SCIENCE FRAMEWORK

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STATE OF TENNESSEE

Prepared by
Tennessee Science Teachers
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SCIENCE FRAMEWORK

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PREFACE

Consistent with the State Board of Education Rules, Regulations, and Minimum Standards, the Tennessee Science Curriculum Framework, K-12, was developed by a statewide committee of science educators. A concerted effort was made to ensure that the revised document is in alignment with the national science education standards developed by the National Research Council. It is designed to serve as a foundation for developing a comprehensive science program that includes **both** process and content. This document is provided as a **descriptive** tool, rather than a **prescriptive** device, to be used to identify concepts which all students need to know. Each local school system is required to implement the Tennessee Science Curriculum Framework, K-12 beginning with the 1997-98 school year.

Three science credits are required for graduation. These credits must be drawn from both the life sciences and the physical sciences. All science courses require a laboratory component. Successful implementation of the science framework requires the active participation of students as they explore the natural world. Content and process must merge so that students understand scientific concepts and their applications in technology, as well as make connections among science, technology and society.

The State Department of Education expects to have sufficient computer and print copies of the framework available to each school system to facilitate the correlation of performance objectives with the stated concepts and content.

PHILOSOPHY

The Tennessee Science Curriculum Framework Committee believes that a science framework should help science educators at all levels understand and appreciate the reforms that are needed. A framework should organize, specify, and integrate the content, themes, processes, and attitudes of science for all of Tennessee's public school teachers. It should provide examples of what students should know and be able to do in science at all levels, K-12. The framework should provide an umbrella under which Local Educational Agencies (LEA's) can organize and specify the components of their science curriculum. Moreover, it should provide direction and guidance to districts and schools as they bring their science curriculum in alignment with national and state curriculum reform efforts. It is essential that the framework be descriptive and not prescriptive. It should be a document that is evolving and changing as new ideas and experiences become known.

We believe that a Tennessee Science Curriculum Framework should be a document that assists LEA's in translating content, teaching, and assessment standards into the science program. A framework should provide goals and a road map for achieving those goals. The Tennessee Science Curriculum Framework will help to insure that Tennessee students will have rich and meaningful science experiences that will produce a citizenry that is scientifically literate. Curriculum guides, on the other hand are more detailed than a framework, providing content synopses and activities for schools, and representing the unique flavor and need of the community. Curriculum guides may be developed at the state or local level. Classroom connectors require significant preparation time, due to greater curricular specificity than that required for the curriculum guide. However, they provide a more complete presentation of content and a more detailed set of instructions for activities. Both of these emphases are desirable for a complete development of the performance objectives, and attainment of the desired response(s) on the assessment activities. Classroom connectors may be developed at the state or local level.

VISION STATEMENT FOR FRAMEWORK

Science is a way to explore and understand the world. It is a response to curiosity. Through a basic knowledge of science, people learn about the world, its technology, its environment, and the decisions that must be made to preserve the planet. Science strengthens the ability to think reactively and objectively. A scientifically literate person makes informed decisions and has rich and meaningful experiences in the natural world at an early age.

If students are to construct meaning from experience, they must be provided with the time and the opportunity to experience the natural world. These experiences help to develop the skills of reading, writing and numeration as the child makes observations, collects data, orders and classifies objects, manipulates variables, and communicates findings (orally and in writing) to others.

Science is the cornerstone of early achievement. Using the natural curiosity of a child as the building block, the skills of reading, writing, and numeration are enhanced.

Science is a capstone for living. Ethical decisions are often decided by an understanding of scientific principles involved.

Science is a way of knowing. The practice of science builds on experiences and is an important way new knowledge is discovered. Science is a way of thinking. It is constantly questioning, seeking alternative solutions, looking for a better way. Science is a way of doing. It is experimenting, finding and evaluating new ideas, new solutions. Doing science is a life-long adventure that positively affects all people in their daily lives and careers. As students do science they see the relationship between science and other areas of human understanding. Science instruction is relevant and recognizes the different ways and settings in which people learn. Science enhances curiosity, excitement, adventure, wonder, and joy.

There are certain underlying principles supporting the framework vision for science education in Tennessee. These have emerged from several major scientific, educational, and business groups, as well as government agencies, on ways to improve science teaching and learning. They include:

- The content of the science curriculum must be composed of significant and accurate science concepts and reflect thoughtful coordination across science domains and with other curricular areas.

- All students should have the opportunity to learn science and should be taught in ways that encourage and build upon their natural curiosity and other abilities.

- Students learn more readily and remember things longer when they can connect new experiences with their natural and cultural environment.

- Young people build critical thinking skills and scientific habits of mind when they are allowed to become scientists - rather than simply studying science.

- Students gain coherent understanding of major science concepts when they revisit these concepts with increasing sophistication at various cognition levels.

- Not all science learning takes place in the schools. Experiences with the natural and cultural environment greatly enhance scientific literacy.

- Excellence in science requires a safe and adequate physical environment and grows from a commitment shared by students, parents, teachers, administrators, and the community.

NATIONAL AND STATE GOALS OF EDUCATION AND SCIENCE EDUCATION

NATIONAL EDUCATION GOALS

The National Education Goals codify into law eight goals and their objectives. The goals state that, by the year 2000:

1. all children in America will be ready to learn;

2. the high school graduation rate will increase to at least 90 percent;

3. American students will leave grades 4, 8, and 12 having demonstrated competency over challenging subject matter including English, math, science, arts, foreign languages, history and geography, civics and government, and economics;

4. the Nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century;

5. U. S. students will be first in the world in math and science achievement;

6. every American will be literate and will possess the knowledge and skills necessary to compete in a global economy;

7. every school in America will be free of drugs, alcohol, and violence and will offer a disciplined environment conducive to learning;

8. every school will promote partnerships that will increase parental involvement and participation in promoting the social, emotional, and academic growth of children.

NATIONAL GOALS OF SCIENCE

The goals for school science that underlie the National Science Education Standards as produced in the 1994 draft are designed to educate students who are able to:

1. use scientific principles and processes appropriately in making personal decisions;

2. experience the richness and excitement of knowing about and understanding the natural world;

3. increase their economic productivity; and

4. engage intelligently in public discourse and debate about matters of scientific and technological concern.

Achieving these primary goals of science education also should result in students who are aware of careers in science, technology, and the health professions.

Achieving these goals is possible when all citizens are scientifically literate. The standards for content define what the scientifically literate person should understand and be able to do after 13 years of schooling.

The standards for assessment, teaching, program, and system describe the conditions necessary to achieve the goal of scientific literacy for all students, including opportunities for students to learn and for teachers to teach. Implementation of the standards calls for schools to be centers for inquiry and for an educational system that supports such schools and teachers.

Students could not achieve the standards in most of today's schools. Schools that implement the standards will have students learning science by actively engaging in inquiries of interest and importance to them. Such students will establish a knowledge base for understanding science. Teachers will be empowered to make decisions about what students learn and how they learn it and about how resources are allocated. Teachers and students together will be members of a community focused on learning science and nurtured by a supportive education system.

GOALS OF SCIENCE IN TENNESSEE

Science education is closely related to the goals of education set forth by the State Board of Education. The <u>Rules, Regulations, and Minimum Standards</u> require that a continuous program in science be provided for every child. Goals of Science in Tennessee will enable students to:

1. demonstrate the processes of science by posing questions and investigating phenomena through language, methods and instruments of science;

2. acquire scientific knowledge by applying concepts, theories, principles and laws from life science, physical science, earth/space science, and environmental science;

3. demonstrate ways of thinking and acting inherent in the practice of science and exhibit an awareness of the historical and cultural contributions to the enterprise of science; and

4. demonstrate positive attitudes toward science in solving problems and making personal decisions about issues affecting the individual, society and the environment.

INTRODUCTION

This framework is designed to help science educators at all levels understand and appreciate a new dynamic in science learning. Its significance lies in the fact it requires actively engaging students in learning about the natural and technological world in which they live. The framework provides an opportunity for innovative approaches to science education. Innovation is especially important in a field that is constantly adapting to new advances in basic knowledge in such areas as medicine, engineering and technology. To be prepared for the twenty-first century, students must be able to apply the principles and practices of science. For all students to achieve scientific literacy, it is critical that schools:

- provide quality instruction and promote integration in the four basic scientific fields of study: life science, physical science, earth/space science, and environmental science;
- present science in connection with its application in technology and its implication for society;
- present science in connection with students' own experiences and interests using hands-on approaches that are integral to the instructional process;
- provide students with opportunities to reflect on historical and cultural perspectives and to develop the important ideas of science through inquiry and investigation;
- provide students with fewer content topics taught to higher cognition levels;
- teach students to reason logically and evaluate critically the results and conclusions of scientific investigations.

WHAT IS SCIENCE?

Science is the component of the school curriculum in which student inquiry and discovery can develop and flourish. Science instruction encourages questioning, examining, probing, and exploring; it allows students to cultivate personal strategies for learning. Science is, above all, a problem-solving activity that seeks answers to questions by collecting and analyzing data offering explanations of naturally occurring events. The knowledge that results from scientific problem solving is most useful when it is organized into concepts, generalizations, and unifying principles, which lead to further investigations of objects and events in the environment. Science is practiced in the context of human culture, and therefore, dynamic interactions occur among science, technology, and society. Four components of science education - process of science, unifying concepts of science, habits of mind, and science in society - are critically important to instruction in science.

SCIENCE SHOULD BE A POSITIVE EXPERIENCE FOR ALL STUDENTS

In order to function in an information age, all students must have an understanding of scientific ways of thinking and science knowledge. Learning science helps develop critical thinking skills and gives practice in the use of evidence in decision making. All citizens use a basic understanding of science and technology to make good decisions about various social issues that affect their lives. Therefore, the most significant goal of science education is to improve the quality of life of the nation's children so that they will be well rounded, clear-thinking, scientifically literate citizens. As this goal is accomplished the best foundation for producing scientists will be laid, and the production of scientists is clearly seen as a need in our society.

EMPHASIZING UNDERSTANDING OVER CONTENT COVERAGE

Recent research in science teaching and learning provides clear evidence that most students are memorizing facts rather than becoming scientifically literate. There is now a large body of research-based knowledge compiled over a long period of time that supports the belief that the "facts only" approach to science teaching when compared to the "hands-on" and upper cognition level approaches is practically and developmentally inappropriate. Validation of this position can be shown by a review of numerous studies done a minimum of ten years ago that compared the hands-on approach to the traditional textbook approach (Shymansky, Kyle, and Alport, 1982). The particular hands-on programs studied were the Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), and the Science A Process Approach (SAPA). A review of these studies will indicate a likeness to the intent of the Tennessee Science Curriculum Framework, K-12.

Some twenty studies were analyzed with regard to academic achievement. The authors concluded:

> Contrary to a popular notion that hands-on, activity-based science curricula lacked a potent academic content base, we found that students using ... programs actually outscored students in the more traditional classrooms - by as much as 34 percentile points.

Attitude toward the hands-on approach with its higher cognition level focus was investigated through the analysis of 21 studies. The findings were:

> The studies approached the question of attitude in three ways: (1) attitude toward the new course, (2) attitude toward science, and (3) attitude toward self. In each of these categories, student attitudes were more positive toward the new programs than the traditional ones, with differences ranging from 3 to 20 percentile points.

Process skills development was also analyzed in the review. The results of the investigation were:

> The new elementary science curriculum placed great emphasis on the development of process skills, including observing, inferring, interpreting data, hypothesizing, and graphing. We analyzed the results of 13 studies that focused on process skill development in new curricula versus traditional classrooms. In the three elementary science curricula we studied, new curricula students score at least 18 percentile points higher than traditional class students on measures of process development.

In summary the authors reported:

> Our quantitative synthesis of the research clearly shows that students in those programs achieved more, liked science more, and improved their skills more than did students in traditional, textbook-based classrooms. The report for the hands-on curricula is impressive.

In another study (Bredderman, 1985), supported by the National Science Foundation, the effects of the same three programs on student outcomes were assessed by quantitatively combining the results of 57 reported evaluations of the programs. Only evaluations in which controls were used were included. In summary:

> It appears that the programs designed to encourage the use of laboratory science, starting in the elementary school years, do in fact result in improved student performance in a number of valued curricular areas. Based on the available research evidence, it also appears that the use of inquiry programs increases the amount of student-laboratory activity and decreases the amount of teacher talk in the classrooms, as intended (Bredderman, 1984).

