Specify)
☐ Parking Area ______

F. IMMEDIATE ACTION TAKEN

☐ First Aid By ______
☐ Sent to Health Aide By ______
☐ Sent Home By ______
☐ Sent to Doctor By ______
Doctor's Name ______
☐ Sent to Hospital By ______
Hospital's Name ______
By What Means ______

C. ACTIVITY INVOLVED IN ACCIDENT

☐ Athletics ☐ Play/Free Time
☐ Classroom ☐ Transportation/Trip
☐ Physical Education ☐ Other (Specify)
______

G. PERSON NOTIFIED

☐ Parent ☐ Guardian ☐ Friend
Name of Person Notified ______
By Whom Notified ______
By What Means ______
If so, how long after injury ______
______

D. APPARENT NATURE OF INJURY

☐ Abrasion ☐ Poisoning
☐ Bruise/Bump ☐ Puncture
☐ Burn ☐ Shock (Electrical)
☐ Cut/Laceration ☐ Sprain
☐ Dislocation ☐ Sting
☐ Fracture ☐ Other (Specify)
☐ Head Injury ______

H. WITNESS TO ACCIDENT
(Additional witnesses may be attached)

Name ______ ☐ Staff ☐ Student

Name ______ ☐ Staff ☐ Student

First Staff Person at Scene of Accident
______

I. DESCRIPTION OF ACCIDENT
(How did accident happen? What was student doing? Additional information may be attached.)

______
______
______
______

______ Principal's/VP's Signature ______ Date

DISTRIBUTION: WHITE-School; CANARY-District Office; PINK-School Safety & Security, OBS