Although the research quoted refers to "hands-on science" programs prepared for elementary school age students, there are a number of similar programs for secondary school students. Among these are Physical Science Study Committee (PSSC), Project Physics, CHEM Study, and Biological Science Curriculum Study (BSCS). There is every reason to believe that a similar research result would be found for secondary school students like the one found for elementary school students. Students of all ages ask a great many questions. Thus, most students need to engage in activities requiring "higher order thinking," in order to find answers for those questions.

References

Bredderman, Ted. "Laboratory Programs for Elementary Science: A Meta-Analysis of Effects on Learning." Science Education, 1985, 69,577-591.

Shymansky, James A., Kyle, William C. and Alport, Jennifer M. "How Effective were the Hands-on Programs of Yesterday?" Science and Children, 1982, 20, 14-15.

THE SCIENCE EDUCATOR'S ROLE IN FACILITATING STUDENT LEARNING

The role of the science educator is that of a facilitator of learning rather than that of a primary dispenser of knowledge. Information should be presented in the context of a rich learning environment, in which the student is an active participant. Rather than telling the students what they are to learn, an environment should be created in which the student can be active in acquiring knowledge through the process of experimentation and discourse. The science educator is to engage students in problem solving by asking probing questions, promoting inquiry, guiding discussion, and creating situations and scenarios that beg for exploration and explanation.

Facilitating science learning also requires the science educator to have a working knowledge of resources, which may include curricular materials, technology, community members, professional colleagues, and institutional resources such as museums, science centers, or nature centers. For science educators to be successful, support must be made available both within the school and from the broader professional community. Educators must have opportunities to exchange ideas and experiences with colleagues, to reflect on their teaching, to read research, and to contribute as part of a research team.

Safety in the Science Classroom

Safety is a critical part of planning for any kind of activity with children or adolescents. This is especially true in the science classroom. We have all heard horror stories about students and teachers being hurt in accidents in the school science laboratory. Careful preplanning can eliminate most problems and vastly reduce the risk of accidents. To assist you in thinking about safety in the science laboratory, this section of the framework has been separated into three sections. The first focuses on a number of cases based upon actual events which occurred in science classrooms. As you read through these cases, think about ways the accident might have been avoided. If you are unsure, you might want to talk with other teachers in your building or your district. The second section includes sample safety rules specifically related to science laboratories. The third section is a list of references which might help you attend to science safety in your own setting.

Cases

Pesky Thermometers

Steven, a high school senior, was conducting a physics experiment in which he was required to insert a thermometer into a rubber stopper. He had been required to do this many times before in chemistry, second year biology, and physics class and each time was shown the proper technique. On this particular day, the thermometer gave Steven quite a bit of trouble. Since the physics teacher had been called down to the office, no teacher was available to assist him. Steven decided to force the thermometer by using his palm to shove the thermometer through the hole. The thermometer broke resulting in a large gash in Steven's forearm. Fortunately, a second teacher entered the room just as the injury occurred so was able to provide immediate first aid. Also, fortunately for Steven, the break occurred above the level of the mercury thus avoiding mercury poisoning. The wound itself required over 15 stitches to close.

Storing Sodium Metal

Mr. Frank was a seventh-grade science teacher. At a recent science conference he went to a session on chemical demonstrations. One of the demonstrations included placing a pea-sized piece of sodium metal in a large beaker of water and watching it burn. Mr. Frank thought this might be a nice demonstration to do with his students when studying the periodic table and chemical changes. Therefore, he ordered some of the metal. As he reviewed catalogues, he noticed it was much cheaper by the pound than by the ounce, so he ordered a pound figuring he could use it over several years. The metal arrived in a small cylinder which could not be reused once opened.

On the day of the demonstration, Mr. Frank first looked for some oil and a jar in which to place the metal after it had been opened. he found a large glass jar and some olive oil. He then proceeded to open the cylinder, place the sodium metal into the jar, and place the olive oil on top. Immediately he noticed the oil begin to bubble. He was quite concerned. It just so happened that the chemistry teacher from the high school, Ms. Hardy, was in the building doing work with another teacher. Mr. Frank immediately went to her for assistance. She informed him that olive oil, unlike mineral oil (the recommended oil for storing sodium metal), is not anhydrous and therefore the metal could ignite. The building was rapidly cleared of students and local bomb squad called to assist in properly disposing of the volatile substance.

Mercury Problems

A group of students gained unauthorized access to a bottle of mercury through their second period science class when their regular science teacher was absent and a substitute was present. They had been informed by their science teacher that mercury is a highly toxic metal that can easily pass through the skin directly into the bloodstream and from there enter the brain, liver, and other tissues often causing permanent damage. The students did not think much of those words because they had previously played with mercury from broken thermometers at home and had never gotten sick. They were fascinated by mercury's physical properties and proceeded to play with it. The students were able to conceal the mercury during most of their classes, playing with it only when teachers were not looking. Therefore, they were not caught until the end of the school day. In the meantime, several classrooms, the lunch room, and most hallways were contaminated. The next day school was cancelled to remove the mercury contamination.

Using Mallets, Newspaper, and Paint Sticks to Explore Air Pressure

Ms. Janik, a third grade teacher, was quite interested in giving her students opportunities to explore different physical phenomena. One such phenomena was air pressure. To investigate this, she asked pairs of students to place a full sheet of newspaper out flat on their desk tops. She then asked them to place paint sticks half way underneath the newspaper and half way over the edge of their tables. Before beginning the actual experiment, students were required to predict what they expected would happen to the paint stick when they hit the exposed end with a rubber mallet. Most predicted the newspaper would rip or be pushed out of the way or fly up when the paint stick was struck. After discussing their predictions, students were reminded they would need to wear their safety glasses and aprons during lab as usual.

During the experiment, the student pairs were placed in close proximity with one another. They were amazed when they saw the paint stick break in two. As the excitement level built, the students became a bit wild with their swings of the mallets. Suzy and Johnny were in two different groups back-to-back. At one point, Suzy accidentally whacked Johnny on top of the head with her mallet when she was preparing to hit the paint stick. This caused a large lump to form on top of Johnny's head and caused both Suzy and Johnny to become quite upset.

Van de Graaff Generator: A Shocking Experience

Ms. Francis, a first year teacher, planned to use a small Van de Graaff generator during her science class. She wanted her students to see how static charges can build up and how changes can move from object to object. At the start of the day she read over all the safety rules then made sure it was set up properly. When the class arrived, many of the students asked about the equipment. As planned, when class started she explained how the equipment worked, told them about the safety precautions, then proceeded with some experiments. Several of the boys in the class, especially Joey and Timothy, found shocking their fingers from a distance quite interesting. They wanted to see how far they could get from the generator and still get a shock. The children also found watching each other's hair stand out straight to be great fun. So long as the students were having fun and attending to the laboratory, Ms. Francis let the students enjoy the experience.

The next day, Joey and Timothy came into class and showed Ms. Francis their fingers. Several of their finger tips had 10 to 20 pinhead sized bruises. These bruises were caused from their experiments of shocking their fingers the day before.

Safety Guidelines

The above cases include not only issues specific to the cases but also a number of important broad issues teachers must consider when thinking about safety in their science classrooms. Among those broad issues are: chemical storage, hazard, and disposal; equipment instructions, proper uses, and safety guidelines; first aid procedures; laboratory specific safety issues, room arrangement, and safety equipment instructions. All of these issues are important to teachers of all grade levels-- kindergarten through college. Other issues of equal importance to all teachers are: maintaining an up-to-date chemical inventory, dating all chemicals as they are received, keeping an Material Safety Data Sheet (MSDS) on file for all chemicals being stored or used, storing all chemicals in a safe and appropriate manner (see the Flinn Catalog), and knowing and following the district Chemical Hygiene Plan. If you are ever unsure of how to use a piece of equipment, how to properly store chemicals, what potential dangers exist for a particular chemical or piece of equipment, or of other safety issues be sure to ask. Many school districts have personnel who may know the answer to your question. If no one at your school or district is able to assist you, you might contact a local university, the poison control center, the local fire department or the chemical/equipment manufacturer to assist.

Below are listed sample safety guidelines. The lower elementary guidelines were written primarily for purposes of class discussion and communication with parents. The upper elementary/middle school and middle/high school guidelines were written not only for purposes of class discussion and communication with parents but also for written communication with students. These guidelines are intended to provide you with minimum safety and conduct rules. You may need to alter or add to these guidelines in order to make them more specific to your needs. Many science methods books provide nice descriptions of science safety guidelines (e.g. Frederick and Cheesebrough, 1993), which might provide you with additional ideas. For all grade levels, pictures and posters can be placed around the room to remind students of the safety tips (these can be purchased through many scientific supply houses and teacher centers).

SAMPLE
Class Safety Rules Guidelines
Lower Elementary School

Safety Rules for the Science Laboratory

Your personal safety and that of others working near you depend upon the care with which you observe the rules listed below. Become familiar with these rules and follow them AT ALL TIMES.

1. Listen carefully and follow ALL directions given by the teacher.
2. Inappropriate behavior during science activities is unacceptable.
3. Ask questions if you are unsure of what to do.
4. Never touch, taste, or smell any material unless directed by the teacher.
5. Students may be asked to secure long hair, remove jewelry, or adjust loose clothing in order to maintain safe working conditions.
6. Proper safety eyewear and protective aprons or smocks will be used when necessary.
7. Clear your work area of all extra books, papers, notebooks, etc. before beginning science activities. Always leave your work area clean and dispose of trash as directed by the teacher.
8. Always wash your hands thoroughly after each and every science activity.
9. Tell the teacher about any accident, no matter what happens.
10. Science activities should not be done at home without adult supervision.

I ____ have read, understood, and agree to follow the above safety rules and conduct guidelines. I agree to follow any additional verbal or written guidelines provided by my teacher. I also understand that I am responsible for replacing any equipment or materials that I may damage.

Signature of Student Date ______________________________ Signature of Parent/Guardian Date

SAMPLE
Class Safety Rules Guidelines
Upper Elementary/Middle School

Safety Rules for the Science Laboratory

Your personal safety and that of others working near you depend upon the care with which you observe the rules listed below. Become familiar with these rules and follow them AT ALL TIMES.

1. Always pay attention to your work.
2. Never goof off during lab.
3. Never bring food or drink into the laboratory.
4. Dispose of trash and other waste as indicated by the teacher.
5. Follow directions carefully using only the amount of materials called for--more is NOT always better.
6. Wash your hands thoroughly after each and every laboratory sessions.
7. Always leave your laboratory station clean and dry.
8. Whenever you are unsure of directions, ask the teacher for help.
9. Whenever you are unsure how to use a piece of equipment, ask the teacher for help.
10. Anything you damage or break will be paid for by you.
11. Know where fire extinguisher and fire blankets are and how to use them.
12. Wear appropriate eye protection when conducting an experiment.
13. Contact lenses can cause an eye hazard so should not be worn during certain laboratories involving chemicals.
14. Appropriate protective aprons or smocks should be worn when conducting experiments.
15. Do not wear long, loose sleeves or a loose laboratory coat in the laboratory.
16. If you have long hair, tie it back while working in the laboratory.
17. Bracelets, dangling jewelry, and ties should be removed before working in the laboratory.
18. Only perform experiments which have been approved by your teacher.
19. Tell your teacher of any accident, no matter how minor it may seem to you.
20. Never put anything in the laboratory into your mouth unless specifically directed by the teacher.
21. Always clear your lab area of all extra books, papers, notebooks, etc. before beginning your lab work.
22. Be sure to have clear exit pathways in case of emergencies.

I ____ have read and understood the above safety rules and conduct guidelines and I agree to follow them. I also agree to follow any additional verbal or written guidelines provided by my teacher.

Signature of Student	Date	Signature of Parent/Guardian	Date

SAMPLE

Class Safety Rules Guidelines

Middle School/High School

Rules of Conduct in the Laboratory

Certain rules of conduct, listed below, are advisable in a science laboratory. Study them carefully and then list a reason for each rule in your laboratory notebook.

1. Always maintain a business like attitude.
2. Never engage in practical jokes.
3. Never bring food or drink into the laboratory room.
4. Dispose of wastes as indicated by the teacher.
5. NEVER return unused reagents to stock bottles.
6. Follow directions carefully using only the amount of materials called for--more is NOT always better.
7. Wash your hands thoroughly after each and every laboratory sessions.
8. Always leave your laboratory station clean and dry.
9. Be sure water and gas outlets are turned off completely after use.
10. Whenever you are unsure of a procedure, ask the teacher for help.
11. Anything you damage or break will be paid for by you.

Safety in the Laboratory

Your personal safety and that of others working near you depend upon the care with which you observe the rules listed below. Become familiar with these rules and follow them AT ALL TIMES.

1. Know where fire extinguishers and fire blankets are and how to use them.
2. Know the location of the safety shower and eyewash fountain and how to use them.
3. ALWAYS wear appropriate eye protection when conducting an experiment.
4. Contact lenses can cause an eye hazard so should not be worn during certain laboratories involving chemicals.
5. Appropriate protective aprons or smocks should be worn when conducting experiments.
6. Do not wear long, loose sleeves or a loose laboratory coat in the laboratory.
7. If you have long hair, tie it back while working in the laboratory.
8. Bracelets, dangling jewelry, and ties should be removed before working in the laboratory.
9. Only perform experiments which have been approved by your teacher.
10. Notify your teacher of any accident, no matter how minor it may seem to you.
11. NEVER ingest anything in the laboratory.
12. NEVER use flammable liquids near an open flame.
13. Never pour a flammable liquid in the sink.
14. Never leave a flame unattended.
15. Check the label on ALL reagent bottles twice before using them.
16. If an acid or base spills, immediately notify your teacher.
17. When diluting acids, always put the acid into water.
    Remember A to W!
18. When inserting glass tubing, a glass rod, or a thermometer into a rubber stopper or rubber tubing, always protect your hand with several thicknesses of cloth and always lubricate the glass before inserting it into the stopper or tubing.
19. When heating the contents of a test tube, keep it tilted and moving in the flame with the mouth pointed away from yourself and your neighbors.
20. When investigating odor, always waft the odor toward your nose.

I ______________________________ have read and understood the above safety rules and conduct guidelines and I agree to follow them. I also agree to follow any additional verbal or written guidelines provided by my teacher.

Signature of Student	Date	Signature of Parent/Guardian	Date

Reference List

Below are listed a number of references which might assist you in attending to laboratory safety issues in your classroom and with your students. The references are categorized into three basic categories: (a) safety manuals, (b) chemical storage, hazards, and disposal, and (c) specific safety issues.

Safety Manuals

Accrocco, J. O., & Cinquanti, M. (1990). Right to know: Pocket guide for laboratory employees. Schenectady, N. Y.: Genium Publishing Corporation

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Chemical Storage, Hazards, and Disposal

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[1] Flinn Scientific has developed a series of fact sheets call "Flinn Fax" which cover a wide variety of issues in school laboratories including safety. This is just one of those available.

SIGNIFICANT FRAMEWORK INCLUSIONS

The Tennessee Science Curriculum Framework, K-12 is an attempt to change the way the Tennessee community of learners thinks about science. The community of learners includes students, families, educators, governmental organizations, businesses, industries, political leaders and all participants in society. The framework promotes learning science by doing science. It is a thoughtful response to a variety of reforms, beginning with the Tennessee landmark Education Improvement Act (EIA) of 1992. This document has also incorporated ideas from the National Science Education Standards Project, American Association for Advancement of Science's (AAAS) Project 2061, and National Science Teachers Association's (NSTA) Scope Sequence and Coordination Project, as well as other state and national curriculum reform initiatives. The standards outlined in this framework can be used by Tennessee educators to make the decisions necessary for effective science programs at the elementary, middle and secondary levels.

The framework is organized around four components: Process of Science, Unifying Concepts of Science, Habits of Mind, and Science in Society. These four components are the foundation of the K-12 science curriculum in Tennessee. In each component, the generalized standards are written to accommodate a variety of instructional strategies and resources, yet they are pointed at specific concepts and skills that students should know and be able to do. Local curricula should be developed from this framework beginning with the preparation of performance objectives that describe precisely what intended outcomes related to the benchmark have been selected as educational focal points.

The intent of the document is to increase students' understanding of essential scientific concepts by promoting activities that engage students in doing science, using available technological tools, and rationally thinking about the natural world. To this end, the Tennessee Science Curriculum Framework, K-12 gives directions for an innovative approach to science education. It provides a philosophical foundation and a curricular framework from which educators may construct comprehensive science education programs for elementary, middle, and high schools.

This framework is a document developed by science teachers for science teachers. Therefore, this document is dedicated to the science teachers of the State of Tennessee.

TENNESSEE'S FOUR COMPONENTS OF SCIENCE EDUCATION

1. Process of Science

The processes of science enable students to pose questions and investigate phenomena through the language, methods, and instruments of science. Common science process themes include observing, questioning, collecting data, analyzing, explaining, and communicating. The process of science follows no single pathway but involves imagination, inventiveness, experimentation and logic, and evidence to support results. Once a question is posed, the search for answers follows a purposeful sequence of experimentation, data collection, analysis, and evaluation of conclusions, perhaps leading to new questions.

Technology provides tools and techniques that improve students' skills in measuring, calculating, recording, analyzing, modeling, and communicating. Hands-on explorations provide students with opportunities to use materials in new and concrete situations, to analyze results for greater understanding, to synthesize new ideas with what has been previously learned, and to evaluate how this new knowledge will be of practical use in their lives. Students may work in teams and share findings with others, but each individual should contribute to the group.

2. Unifying Concepts

Students acquire scientific knowledge by applying concepts, theories, principles and laws from life/environmental, physical and earth/space sciences. Any field of knowledge is more than an accumulation of isolated facts and ideas. In science, particularly, recurrent themes and concepts occur as our knowledge and understanding of the phenomena encountered in the natural world increase. Unifying themes connecting the science disciplines are scale and model, form and function, organization, interactions, change, and conservation. These themes provide the framework into which one can fit new discoveries and insights, thus making a complex field of knowledge more comprehensible and meaningful. Utilizing these themes to organize instruction in science will ultimately provide students with a more coherent and integrated understanding of the world in which they live. This organization is especially important as scientific knowledge continues to increase at an exponential rate.

3. Habits of Mind

Students must be able to demonstrate ways of thinking and acting inherent in the practice of science and to exhibit an awareness of the historical and cultural contributions to the enterprise of science. Habits of mind include historical and cultural perspectives, assumptions, estimations and computations, scientific methods, an understanding of science and technology, and an appreciation of creative enterprises. Science is a creative process that attempts to discover and understand. Science questions all things and opens itself to continual scrutiny and modification. Science is carried out according to informed rules and assumptions. The rules and assumptions have developed over centuries from the experiences of those who have attempted to understand the natural world. However, as scientific knowledge grows, students should be prepared to alter their points of view. In this way, science is a never ending process of discovery, interpretation, and evaluation.

4. Science in Society

The student should be able to develop positive attitudes toward science in solving problems and making personal decisions about issues affecting the individual, the society and the environment. Attitudes, personal needs, career goals, societal needs, economics, and politics all contribute to the role of science in society. Over the last several decades, the rate of scientific knowledge acquisition has increased dramatically. Fields such as medicine, space science, particle physics, and organic chemistry continue to produce information faster than it can be processed by any individual or group. The demand for science to investigate and technology to solve many of the world's problems has served to further accelerate this growth of knowledge.

The achievements of science and technology influence society, which either supports or limits the progress of science and technology. Therefore, the science curriculum should be structured to develop awareness of the interactions of science, technology, and society.

To meet these challenges presented by society, it is necessary for the science curriculum of our schools to address the attitudes, processes, tools, knowledge, and societal implications of science. This comprehensive approach to science education requires that learners receive essential readiness skills needed to become scientifically literate. Such skills go beyond learning, they give individuals a foundation for making sound decisions, understanding recent scientific advances and their implications, preparing to enter the job market, and developing a feeling of control over their lives.

TENNESSEE'S THEMES

Themes should be a major emphasis of the science curriculum. The themes of science are large ideas that connect and integrate the traditional science disciplines and incorporate other subjects, such as technology, mathematics, and social studies. Themes presented in this framework can be used as a vehicle to present an interdisciplinary view of science.

PROCESS OF SCIENCE

GOAL: To enable students to demonstrate the process of science by posing questions and investigating phenomena through language, methods and instruments of science.

THEME: 1.1 OBSERVING - The senses are used to develop an awareness of an event or object and the properties thereof.

THEME: 1.2 QUESTIONING - The development of an inquisitive mind and the effective use of questioning techniques furthers the acquisition of information.

THEME: 1.3 COLLECTING DATA - The acquiring, recording, arranging and storing of information must be performed in a complete, accurate, concise, and user friendly manner.

THEME: 1.4 ANALYZING - Data should be examined to find patterns and relationships that may suggest cause and effect or support inferences and hypotheses.

THEME: 1.5 EXPLAINING - Phenomena and related information are made understandable through discussion that culminates in a higher level of learning.

THEME: 1.6 COMMUNICATING - An essential aspect of science is the act of accurately and effectively conveying oral, written, graphic or electronic information from the preparer to the user.

UNIFYING CONCEPTS OF SCIENCE

GOAL: To enable students to acquire scientific knowledge by applying concepts, theories, principles and laws from life/environmental, physical and earth/space science.

THEME: 2.1 SCALE AND MODEL - The development of models provides a conceptual bridge between the concrete and the abstract, while the use of scales allows for a comparison of differences in magnitude between the model and the desired form.

THEME: 2.2 FORM AND FUNCTION - Form may determine the function of a material or a system, and function may alter form.

THEME: 2.3 ORGANIZATION - Everything is organized as related systems within systems.

THEME: 2.4 INTERACTIONS - At all levels of living and non-living systems, matter and energy act and react to determine the nature of our environment.

THEME: 2.5 CHANGE - Interactions within and among systems may result in changes in the properties, position, movement, form, or function of systems.

THEME: 2.6 CONSERVATION - In any natural process the form may change but nothing is lost.

HABITS OF MIND

GOALS: To enable students to demonstrate ways of thinking and acting inherent in the practice of science; and to exhibit an awareness of the historical and cultural contributions to the enterprise of science.

THEME: 3.1 HISTORICAL AND CULTURAL PERSPECTIVE - The knowledge and processes of science have evolved over time as an approximation of truth within cultural contexts.

THEME: 3.2 ASSUMPTIONS - The recognition and criticism of the validity of an argument through presentation of data and differentiation between fact and assumption in the preparation of an explanation for a natural phenomenon are vital parts of the scientific process.

THEME: 3.3 ESTIMATION AND COMPUTATION - Scientists judge the level of precision needed to approximate a reasonable response and perform calculations with or without the aid of mechanical devices.

THEME: 3.4 METHODS - A variety of techniques is used by scientists to classify and solve problems.

THEME: 3.5 SCIENCE AND TECHNOLOGY - Science and technology are separate but interdependent entities.

THEME: 3.6 CREATIVE ENTERPRISE - Creativity contributes to the processes of science through ideas and inventions.

SCIENCE IN SOCIETY

GOAL: To enable students to demonstrate positive attitudes toward science in solving problems and making personal decisions about issues affecting the individual, society and the environment.

THEME: 4.1 ATTITUDES - The progress of science and the attitudes of society influence one another.

THEME: 4.2 PERSONAL NEEDS - The application of science may be used to change the quality of life for the individual.

THEME: 4.3 CAREER GOALS - The development of scientific skills may lead to a rewarding career and productive contributions to society.

THEME: 4.4 SOCIETAL NEEDS - Science establishes the basis for applying technology to needs within a society.

THEME: 4.5 ECONOMICS - Scientific knowledge should provide a premise for understanding the economic value of applied technology as it relates to society.

THEME: 4.6 POLITICS - Basic scientific concepts should be available to all individuals enabling each to make logical decisions for himself or herself and others.

A FRAMEWORK FORMAT EXPLANATION

The learning process proposed by the Tennessee Science Curriculum Framework, K-12 is one that depicts a narrowing of the community of learner's concentration as the educational focus moves from the Goal to the Benchmark, by way of the Theme and Standard. The intent of the lowest level of the process, the Benchmark, is to provide a point of reference toward which instruction can be aimed and finally to provide a target whose degree of attainment can be measured by ordinary assessment activities. In practice, one or more performance objectives that relate directly to the Benchmark must be teacher constructed for inclusion in the lesson plan. Each performance objective written by the teacher identifies a segment of content related to the Benchmark that is to be taught and also provides the root for an assessment activity.

The importance of the selection of the performance objectives is significant in today's world because of the value placed on scores such as those obtained from the Tennessee Comprehensive Assessment Program test. More often than in the past, standardized tests are based on questions that address the upper levels of cognition. In the case of Bloom's Taxonomy of Education Objectives, the upper levels of cognition would be the Comprehension, Application, Analysis, Synthesis, and Evaluation levels rather than the Knowledge level. Care should be taken in designing the performance objectives in the classroom to address the various higher levels of cognition. This instructional strategy prepares the individual learner with a science background that is most likely to improve the student's quality of life, while at the same time better preparing the student to be more competitive on standardized tests.

Definitions that will help the science educator understand the educational thrust of the Tennessee Science Curriculum Framework, K-12 are:

Goal
A goal is the identification of the general direction toward which the community of learners will direct their education efforts.

Theme
A theme is a statement which identifies a topic to be given special investigative consideration by the community of learners.

Standard
A standard is a segment of information drawn from the theme that the community of learners perceives to have recognized and lasting value.

Benchmark
A Benchmark is an instructional point of reference or target whose degree of attainment can be measured by analysis of the success and/or lack of success in meeting the related performance objectives.

Performance Objective
A performance objective is a statement that describes precisely what outcome related to the benchmark has been selected as an educational focal point. In general, performance objectives begin with "The learner will be able to" and conclude with an outcome that is measurable by completion of an assessment activity. Performance objectives should be organized in ascending order of cognition level, thus determining the order of content presentation.

Assessment Activity
An assessment activity is a test item or a more complex problematic situation where the student is required to demonstrate the ability to reach a specified outcome that allows for judgment of the student's effort as to accuracy and/or value.

PROCESS OF SCIENCE

GOAL: To enable students to demonstrate the processes of science by posing questions and investigating phenomena through language, methods and instruments of science.

THEME: 1.1 OBSERVING - The senses are used to develop an awareness of an event or object and the properties thereof.

Tennessee Standard 1.1a - Observing is a process used to develop an awareness of the surrounding environment.

Benchmarks:

K-2
Students can learn about things around them by careful observation.

3-5
Awareness of our surroundings is a result of individual observations and prior knowledge.

6-8
By incorporating prior knowledge with the process of observation, a better understanding of one's environment may develop.

9-12
Written narratives are used to describe an observed scientific phenomenon.

Questions based on observations may be answered through experimentation.

Safe conditions and methods for making observations are necessary.

Multiple explanations may be used for the same set of observations.

Tennessee Standard 1.1b - The human senses and technological instruments are used to gather information from the environment.

Benchmarks:

K-2
Students experience and learn about the world through their senses.

3-5
Information is gathered by using human senses and various instruments such as magnifying lenses, microscopes, telescopes, thermometers, scales, and balances.

6-8
Scientific investigation is enhanced through the use of technology.

9-12
Data collected from the scales of scientific instruments are accurately read and recorded using significant digits.

Recognition of the limitations of human senses and of technology in data gathering is critical to interpreting data.

Resolution of details of natural phenomena is constantly being enhanced.

The utility of instruments for extending the human senses for observations is limited by their accuracy and precision.

THEME: 1.2 QUESTIONING - The development of an inquisitive mind and the effective use of questioning techniques furthers the acquisition of information.

Tennessee Standard 1.2a - Initial information and prior knowledge are used to ask questions.

Benchmarks:

K-2
Students have natural curiosity causing them to raise questions about the world around them.

3-5
Questions developed to study scientific concepts are based upon previous knowledge and experiences.

6-8
Shared experiences may help to develop an inquisitive mind.

9-12
Prior experience and knowledge are used to formulate working hypotheses to explain natural phenomena.

Tennessee Standard 1.2b - Questions may be structured so that they can be investigated scientifically.

Benchmarks:

K-2
Students will seek answers to questions by making careful observations.

3-5
The formulation of questions which address a specific concern or problem more readily lend themselves to scientific investigation.

6-8
Scientists differ greatly in what field they study and how they go about their work, using various scientific methods of investigation.

9-12
To test hypotheses, appropriate procedures are designed for laboratory and field work.

Controls are used for comparison when testing variables.

In order for a question to be scientifically feasible it must be experimentally testable and answerable.

Working hypotheses are formulated to guide the process of research.

When events of the past are presented to explain present phenomena, validity is contingent upon similarity of conditions.

Tennessee Standard 1.2c - Not all questions can be answered.

Benchmarks:

K-2
Some events are predictable while others are uncertain.

3-5
Within the questioning process, every investigation will not yield concrete results.

6-8
If more than one variable changes in an experiment, the end result of the experiment may not be clearly attributable to any one of the variables.

9-12
There are limits to scientific investigations.

Hypotheses are valuable; even if false, they may lead to fruitful investigations.

Different explanations often can be given for the same evidence, and it is not always possible to tell which, if either, is correct.

THEME: 1.3 COLLECTING DATA - The acquiring, recording, arranging and storing of information must be performed in a complete, accurate, concise and user-friendly manner.

Tennessee Standard 1.3a - Data are collected using the senses, instrumentation, and a variety of other technologies.

Benchmarks:

K-2
Students experience and learn about the world through their senses. Tools, such as thermometers, magnifiers, rulers, calculators, computers, scales and balances supply additional information for scientific investigation.

3-5
Information gathered through the use of instrumentation and/or experimentation is to be managed so that data can be easily retrieved.

6-8
The reading and interpretation of measuring instruments are necessary in determining length, volume, weight, elapsed time, rates, and temperature.

9-12
Multiple information sources are used to investigate phenomena.

Scientific notation is used to express and compare very small and very large numbers.

Tennessee Standard 1.3b - Data should be appropriate, accurate, and free of bias.

Benchmarks:

K-2
Records of observations and experiments are to be accurate and free of bias to ensure scientific comparison of data.

3-5
A journal is kept to describe observations made and scientific data collected. Entries distinguish actual observations from speculations about what was observed.

6-8
The larger a scientific sampling is, the more likely it is to represent the whole.

Information may be acquired from a variety of sources such as reference books, computer disks and databases, and back issues of periodicals.

9-12
Data collected during different experiments of common phenomena may be related.

Tennessee Standard 1.3c - Safety features should be observed in all areas of data collection.

Benchmarks:

K-2
Proper safety methods are practiced at all times.

3-5
Proper safety procedures must be followed in the classroom, laboratory, and home environment.

6-8
Safety procedures are introduced prior to and practiced during all data collection.

9-12
Proper safety procedures and safe use of equipment and materials are the responsibility of each person engaged in scientific investigations.

THEME: 1.4 ANALYZING - Data should be examined to find patterns and relationships that may suggest cause and effect or support inferences and hypotheses.

Tennessee Standard 1.4a - Data should be examined to find patterns and relationships.

Benchmarks:

K-2
Patterns are evident in nature.

Geometrical shapes are found in nature and may be created by people.

Patterns may be developed by arrangements of different shapes.

3-5
Information is organized in ways that show possible relationships, similarities, or differences; examples: graphs, charts, tables, etc. Data extremes (highest/lowest values) may be more revealing than means or averages.

6-8
An equation containing a variable may be true for just one value of the variable.

Information is organized into simple tables and graphs to identify relationships.

Rectangular and polar coordinates are used to find and describe locations on maps or other flat surfaces.

The mean, median, and mode tell different aspects of data set.

One example can never be used to prove that something is true, but sometimes a single example can prove that something is not true.

9-12
Statistical analysis may be used to analyze data.

Computer spreadsheets, graphing, and database programs may be used to examine trends in data.

Comparisons made between experiments conducted under dissimilar conditions are not valid comparisons.

Tennessee Standard 1.4b - The accuracy and precision of data should be used to determine the selection or rejection of any given piece of data.

Benchmarks:

K-2
Accurate descriptions of observations enable students to compare results with others.

Conflicting descriptions of an event require fresh observation rather than argumentation.

3-5
Adherence to procedures and concise record keeping are essential to the process of scientific investigation.

6-8
Some means of checking for accuracy is needed because errors can occur in recording or communicating information.

The collection of data requires the most accurate degree of precision.

9-12
Data are critically examined to determine which are to be used.

Repetition of trials and investigations enhances the reliability of the data collected and, therefore, the conclusions drawn.

Tennessee Standard 1.4c - Scientific investigation may not produce concrete solutions.

Benchmarks:

K-2
Predictions may not always occur.

3-5
Scientific inquiry does not always result in predicted or expected outcomes.

6-8
There may be more than one good way to interpret a given set of findings.

9-12
Until investigations are conducted to limit interpretation, all reasonable conclusions should be considered.

THEME: 1.5 EXPLAINING - Phenomena and related information are made understandable through discussion that culminates in a higher level of learning.

Tennessee Standard 1.5a - Tables and graphs may be used to interpret the meaning and significance of data.

Benchmarks:

K-2
Graphs and tables provide visual results of observations.

3-5
Things change in steady, repetitive, or irregular ways. Tables, charts, and graphs are effective ways to show quantitative values and relationships.

6-8
Mathematical statements can be used to describe the magnitudes of change one quantity has on another.

The graphic display of numbers may help to show patterns such as trends, varying rates of change, gaps, or clusters.

9-12
Data in maps, charts and graphs may be used to answer questions.

Extrapolation and interpolation from graphs may provide the basis for new hypotheses.

Graphical analysis of data may reveal functional relationships.

Tennessee Standard 1.5b - Nonmathematical language may be used to interpret the relationships presented in mathematical form.

Benchmarks:

K-2
Pictures may illustrate relationships observed.

Descriptions and comparisons may be presented in terms of number, shape, texture, size, weight, color and motion.

Prior knowledge helps one interpret new information.

3-5
Written and verbal presentations are used to explain information presented in charts, graphs, and tables.

6-8
Written, verbal and visual presentations can be used to interpret and expand more abstract mathematical concepts.

9-12
Narrative should be used to explain mathematical relationships.

Formulation of appropriate generalizations is warranted by the relationships found among data.

Tennessee Standard 1.5c - Information should be related to prior knowledge.

Benchmarks:

K-2
New learning is developed from existing knowledge.

3-5
The process of making predictions, drawing inferences, and developing conclusions is based upon an individual's prior learning and understanding of scientific principles.

6-8
Prior knowledge provides a foundation for new learning experiences.

9-12
When interpreting results of new experiments the results are generalized to a scientific theory.

THEME: 1.6 COMMUNICATING - An essential aspect of science is the act of accurately and effectively conveying oral, written, graphic or electronic information from the preparer to the user.

Tennessee Standard 1.6a - The sharing and disseminating of results should be done in a clear and concise manner.

Benchmarks:

K-2
Results are presented in a clear and concise manner to ensure credibility.

3-5
Effective communication is essential to the sharing of information and to the exposure to criticism by the scientific community.

6-8
Human beings learn complicated concepts from others through various methods of communication.

Scientists are linked worldwide both personally and professionally through international scientific organizations.

9-12
A variety of media may be used to prepare reports and to disseminate results.

Style of writing used is partly dependent upon the audience and the nature of the research.

Reporting is clear, concise, and free of error.

UNIFYING CONCEPTS OF SCIENCE

GOAL: **To enable students to acquire scientific knowledge by applying concepts, theories, principles and laws from life/environmental, physical and earth/space sciences.**

THEME: 2.1 SCALE AND MODEL - The development of models provides a conceptual bridge between the concrete and the abstract, while the use of scales allows for a comparison of differences in magnitude between the model and the desired form.

Tennessee Standard 2.1a - A model is a representation used to simplify complex phenomena.

Benchmarks:

K-2
A model is a representation of a real item or concept. Toys may serve as models assisting with the understanding of complex ideas.

3-5
Models are developed to represent structures or concepts. These models may be manipulated for simplified analysis of complex ideas.

6-8
Models are often used to represent concepts of various magnitudes.

9-12
Physical Science
Mathematical, physical or mental models can be used to describe phenomena such as atomic structure, forces and motion, conservation of energy, and interactions of matter and energy.

Chemistry
Mathematical, physical or mental models can be used to describe phenomena such as atomic structure, molecular bonding, molecular shape, solution concentration, electromagnetic radiation, phases of matter, energy changes and radioactivity.

Physics
Mathematical, physical, and mental models can be used to represent atomic structure, forces and motion, conservation of energy, and interactions of matter and energy.

Earth/Space Sciences
Many forms of diagrams and programs may be used to model the interrelationships of earth's physical and biological systems.

Models may be used to illustrate the molecular organization of earth materials.

Biological Sciences
The cellular organelles, internal biochemical processes, and involved interactions can be described using appropriate models.

The structure of DNA and all cellular processes can be studied using models.

Environmental Sciences
A variety of models can be used to describe atoms, molecules, cells, tissue, organs, organisms, ecosystems, and the biosphere.

Tennessee Standard 2.1b - Different models can be used to represent the same thing. The kind of model used and its complexity depends on its purpose.

Benchmarks:

K-2
Various models may be constructed to represent a given item or concept.

3-5
Models allow us to make inferences about real world processes or events.

6-8
Models can be simulated on a computer and then altered to see what happens.

The usefulness of a model may be limited by its simplicity or complexity.

9-12
Physical Science
Models such as the Bohr model of the atom are used to explain abstract concepts.

Chemistry
Models such as the Bohr model, Lewis structures and electron configurations are used to explain the types of bonding of atoms.

Physics
Physical and theoretical concepts may be represented by mathematical, mental, and/or tangible physical models. Mathematical models may be used in applications.

Earth/Space Sciences
The configuration of the earth may be portrayed by a variety of different map and globe forms.

Models can be used to illustrate the cyclic changes within the earth.

Pressure/temperature diagrams can be used to explain many earth phenomena.

Isopleth/contour maps are effective means for illustrating the distribution of earth characteristics and processes. The accuracy of such maps varies with the number of data control points.

Biological Sciences
In addition to the concepts inherent within processes, models of processes such as the nitrogen cycle, water cycle, and food chains, can be used to represent conservation of matter.

Environmental Sciences
Models can be static or dynamic, animate or inanimate, two-dimensional or three-dimensional.

Models can represent individual phenomenon, a series of events, and complex systems.

Tennessee Standard 2.1c - Models are often used to study processes that happen too slowly, too quickly, or on too small or too large a scale to observe directly.

Benchmarks:

K-2
Models can be used to demonstrate time progression or visual enhancements.

3-5
Scale models represent real objects, events and processes. These representations may not be exact in every detail.

6-8
Models are often used to represent processes that cannot be directly observed.

9-12
Physical Science
Symbols, formulas and equations can be used to represent chemical interactions.

Graphs can be used to visualize the relationship between variables.

Chemistry
Symbols, formulas and equations can be used to represent chemical interactions and stoichiometric relationships.

Graphs can be used to visualize the relationship between variables.

Physics
Models allow physicists the ability to manipulate variables for studies of extremely large to extremely small systems.

Earth/Space Sciences
Models can be used to illustrate plate tectonics, rock deformation, crystal growth, atmospheric and oceanic circulation, erosion/depositional processes, etc.

Phenomena related to the solar system and the earth's place in space can be modeled, i.e., eclipse, seasons, etc.

Graphs can be used to visualize the relationship between variables.

Biological Sciences
Mathematical symbols and anthropological concepts can represent the principles of Mendelian inheritance and population genetics.

Environmental Sciences
Time lines, enlargements, and miniatures provide tangible examples of phenomena beyond usual frames of reference.

Tennessee Standard 2.1d - The scale chosen for a model determines its effectiveness.

Benchmarks:

K-2
The model's effectiveness is dependent on choice of materials, size, weight, age and speed.

3-5
The development of models is based on scale, representations of size, shape, volume, speed and other properties.

6-8
The usefulness of a graph or drawing is determined by the scale utilized.

9-12
Physical Science
Scale reflects the relative dimensions of the components of the system being modeled.

Chemistry
Scale reflects the relative dimensions of the components of the system being modeled.

Physics
A model may be accurately replicated, enlarged or reduced when constructed to scale.

Earth/Space Sciences
The level of detail on various geologic maps and diagrams depends upon the scale used.

There are many aspects of the earth that are difficult to scale, i.e., time and gravity.

Biological Sciences
The proportionate scale of a model is well-defined according to its purpose. For example, a cellular model necessitates a grossly disproportionate scale for viewing whereas the body organs can be viewed in real scale.

Environmental Sciences
Models are evaluated to determine how accurately they depict reality.

Tennessee Standard 2.1e - Different properties are not affected to the same degree by changes in scale; large changes in scale typically change the way things work.

Benchmarks:

K-2
Some properties remain constant even when other features are changed.

3-5
Changes made to scale models represent how real objects or processes are affected by change.

6-8
The way a model works may change with scale.

9-12
Physics
The fundamental properties can be affected by scale. When linear dimensions are increased surface area, mass, and volume are affected exponentially.

Earth/Space Sciences
Scale models of the earth constructed with vertical exaggeration in order to show land forms will distort all other elements shown.

Real time and rates are difficult to scale in modeling earth processes.

Biological Sciences
Models are represented in a factual manner; all components should be understood in actual dimension as well as in scale.

Environmental Sciences
Simple and complex models may respond differently to changes in scale.

THEME: 2.2 FORM AND FUNCTION - Form may determine the function of a material or a system, and function may alter form.

Tennessee Standard 2.2a - How an object functions is related to its form.

Benchmarks:

K-2
The kind of material used to build an object will influence the effectiveness of that object.

Any alteration in design of an object will affect the efficiency of the object.

3-5
The form of a structure implies its function. The function of a structure tends to dictate its form.

6-8
Specialized structures perform specific functions.

Symmetry (or the lack of it) may determine properties of many objects, from molecules and crystals to organisms and designed structures.

All objects in the universe are affected by the gravitational forces.

Equal volumes of different substances usually have different weights.

There are different forms of energy such as heat, mechanical, chemical, electrical, nuclear, and light.

The flow of energy has an impact of geological, biological and environmental conditions.

9-12
Physical Science
Atomic structure is an underlying form that determines bond type and properties of matter.

Physical laws relate the form and function of objects in the study of motion.

Electricity has different forms, and a relationship exists between electricity and magnetism.

Chemistry
Atomic structure is an underlying form that determines molecular structure, bond type and properties of matter.

Physics
Physical laws relate the form and function of mass-energy systems.

Earth/Space Sciences
Because the physiology of modern organisms is related to their environment, the forms of fossils may be used to reconstruct ancient environments.

Land forms approach a condition of dynamic equilibrium with the processes forming them.

The diversity of earth materials is a function of the environment in which they form - all matter tends to equilibrate with temperature and pressure.

The crystal form of minerals depends upon atomic size and method of bonding.

The form of the water molecule makes it an effective natural solvent.

Biological Sciences
Many organisms survive only under site specific conditions.

Organisms are composed of systems which contribute to the overall operations of an organism.

Physiology of an organism provides a groundwork of responses and adaptations to the climate, topology, available resources, and predator/prey relationships of a given region.

Environmental Sciences
The form of producers, consumers and decomposers determines how they effect the environment.

The function of all biological systems, molecules to ecosystems, is dependent on their form.

The unique form of water causes it to function as solid, liquid and gas in the biosphere.

Tennessee Standard 2.2b - Form tends to dictate function, thus an alteration of form may lead to a change in function.

Benchmarks:

K-2
Things generally consist of parts and may not function properly if a part is missing.

3-5
Physical and biological systems are interactive. Changes of component forms may alter the function(s) of those systems.

6-8
Any change or error in design may affect function.

The survival of individual organisms and entire species is dependent upon environmental conditions.

9-12
Physical Science
The properties of compounds and their constituent elements are very different.

Characteristics of mixtures and compounds differ greatly even when containing the same elements.

A desired function may be achieved by changing the form of matter such as changing an inclined plane to a screw or changing the position of the fulcrum of a lever.

Chemistry
The chemical bonding of water causes it to have unique properties.

The properties of compounds and their constituent elements are very different.

Characteristics of mixtures and compounds differ greatly even when containing the same elements.

Differences in the molecular structure of organic compounds causes different properties even for compounds with the same ratio of elements.

Physics
A desired function may be achieved by changing the form of matter or energy in a system.

Earth/Space Sciences
Many modifications of the earth's atmosphere, hydrosphere, and lithosphere, both natural and anthropogenic, create malfunctioning systems threatening the biosphere.

Biological Sciences
Environmental, sociological, psychological, electrochemical, and biochemical alterations may induce changes in the form, and may alter the function of an organism.

Environmental Sciences
New varieties of organisms result from genetic engineering.

The form and function of DNA provide a basis for generational continuity and mutations.

The formation, weathering, sedimentation, and reformation of the lithosphere create a variety of environmental conditions.

As elements combine in different molecules they function differently.

Resource usage increases with population growth.

THEME: 2.3 ORGANIZATION - Everything is organized as related systems within systems.

Tennessee Standard 2.3a - Natural phenomena display a wide variety of similarities and differences.

Benchmarks:

K-2
Human external features (size, height, hair color, eye color, etc.) may vary, yet the overall similarities are constant.

Offspring may resemble their parents, but individuals within a general population may vary.

3-5
There are variations among individuals within all systems.

Things can be sorted into groups according to their similarities and differences.

6-8
Similarities and differences can be observed from the most minute phenomena to the vastness of the universe.

9-12
Physical Science
The Periodic Table is an example of a natural organization reflecting a broad range of similarities and differences.

Solutions are described in terms of the relative amounts of solute and solvent.

Descriptive relationships may be derived from chemical formulas and balanced chemical equations.

Matter can be classified as element, compound or mixture.

Chemistry
The Periodic Table is an example of a natural organization reflecting a broad range of similarities and differences.

Solutions are described in terms of the relative amounts of solute and solvent.

Descriptive relationships may be derived from chemical formulas and balanced chemical equations.

Matter can be classified as element, compound or mixture.

Physics
In the study of matter and energy interactions, two very different concepts may have similar explanations. An example is the inverse square relationship with distance of gravitational and electrical forces.

Earth/Space Sciences
All systems have boundaries.

Mineral species may be isomorphic, polymorphic, or pseudo morphic.

Stars differ in size, temperature, and age, but strong evidence suggests that they all consist of the same chemical elements present in the Solar System. Stars respond to the same physical laws observed on Earth.

The earth's lithosphere, hydrosphere and atmosphere are made of a relatively few fundamental substances in diverse arrangements.

Biological Sciences
Both the uniqueness and commonality of organisms affects the relationship within and among ecosystems.

An interrelationship of predator and prey dictates great variation from ecosystem to ecosystem.

Physiological and biochemical diversity is often the result of environmental influences.

Environmental Sciences
All ecosystems are similar in structure but vary in size and complexity.

All organisms are dependent on nutrient cycles and energy flow.

Variations among organisms exist within any species.

The genetic code is the basis for all forms of life.

A variety of ecosystems results from the effects of the hydrosphere, lithosphere, and atmosphere.

Tennessee Standard 2.3b - Groupings are based on similarities related to structure and function.

Benchmarks:

K-2
Classification of sets can be constructed using likenesses of materials and physical properties, such as color, texture, size or mass.

3-5
Organisms are separated into groups according to identifying characteristics.

Some individuals operate independently of the system, while others operate as a collective group.

6-8
Thinking about things as systems means looking for how every part relates to others.

Many systems contain feedback mechanisms that serve to keep changes within specified limits.

Different arrangements of atoms into groups compose all substances.

A system can include processes as well as objects.

9-12
Physical Science
Elements are organized in the standard Periodic Table according to atomic number and electron arrangement which reflect properties.

Compounds which form electrolytes in water solution may be classified as acids, bases, or salts. Relative acidity is described using the pH scale.

Most chemical reactions can be classified as single replacement, double replacement, synthesis, or decomposition.

Chemistry
Elements are organized in the standard Periodic Table according to atomic number and electron arrangement.

Compounds which form electrolytes in water solution may be classified as acids, bases, or salts. Relative acidity is described using the pH scale.

Most chemical reactions can be classified as single replacement, double replacement, synthesis, decomposition or oxidation-reduction.

Physics
Fundamentally, all energy systems are grouped as mechanical, thermal, fluid, and electrical. The prime movers that act on these systems are force, pressure, voltage, and temperature differences.

Earth/Space Sciences
Earth's principal systems are hydrosphere, lithosphere, atmosphere, and biosphere.

Matter in space is organized into gravitational units.

Biological Sciences
Similarities and differences of organisms usually lead to a system of classification terminating in the process of binomial nomenclature.

Environmental Sciences

Producers are capable of chemosynthesis or photosynthesis. Consumers must feed on other organisms for nutrient and energy.

Decomposers render complex molecules into simple molecules.

Terrestrial biomes are designated by large climate patterns.

Single cell and multi-cell organisms inhabit the biosphere.

There are industrial and primitive societies in the human population.

THEME: 2.4 INTERACTIONS - At all levels of living and non-living systems, matter and energy act and react to determine the nature of our environment.

Tennessee Standard 2.4a - Interactions occur on scales ranging from elementary particles to galaxies.

Benchmarks:

K-2

A pushing or a pulling force may alter the path of a moving object.

Sometimes changing one thing may cause changes in something else. If changes occur in the same manner, similar results may be expected.

3-5

Interactions among the smallest particles determine the nature of matter. Interactions among larger collections of matter determine its behavior.

The same fundamental particles are present in both living and non-living matter. The interactions of these particles shape our universe.

6-8

Every object exerts gravitational force on every other object.

Atoms and molecules are perpetually in motion.

There are groups of elements that have similar properties.

Gravitational force depends on how much mass the objects have and on how far apart they are.

Human beings cope with changes in their environment through the interactions among the senses, nerves, and brain.

Viruses, bacteria, fungi, and parasites may alter the function of an organism.

Scientists are still working out the details of what the basic kinds of matter are and how they combine.

9-12
Physical Science
Interactions between the electrons of different atoms form chemical bonds.

Matter can absorb and release energy.

Many interactions involve heat or the wave properties of light or sound.

Chemistry
Interactions between the electrons of different atoms form chemical bonds.

Matter can absorb and release energy.

The rate of reactions among atoms and molecules is affected by the nature of the reacting particles, temperature, concentration and presence of a catalyst.

Oxidation-reduction reactions occur as one atom loses electrons and another atom gains them.

Physics
Since matter ranges in size from sub-atomic to galactical levels, its interaction with energy will have an extremely large range.

Earth/Space Sciences
The interaction of elemental particles over billions of years has resulted in the formation of a universe containing gravitational units which include the solar system.

Chemical elements interact in different ways as they are cycled through the earth's systems - the hydrosphere, lithosphere, atmosphere, and biosphere. Typical examples include the rock cycle and the geochemical cycle.

Concentration, temperature and pressure affect how often atoms and molecules collide with one another, which in turn affects reaction rates within the universe.

Biological Sciences
All matter at every level must in some way exchange energy.

Environmental Sciences
The biosphere is composed of elements, molecules, and complex organic systems.

Ecosystems develop and change depending on interactions of abiotic and biotic factors.

Earth possesses the only known biosphere in the universe.

Human interaction with the biosphere is unique in environmental impact and control.

Geologic and meteorologic interaction precede biotic succession.

Tennessee Standard 2.4b - Interactions of matter and energy shape our world.

Benchmarks:

K-2
Changes that occur in an environment may affect both living or non-living things.

3-5
Living things contribute energy to and take energy away from non-living surroundings causing changes in both.

The interactions of matter and energy are subject to accepted physical laws.

6-8
The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns.

Heat can be transferred either through materials by the collisions of atoms or across space by radiation.

Electric currents and magnets can exert force on each other.

In any particular environment, the growth and survival of organisms depend on the physical conditions.

The relationships between two organisms may be competitive or mutually beneficial.

9-12
Physical Science
The organization and function of the physical universe is the result of interaction of matter and energy.

The relationship between force, work, and motion are described by the physical laws which govern the universe.

Conserving resources and protecting the environment are linked to the effective production and wise use of energy.

Chemistry
Elements and compounds interact in chemical reactions to form new substances.

During a chemical reaction, energy is absorbed or released.

Temperature, pressure, volume and number of particles are interdependent in a gaseous system.

Physics

The organization and function of the physical universe is the result of interaction of matter and energy.

Earth/Space Sciences

Earth's internal heat flow has resulted in the formation of moving plates that separate where heat is rising and new crust is forming and collide along their other margins.

Earthquakes, volcanic eruptions and mountain chains are closely associated with collisions between crustal plates and rifting of the earth's surface occurs where heat rises and new crust is forming.

There have been major impacts from extra-terrestrial matter that have impacted plate behavior and the biosphere.

Tidal forces on the Earth result from gravitational effects of the Earth, moon, and sun.

The earth's magnetic field has changed over time.

Biological Sciences

Natural resources and ecosystem dynamics are controlled by the interchanges of matter and energy.

Environmental Sciences

Most organisms in the biosphere are dependent on solar energy.

All organisms and ecosystems depend on abiotic and biotic conditions within a range of tolerance.

The human ecosystem adds complexity to the interaction of matter and energy in nature.

Nutrient cycles result from a flow of energy through an ecosystem.

THEME: 2.5 CHANGE - Interactions within and among systems may result in changes in the properties, position, movement, form, or function of systems.

Tennessee Standard 2.5a - Everything is constantly changing; rates of change vary over a wide scale with a great variety in patterns of change.

Benchmarks:

K-2

Some things may stay constant while others change.

Some changes occur so rapidly or so slowly that they become difficult to detect.

3-5
Things change in consistent, inconsistent and repetitive ways. Some features may stay the same while others change.

6-8
New information can modify existing scientific knowledge.

Human activities have decreased the capacity of the environment to support some life forms.

Selective breeding has resulted in new varieties of plants and domestic animals.

Various changes occur as an organism progresses through its life cycle.

9-12
Physical Science
Change in energy may result in a change in the phase of the material.

Chemical reactions occur as elements rearrange to form new substances.

During a chemical reaction, energy is absorbed or released.

Chemistry
Solution concentration may affect the properties of solutions such as freezing point, boiling point and vapor pressure.

Stoichiometric relationships quantitatively describe changes that occur during chemical reactions.

Energy is released or absorbed whenever chemical bonds are formed or broken.

Chemical reactions occur as elements rearrange to form new substances.

Change in energy may result in a change in the phase of the material.

Factors such as the nature of the solute and solvent, pressure, temperature and concentration affect the properties of a solution.

Energy relationships can be used to describe and predict the stability of molecules and the rate of reactions.

Physics
Matter and energy are interchangeable. The rate and degree of change depends on the availability of matter and energy and the duration of the interaction.

Earth/Space Sciences

Earth processes occur over a wide range of rates - some extremely swift and others so slow that they are difficult to measure in a human lifetime.

The probability of spontaneous decay rates of certain isotopes can be used as a reliable tool for radiometric dating.

Biological Sciences

The degrees of change possible in a system relate to its function, form, properties, position, and movement.

Environmental Sciences

Human interaction accelerates rates of change in the biosphere.

Rates of change in the biosphere vary from rapid cellular metabolism to slow continental drift.

Change is dependent on biotic and abiotic factors.

Tennessee Standard 2.5b - Cycles of change can be extended in scales of time, space, and material.

Benchmarks:

K-2

Changes occur in various ways and may be altered by controlling some variables.

3-5

Changes can occur slowly or quickly within any system.

Materials may combine to form new materials. The properties of the new materials may be unlike the original materials.

6-8

Some changes in the earth's surface are abrupt while other changes happen very slowly.

In the absence of retarding forces, such as friction, an object will keep its direction of motion and its speed.

Sedimentary rocks provide evidence for the long history of the earth.

The motion of an object is always judged with respect to some other object.

9-12

Physics

Wave patterns and propagation are a result of time rate of change in the position of vibrating particles.

Earth/Space Sciences
Cycles of change throughout time are recorded in the earth's rock and fossil records.

Recent changes in Earth's systems are often recorded in glacial ice.

Reversals in the earth's magnetic field are recorded as new crust is formed at spreading centers.

Processes of change may cause the order of the earth's chronological record to be reversed.

Biological Sciences
Small changes in an ecosystem can potentially effect the entire biosphere.

Interdependence conveys a need for all organisms within the environment to develop a natural, uninhibited, rate of change.

Some changes in organisms may be predicted using genetic inheritance and other theories of system change.

Environmental Sciences
Predictions can be made regarding the extent of change resulting from human interaction with the biosphere.

Predictions can be made regarding the extent of change in any ecosystem with sufficient data on biotic and abiotic factors.

THEME: 2.6 CONSERVATION - In any natural process the form may change but nothing is lost.

Tennessee Standard 2.6a - Although there can be transformations of matter and energy in changes, the sum of matter and energy is conserved.

Benchmarks:

K-2
When taken in parts, the parts of the whole still equal the mass of the original object.

3-5
Mass is a measure of how much matter an object contains. Breaking that object into parts does not change the total mass.

6-8
No matter how atoms are rearranged, their total mass stays the same.

As in all material systems, the total amount of matter remains constant, even though its form and location change.

Energy is neither created nor destroyed but only changes form.

9-12

Physical Science

Physical laws operate on the assumption that matter and energy are interchangeable and the total amount of matter and energy within a system remains constant.

In ordinary chemical reactions, there is no gain or loss of matter.

Chemistry

The mole quantity is used to describe equivalent amounts of substances.

In ordinary chemical reactions, there is no gain or loss of matter.

The energy gained or lost by any one system must exactly equal the energy gained or lost by the surroundings.

Physics

Physical laws operate on the assumption that matter and energy are interchangeable, and the total amount of matter and energy within a system remains constant.

Earth/Space Sciences

On Earth, all matter is cycled via the geochemical and rock cycles.

Biological Sciences

The chemical elements that make up the molecules of living things pass through the food webs and are combined and recombined in different ways.

Systems often cannot individually recover all energies consumed. Unrecovered energies may transfer to other organisms (pregnancy), the environment (heat), or waste materials (reaction by products).

Environmental Sciences

The presence of various compounds and elements in the biosphere is finite.

Energy and matter transformations affect ecosystem structure.

Regardless of the source, ultimately, all energy in an ecosystem becomes heat energy.

HABITS OF MIND

GOAL: To enable students to demonstrate ways of thinking and acting inherent in the practice of science; and to exhibit an awareness of the historical and cultural contributions to the enterprise of science.

THEME: 3.1 HISTORICAL AND CULTURAL PERSPECTIVE - The knowledge and processes of science have evolved over time as an approximation of truth within cultural contexts.

Tennessee Standard 3.1a - Although some scientific knowledge is very old, it is still applicable today.

Benchmarks:

K-2
When established scientific investigations are repeated, predictable results are expected.

3-5
Current scientific knowledge and future progress are based upon past scientific truths.

6-8
Mathematics has been important to science and technology for thousands of years and is still vital today.

9-12
Historic knowledge has been the foundation for some current scientific applications.

Tennessee Standard 3.1b - Individual initiative and vision create changes in science.

Benchmarks:

K-2
Motivation, creativity, and talent of individuals contribute to the progression of science.

3-5
Scientific advances and discoveries are often the result of individual creativity and insight.

6-8
Scientists around the world have made significant contributions to the body of scientific knowledge.

9-12
New ideas are not always accepted by the scientific community.

Tennessee Standard 3.1c - The desire to understand the natural environment and to predict the course of natural events is universal.

Benchmarks:

K-2
It is natural and desirable to seek an understanding of natural events.

3-5
Curiosity and interaction with the environment compel people to question and explain events that influence their lives.

6-8
People have developed theories to explain events.

9-12
Most cultures developed theories to explain and predict natural events.

Tennessee Standard 3.1d - The growth of scientific knowledge and most technological advances have resulted from the work accumulated over many centuries by men and women in every part of the world.

Benchmarks:

K-2
The scientific contributions made by men and women throughout the world have provided our scientific heritage.

3-5
Scientific contributions and advances continue as a result of work done by people from different cultures and backgrounds.

6-8
The history of individual and cultural contributions to science go hand in hand with their influence on the course of history.

9-12
Scientific knowledge is neither ethnic nor gender specific.

The scientific enterprise is an outgrowth of many cultures.

Tennessee Standard 3.1e - There are different traditions in science concerning the subject and method of investigation; however, they all have in common certain basic beliefs about the value of evidence, logic and argument.

Benchmarks:

K-2
The study of science includes a variety of techniques yet values the basic truism of evidence, logic, and argument.

3-5
Scientific investigations have in common the need for reliable data, logical thinking, and the communication of results.

6-8
Even if theories are inaccurate by today's standards, they seem to explain many observations about the world.

9-12
Regardless of the conclusion, findings should be substantiated by evidence acquired in a logical manner.

Tennessee Standard 3.1f - Progress in science depends heavily on societal events, and the course of history often depends on scientific and technological developments.

Benchmarks:

K-2
Scientific development throughout history has mirrored the events and needs of society.

3-5
Scientific advances are driven by societal needs and may directly influence the course of history.

6-8
Many inventions occurred by accident or because they fulfilled a basic need.

Inventions have enhanced our abilities to study science.

9-12
Advancement of a new idea often relates to the technology needed to develop and implement the idea.

THEME: 3.2 ASSUMPTIONS - The recognition and criticism of the validity of an argument through presentation of data and differentiation between fact and assumption in the preparation of an explanation for a natural phenomenon are vital parts of the scientific process.

Tennessee Standard 3.2a - Science is based upon suppositions derived from observations of natural phenomena.

Benchmarks:

K-2
Careful observation can yield scientific knowledge.

3-5
Unknown or unobserved variables may lead to unanticipated results.

No design is likely to be free of all possibility of error or even failure.

6-8
New ideas in science sometimes spring from unexpected findings, and they usually lead to new investigations.

Practice at making observations allows for discoveries from otherwise unnoteworthy events.

9-12
Scientific investigation begins with the observation and questioning of natural phenomena.

Tennessee Standard 3.2b - Predictions are based on previous knowledge.

Benchmarks:

K-2
Prior knowledge is the framework for making predictions.

3-5
Logical predictions are formulated from the evaluation of observations and prior learning.

6-8
Knowledge and creative insight are usually required to recognize the meaning of the unexpected.

9-12
Prior knowledge of the behavior of matter is used to make predictions when similar patterns are observed.

Tennessee Standard 3.2c - The critical assumptions behind any line of reasoning must be made explicit so that the validity of the position taken can be judged.

Benchmarks:

K-2
Claims of findings made during scientific investigation must be supported with evidence to ensure logical argument.

3-5
Prior learning must be accurate and free of incorrect assumptions.

6-8
Analyzing different possibilities may eliminate incorrect assumptions.

9-12
Inductive and deductive reasoning are used to evaluate data.

The critical assumptions behind any line of reasoning must be made explicit so that the validity of the position taken can be judged.

Tennessee Standard 3.2d - The validity of an investigation cannot be accepted unless the complete investigation can be independently duplicated.

Benchmarks:

K-2
If variables remain constant, an investigation can be repeated with expectations of predictable results.

3-5
Scientific truths must be supported by data in conjunction with logical evaluations.

6-8
Design usually requires taking constraints into account.

Accurate record keeping and replication allow students to test the validity of experiments.

9-12
Results of an investigation are valid if they are reproducible.

THEME: 3.3 ESTIMATION AND COMPUTATION - Scientists judge the level of precision needed to approximate a reasonable response and perform calculations with or without the aid of mechanical devices.

Tennessee Standard 3.3a - Estimation provides a way to judge, if the result of a computation is reasonable.

Benchmarks:

K-2
Giving a rough estimate is a preliminary step which can lead to further study.

3-5
Estimation provides a basis for evaluating the accuracy of computations.

6-8
Estimation of probability can be based on data from similar conditions in the past or what is known about current situations.

9-12
Estimation is a vital part of problem solving and should be made prior to computation.

Tennessee Standard 3.3b - Computation is the process of determining results by mathematical means.

Benchmarks:

K-2
Measurable explanations of scientific results are made credible by mathematical computation.

3-5
Mathematics allows for comparative evaluations which may lead to the solution of problems or a better understanding of both abstract or concrete concepts.

6-8
An investigator's credibility depends upon accurate record keeping, openness, and replication.

Logical connections can be found among different parts of mathematics.

The answer to every mathematical computation has a number and a unit.

9-12
Mathematical processes are applied to scientific data to determine results and conclusions.

Tennessee Standard 3.3c - All measurements are approximations.

Benchmarks:

K-2
Standard and non-standard measurement tools provide means for collecting data.

3-5
Measurements such as length, area, volume, mass, time or temperature may be judged in accordance with accepted values.

6-8
Accuracy is only as good as the least accurate component.

Numbers can be written in different forms, depending on how they are being used.

Rounding of numbers can affect the accuracy of measurement.

9-12
Measurements are human interpretations, not absolutes.

THEME: 3.4 METHODS - A variety of techniques is used by scientists to classify and solve problems.

Tennessee Standard 3.4a - Differences may exist between mathematical models and computations based on the models.

Benchmarks:

K-2
Since a model is a representation of events and processes, differences of interpretation may exist.

3-5
Mathematical models or analyses may vary subject to the operations performed.

6-8
When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant.

9-12
Mathematical models have many applications which determine their usefulness in scientific investigations.

Tennessee Standard 3.4b - Problems and methodology influence each other.

Benchmarks:

K-2
The methods of investigation is often determined by the nature of problems under study.

3-5
The choice of methodology is dependent upon the nature of the problem to be solved.

6-8
Different ways of obtaining, transforming, and distributing energy have different environmental consequences.

9-12
The nature of the inquiry often dictates the method of inquiry.

Tennessee Standard 3.4c - Different scientific domains may employ different methods of inquiry.

Benchmarks:

K-2
The level of understanding may increase with additional methods of study.

3-5
Physical, biological and social questions are subject to various types of investigations.

6-8
The method of inquiry is determined by the topic.

9-12
The method of scientific inquiry varies with the subject taught.

Tennessee Standard 3.4d - Each scientific domain uses various methods of inquiry.

Benchmarks:

K-2
Different activities produce a hierarchy of understanding.

3-5
Investigations can involve, but are not limited to, observation, specimen collections and experimentation.

6-8
Each topic under study may incorporate different methods of inquiry.

9-12
A methodology is not specific to a scientific domain.

Tennessee Standard 3.4e - Problems may be solved in more than one way and have more than one solution.

Benchmarks:

K-2
Results of a study may be obtained in various ways.

3-5
Alternative ways to solve a problem may lead to more than one solution.

6-8
Usually there is no one right way to solve a problem; different methods have different advantages and disadvantages.

9-12
Higher order thinking may produce multiple solutions to a problem, each with costs and benefits.

THEME: 3.5 SCIENCE AND TECHNOLOGY - Science and technology are separate but interdependent entities.

Tennessee Standard 3.5a - Science and technology change the environment in beneficial and detrimental ways.

Benchmarks:

K-2
Developments in science and technology can improve our quality of life, yet may have a negative impact on the environment.

3-5
The decision to apply a given technology must be based on the perceived benefits weighed against the possible disadvantages.

6-8
New technology can change cultural values and social behavior.

9-12
The economical, social and environmental cost-benefit ratio of implementing a new technology should be part of the decision-making process.

Tennessee Standard 3.5b - Technology makes it possible for scientists to extend their research or to undertake entirely new lines of research.

Benchmarks:

K-2
Technology may be used to do things more easily or to accomplish things once perceived impossible.

3-5
Technological advances tend to extend the reach of our senses and to expand our ability to manipulate and to understand our environment.

6-8
New technologies in space, computers, medicine and instruments promote research.

9-12
Ideas and principles discovered in the past are implemented as new methods and materials are discovered.

Tennessee Standard 3.5c - Innovations in science and technology are often stimulated by developments in mathematics, and vice-versa.

Benchmarks:

K-2
The partnership of science and math promotes continuous developments in both fields.

3-5
The process of invention yields both predictable and unanticipated results.

Technological advancements in one field are often applied to the solution of problems in unrelated areas.

6-8
Computers have enhanced scientific investigations.

9-12
A cultural climate that is open to creativity often stimulates new ideas.

THEME: 3.6 CREATIVE ENTERPRISE - Creativity contributes to the processes of science through ideas and inventions.

Tennessee Standard 3.6a - Imagination plays an integral role in science.

Benchmarks:

K-2
Toys, games and creative play can provide methods of understanding for the processes of science.

3-5
Science engages the creative nature of all people.

The process of invention is driven by need and individual insight.

6-8
Scientists are open to new possibilities.

9-12
Conceptual models lead to new ideas.

Tennessee Standard 3.6b - Creativity is both a mental and a physical process.

Benchmarks:

K-2
Kinesthetic and cognitive skills can be developed through creative activities.

3-5
Higher order thinking skills, when directed toward the process of science, may produce unique solutions or results.

6-8
Alternative methods of investigating and reporting are offered.

9-12
Physical applications of mental models generate new technologies.

Tennessee Standard 3.6c - Creativity enables development of new concepts, processes, and attitudes toward scientific inquiry.

Benchmarks:

K-2
Imagination may lead to new ideas, to ways of doing things and to influencing attitudes in science.

3-5
People use past experiences as a guide when approaching new and unique situations.
The integration of prior knowledge with new information may produce innovative results.

6-8
People who engage in design and technology use scientific knowledge to solve practical problems.

9-12
Creativity develops an attitude that science is a process, is continually changing and may be improved.

Tennessee Standard 3.6d - The human ability to shape the future comes from a capacity for generating knowledge, developing new technologies and for communicating ideas.

Benchmarks:

K-2
The ability of humans to use knowledge for improvement of life is on-going.

3-5
Humans throughout history have been toolmakers.

Although modern tools tend to be more complex than those of the past, many are actually modifications of ancient tools.

6-8
Economic health is promoted with technological development.

9-12
The ability to conceive, develop and communicate ideas advances the causes of science.

SCIENCE IN SOCIETY

GOAL: To enable students to demonstrate positive attitudes toward science in solving problems and making personal decisions about issues affecting the individual, society and the environment.

THEME: 4.1 ATTITUDES - The progress of science and the attitudes of society influence one another.

Tennessee Standard 4.1a - Scientists can bring information, insights, and analytical skills to bear on matters of public concern.

Benchmarks:

K-2
By making careful observation, questions can be formulated concerning our world.

3-5
Science provides a basis for addressing issues that affect our lives.

6-8
Scientists can use their particular expertise to address public concern.

9-12
Public concerns are often related to scientific knowledge and technology.

Tennessee Standard 4.1b - Science and technology should be viewed thoughtfully, in neither a categorically antagonistic or an uncritically positive manner.

Benchmarks:

K-2
Scientific ideas are more believable when supported with good reasoning and factual information.

3-5
Science does not create nor can it solve all of our problems.

6-8
Science and technology are viewed without bias.

9-12
The pros and cons of science and technology must receive an unbiased assessment.

Tennessee Standard 4.1c - The perceived value of any technology may vary for different groups of people and at different times.

Benchmarks:

K-2
Individual and collective needs and the influence of societal pressures have motivated technological advances throughout our history.

3-5
The extent to which a technology is applied determines the value placed upon that technology.

6-8
Individual views of technology are affected by culture and need.

9-12
The relative importance of a new technology may depend upon cultural norms and its usefulness at a particular time and setting.

Tennessee Standard 4.1d - Beliefs, superstitions and fears can limit the progress of science and technology.

Benchmarks:

K-2
Careful observation and proper use of scientific methods can promote positive attitudes concerning science.

3-5
The extent and direction of scientific research may be limited by real and perceived concerns.

6-8
Progress in science and technology can be affected by culture.

9-12
A cost-benefit analysis of a new technology must be assessed against the value and belief system of a culture.

THEME: 4.2 PERSONAL NEEDS - The application of science may be used to change the quality of life for the individual.

Tennessee Standard 4.2a - Any individual can participate in and contribute to the process of science.

Benchmarks:

K-2
Everyone can be a scientist, inventing and contributing ideas and seeking to solve problems.

3-5
People use and contribute to science to improve their lives.

6-8
People control science and technology and are responsible for its effects.

9-12
The scientific endeavor is a team effort requiring the multiple talents of all citizens in research, technology, and communication of results.

Tennessee Standard 4.2b - Science concepts may be applied to personal decisions.

Benchmarks:

K-2
The influence of scientific knowledge can be used to enhance the quality of life.

3-5
Individual behavior may be influenced by an understanding of science concepts.

6-8
The consideration of science concepts can aid decision making.

9-12
Scientific concepts are real and relevant when applied to daily life.

Tennessee Standard 4.2c - Science solves practical problems but may create new problems and needs for an individual.

Benchmarks:

K-2
Obtaining a need or want may result in conflicting consequences.

3-5
All factors must be considered when determining solutions to problems. A solution to one problem may create other problems.

6-8
Solutions in one area may have a negative impact in another.

9-12
Science is continuous; one solution often leads to new problems.

THEME: 4.3 CAREER GOALS - The development of scientific skills may lead to a rewarding career and productive contributions to society.

Tennessee Standard 4.3a - Career exploration presents an opportunity to challenge stereotype of scientists and to develop greater understanding of scientists and their work.

Benchmarks:

K-2
The opportunity for a career in science exists for all students.

3-5
The increasing complexity of requirements in the workplace demands greater scientific and technological literacy.

6-8
The study of scientists can promote a better understanding of professions in science.

9-12
Career explorations allow a study of the achievement and personal attributes of scientists.

Tennessee Standard 4.3b - Career opportunities in science and technology are available in all industries and will continue to increase.

Benchmarks:

K-2
The study of science and technology can lead to a rewarding career.

3-5
Active science involves people from all segments of society in many kinds of work.

6-8
Scientists can be employed in a variety of occupations such as education, government, industry, and medicine.

9-12
Science and technology are not industry specific.

Tennessee Standard 4.3c - Scientific skills and attitudes will facilitate adaptation to careers as science and technology change.

Benchmarks:

K-2
An enjoyment of science can be the stepping stone for developing future skills and attitudes necessary for a scientific career.

3-5
Advances in science and technology necessitate career changes and retraining of many vocations, some yet unknown.

6-8
People need better learning skills and flexibility to take on new and rapidly changing jobs.

9-12
Most career retraining opportunities require a basic knowledge of science and technology.

THEME: 4.4 SOCIETAL NEEDS - Science establishes the basis for applying technology to needs within a society.

Tennessee Standard 4.4a - Scientific research and development have an ethical component.

Benchmarks:

K-2
Scientific descriptions must be done as accurately as possible to ensure the consideration of ethical consequences.

3-5
Scientific developments may impact personal decisions.

6-8
Scientists must realize that they have an ethical responsibility to society.

Society determines which behaviors are acceptable or unacceptable.

9-12
Scientists consider the effect of research and development.

Tennessee Standard 4.4b - The demand by society for more and better products and services drives scientific research and development.

Benchmarks:

K-2
The expectations of society for scientific and technological advancement direct the progression in research and development.

3-5
The desire for more efficient technology assures the need for more research and design.

6-8
Needs and wants fuel scientific development.

9-12
Societal demands influence the allocation of resources for research and development.

Tennessee Standard 4.4c - Science and technology may produce changes that affect society and groups within societies.

Benchmarks:

K-2
Technological and scientific advances may result in societal changes that produce a means of survival, transportation and communication.

3-5
Technology throughout history has been a product of human culture. Access to any given technology may greatly impact socio-economic lifestyle.

6-8
The global environment is affected by national policies relating to science and technology.

9-12
When participation of individuals in society depends on new technologies, all groups should have access to that technology.

Tennessee Standard 4.4d - Basic research contributes to the body of scientific knowledge and may have unexpected results.

Benchmarks:

K-2
The value of basic research, recording predicted and unexpected results, is essential to the scientific process.

3-5
Social decisions based on scientific knowledge, regardless of the care taken in developing those decisions, may yield unexpected consequences.

6-8
Technology cannot always provide successful solutions for problems or fulfill every human need.

9-12
Knowledge and new questions arise from basic research; however, the results are not always immediately obvious.

THEME: 4.5 ECONOMICS - Scientific knowledge should provide a premise for understanding the economic value of applied technology as it relates to society.

Tennessee Standard 4.5a - Science and technology impact economic growth and productivity.

Benchmarks:

K-2
Advances in science and technology have a direct influence on any society's economic climate.

3-5
Technology provides the benefit of a higher standard of living to a much larger segment of society than was available in the past. These benefits tend to be driven by the level of a society's economic development.

6-8
Economic growth and productivity are fueled by science and technology.

9-12
The efficiency of technology increases productivity and may affect economic growth**.**

Tennessee Standard 4.5b - Needs and interests of society influence financial support and problems that scientists and engineers pursue.

Benchmarks:

K-2
Throughout history people have provided support for development of ideas that relate to their needs and interests.

3-5
The direction of and support for specific areas of research are guided by societal needs and ethical influences.

6-8
Society dictates research and development.

9-12
The availability of both government and private funds often determines research efforts.

Tennessee Standard 4.5c - Limited resources dictate a need for prioritization.

Benchmarks:

K-2
The numerous demands for limited resources necessitate the need for priorities in the utilization of resources.

3-5
Resources are generally allocated according to the perceived needs of society.

6-8
In all technologies, there are always tradeoffs to be made.

Different parts of the world have different types and quantities of resources which govern their use.

9-12
Resources are not always available for research.

Special interest groups often influence research priorities.

Tennessee Standard 4.5d - The total impact of developments in science and technology on the economy is seldom known at the time the development occurs.

Benchmarks:

K-2
Inventions provide improvements while establishing the foundation for future developments.

3-5
Scientific and technological developments may be applied in unforeseen ways. Therefore economic implications cannot always be predicted.

6-8
The economic importance of a discovery may not be realized immediately.

9-12
Historically, the impact of science and technology is determined by its implementation.

THEME: 4.6 POLITICS - Basic scientific concepts should be available to all individuals enabling each to make logical decisions for themselves and others.

Tennessee Standard 4.6a - Scientific literacy influences the political process.

Benchmarks:

K-2
The scientific enlightenment, exposure and educational climate within a population govern the extent of political support.

3-5
When compromise cannot settle a conflict, a vote may resolve the issue.

6-8
A scientifically literate society may lend support to research and development through the political process.

9-12
Everyone should evaluate information and be able to determine its accuracy and validity.

Tennessee Standard 4.6b - The risks and cost benefits must be carefully considered when developing new technology or curtailing existing technology.

Benchmarks:

K-2
Benefits and drawbacks must be included in the consideration of new technological advances.

3-5
Decision-making processes consider the benefits and drawbacks of alternatives and the input of those affected by the decisions.

6-8
All technologies have effects other than those intended by the design.

9-12
The long range risks and benefits must be considered in the development and use of technology.

Tennessee Standard 4.6c - Governments use the development of science and technology in global competition for power and prestige.

Benchmarks:

K-2
(No Benchmark was considered appropriate for this level.)

3-5
National security and national interests dictate the direction of some areas of scientific research.

6-8
Government usually has most of the power in making decisions and in enforcing rules for the uses of science and technology.

9-12
The import and export of science and technology provides a power base for governments.

SECONDARY SCIENCE
COURSE LISTING

COURSE (COURSE NUMBER)	RECOMMENDED (PREREQUISITE)
LIFE SCIENCE (3208)	
BIOLOGY I (3210)	
BIOLOGY II (3216)	(Chemistry I and Biology I)
ANATOMY AND PHYSIOLOGY (3251)	(Biology I, Chemistry I)
ADVANCED PLACEMENT BIOLOGY (3217)	(Biology I)
CHEMISTRY I (3221)	(Algebra I or equivalent)
CHEMISTRY II (3224)	(Chemistry I)
ADVANCED PLACEMENT CHEMISTRY (3225)	(Chemistry I)
EARTH/SPACE SCIENCE(3204)	
GEOLOGY (3205)	(Biology I, Chemistry I or Physics)
ENVIRONMENTAL SCIENCES (3260)	
ECOLOGY (3255)	(Biology I, Chemistry I or Physics)
PHYSICAL SCIENCE (3202)	
PHYSICS (3231)	(Algebra II or Geometry)
ADVANCED PLACEMENT PHYSICS (3232)	(Trigonometry or equivalent)

Vocational courses which may be used to meet science requirements for graduation.

AG SCIENCE IA (5121)	
BIOLOGY FOR TECHNOLOGY (3258)	
NUTRITION SCIENCE (5615)	
PRINCIPLES OF TECHNOLOGY I (3220)	
PRINCIPLES OF TECHNOLOGY II (3256)	

Three years of science are required for high school graduation, one of which must be a life science and one a physical science. The life sciences are: Life Science; Biology I & II; Anatomy and Physiology; Ag Science 1A, and Biology for Technology. The physical sciences are: Earth/Space Science; Geology; Physical Science; Chemistry I & II; Physics; and Principles of Technology I & II. Environmental Science and Nutrition Science are interdisciplinary and may be counted as either.

ADVANCED PLACEMENT COURSES

The Advanced Placement (AP) Program is a cooperative educational endeavor of secondary schools, colleges, and the College Board. It consists of college-level courses and examinations in specific academic disciplines for highly motivated students in secondary schools. The AP program provides course descriptions and teaching materials as well as examinations based upon those descriptions. It does not prescribe the textbook, schedule of lessons, or teaching techniques.

A specific state framework for each course has not been developed. The curriculum is considered to be more accelerated and more in-depth.

1. AP Biology - course code 3217
2. AP Chemistry - course code 3225
3. AP Physics - course code 3232

APPENDIX

Electricity/Magnetism

Matter

Energy/Light/Heat/Sound

Simple Machines/Technology

Geology/Earth Structure

Space Science

Habitats/Ecosystems/Biomes

Meteorology

Environmental Education

Anatomy

Classification

Animals

Plants

Oceanography

Electricity/Magnetism

Matter

Energy/Light/Heat/Sound

Simple Machines/Technology

Geology/Earth Structure

Space Science

Habitats/Ecosystems/Biomes

Meteorology

Environmental Education

Anatomy

Classification

Animals

Plants

Oceanography

6-8 SCIENCE CONTENT TOPICS

Matter

Motions and Forces

Transformation of Energy

Living Systems

Reproduction and Heredity

Regulation and Behavior

Populations and Ecosystems

Diversity and Adaptations of Organisms

Structure of the Earth

Earth’s History

Solar System

PHYSICAL SCIENCE CONTENT TOPICS

Course# 3202

Matter and Energy

Atomic Structure

Force and Motion

Machines

Symbols, Formulas and Equations

Electricity and Magnetisms

Elements, Compounds and Mixtures

Periodic Table

Solutions

Acids and Bases

Heat, Light, and Sound Waves

Chemical Reactions

Electron Configuration and Bonding

Laws of Conservation

EARTH/SPACE SCIENCE CONTENT TOPICS

Course # 3204

Origin and Evoluation of Solar System and Universe

Hydrosphere/Lithosphere/Atmosephere/Biosphere

Earth Materials

Rock Cycle

Plate Tectonics

Internal/External Earth Processes

Landform Evolution

Weather and Climate

Ancient Environments: Rock and Fossil Records

Humans are Affected by the Natural Environment

Topographic Profiles

Map Reading

Earth Structure

Deep Time

Course # 3205

Rock Cycle

Earth's Mineral and Energy Resources

Plate Tectonics Theory

Absolute and Relative Dating

Deep Time - Earth History

Formation of Oceans, Continents and Atmosphere

Paleoenvironments

Earth Structure

Regional Tectonic Settings

Internal/External Earth Processes

Geological Hazards

Hydrologic Cycle/Water Budget

Geochemical Cycles

Landform Evolution

Geologic Maps

Planetary Geology

LIFE SCIENCE - BIOLOGY I AND II CONTENT TOPICS

Course # 3208, 3210, & 3216

Cell

Genetics and Heredity

Cycles and Energy Distribution

Anthropological Concepts

Human Physiology

Ecosystems

Classification Systems

Human Interaction with Ecosystems

Botanical Systems

CHEMISTRY I AND II CONTENT TOPICS

Course # 3221 & 3224

Matter and Energy

Elements, Compounds and Mixtures

Periodic Table

Electron Configuration and Bonding

Atomic and Molecular Structure

Chemical Formula

Chemical Reactions

Stoichiometry; The Mole

Gas Law

Solutions

Acids and Bases

Oxidation and Reduction

Thermodynamics; Kinetics

Organic Compounds

Radioactivity

PHYSICS CONTENT TOPICS

Course # 3231

Mechanics

Thermal Dynamics

Wave Motion

Optics

Electricity and Magnetism

Atomic and Nuclear

ANATOMY AND PHYSIOLOGY CONTENT TOPICS

Course # 3251

Cell

Genetics and Heredity

Cycles and Energy Distribution

Anthropological Concepts

Human Physiology

ECOLOGY CONTENT TOPICS
Course # 3255

Ecological Awareness

Ecological Levels

Cycles in Nature

Population Dynamics

Energy Flow and Nutrition

Adaptation and Behavior

Ecological Succession

People and the Biosphere

Pollution and Environmental Health

Energy Resources and Demands

Stewardship

ENVIRONMENTAL SCIENCE CONTENT TOPICS
Course # 3260

Hierarchy of Ecosystem Organization: Atoms to Biosphere

Modeling of All Systems

Ecosystem Structure and Function

Energy Flow Through Ecosystems

Evolution of Ecosystems

Conservation of Resources

Human Interaction with Ecosystems