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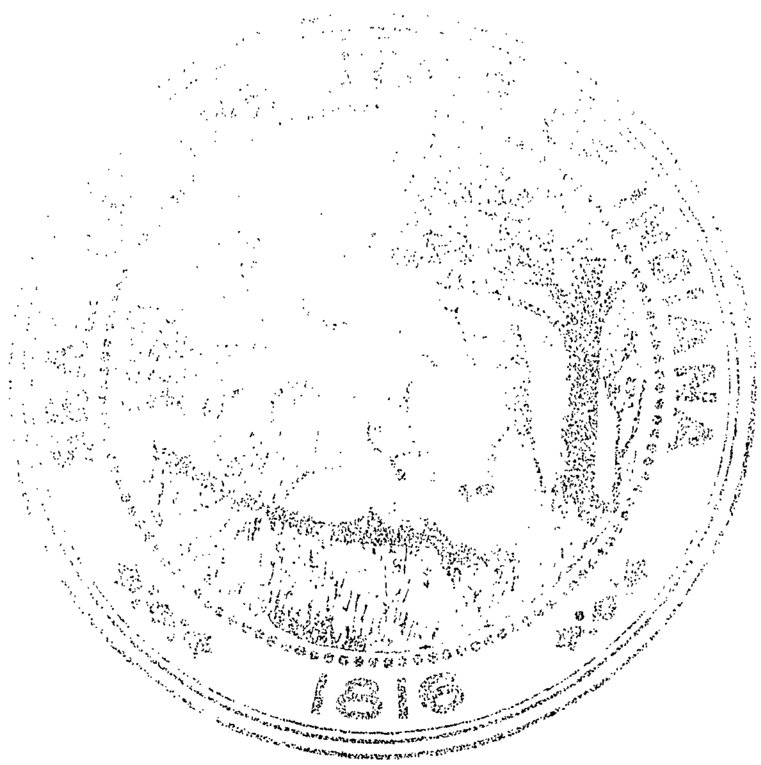
ABSTRACT

This publication is a curriculum guide intended to help implement coordinated K-12 science programs by serving as a framework of reference. The performance objectives that should be developed by students who study science are written in general terms and constitute the heart of the volume. The lists of performance objectives include the processes which the student would use in achieving the objective, the conceptual scheme with which the objective may be identified, a statement of the performance objective, and the values and attitudes that performance of the objective should develop. There is a performance list for each of these grade categories: kindergarten and elementary; middle school and junior high; and senior high school. The introductory chapters review the philosophy, goals and the following themes in school science programs: the processes of sciencing; the conceptual schemes of science; the values and attitudes derived from science learning experiences; psycho-motor skills in science learning experiences; and the subject matter of science. Additional guidelines for sequencing the programs and textbook evaluation are provided in the appendix. An annotated bibliography is included. (PR)

GUIDELINES FOR INDIANA SCHOOL SCIENCE PROGRAMS K-12



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Message From The State Superintendent

This publication was developed to help implement coordinated K 12 science programs in Indiana elementary and secondary schools. It is presented to Hoosier teachers with the hope that it will be useful in reviewing, analyzing and improving science instruction at all grade levels.

This project is the result of the efforts of a committee of elementary teachers, junior and senior high school science teachers, department heads and administrators, science supervisors, general administrators and college science educators. Various members of the committee have had experience in writing and/or implementing major science curriculum projects, writing textbooks and designing local curriculum innovations. All have had wide experience in education and are dedicated to meaningful education for the youth of Indiana.

The committee's intention has been to provide a framework from which local schools can begin studies to improve their science programs. These Guidelines are not intended to be prescriptive but to serve as one frame of reference for the study of local science curriculum and the construction of well articulated, comprehensive science programs.

Much work and thought has been devoted to the development of this publication. This Office is indeed grateful to all who have contributed to its development and review.

JOHN J. LOUGHLIN
State Superintendent of
Public Instruction

ACKNOWLEDGEMENTS

Guidelines for Indiana School Science Programs, K-12., 1971 has been prepared to replace various bulletins dealing in whole or in part with science instruction in Indiana Schools. This publication is the culmination of nearly two years work by the Indiana State Science Advisory Committee under the sponsorship of the Office of State Superintendent of Public Instruction. Its purpose is to provide guidance to the professional personnel of elementary and secondary schools as they search for ways to improve the education of Indiana children, particularly with respect to the science curriculum.

The Office of State Superintendent of Public Instruction is indebted to all members of the Advisory Committee for the long hours, both in and out of committee and subcommittee meetings, which they have devoted to the preparation of this publication.

Three other groups deserve special thanks. First, several persons, outside the committee, prepared various items for inclusion in the publication. These people are listed as "Other Contributors". Others prepared materials which were not used; the Office wishes to thank these people for their efforts and hopes to print their materials at a latter date.

The second group is the many teachers and science educators throughout the state who reviewed the Working Copy during the fall of 1970 and fed back comments to the Editorial Committee for its consideration. All of these comments were helpful in improving the quality and functionality of the final draft. The list of persons who contributed to this review is rather long. Also since many formal statements were the compilation of the comments of several reactors, no published list would be complete. Even though these persons are not named, the Office wishes to express its thanks to each one who took part.

Finally, the Office wishes to also thank the various school boards, superintendents, principals and university administrations represented by the committee for both releasing their personnel for the many lengthy meetings during the 1969–70 school year and the patience extended to the committee members as they devoted themselves to this most essential task of curriculum improvement.

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INTRODUCTION

USING THE GUIDELINES: A CHARGE TO THE READER

Curriculum guides enjoy poor reputations among school personnel. The heavy tomes quickly migrate to the bottom drawer of the file cabinet and live a quiet life in oblivion. So why have we produced another such document at public expense? Obviously we have some hope that *this* will be the exception, that this guide will have value and that it will serve as a tool used by school personnel to improve the quality of science instruction throughout the state. But let us be honest. This is only a dream, and it will not happen. It will not happen . . . . .UNLESS ! ! !

This publication will be useless unless it gets to the right people.

It will be useless unless it is read. No, more than read · *studied*.

It will be useless unless classroom teachers are shown how it can be used and why.

WHO WILL BE INTERESTED IN THIS PUBLICATION? It is easy to say that this should be of interest to all individuals interested in science education in the public schools, from elementary teacher to college scientist. But not all of these individuals will take the time to read it or will even have access to it. Therefore, we had certain people in mind when the book was written.

Probably, the first groups to see this document will be school superintendents, principals and curriculum coordinators. These individuals are responsible for providing overall guidance for the school curriculum. They need to know the general goals of science instruction. They need to know what course offerings might lead to the development of these goals. And they need to be aware of specific state regulations pertaining to the teaching of science. Superintendents, principals and curriculum coordinators will be particularly interested in Chapter 4 which deals with sugg .ed sequences for science learning and Chapters 1 and 2 which identify and discuss current philosophy and goals of school science and important themes in modern science programs. At this point the superintendent, principal or curriculum coordinator is likely either to place this book in a favorite file or to pass it along to local leaders in science education. We hope he will pass it along.

In virtually every school system there is some individual who is looked upon as a leader in science teaching. This is the person who chairs the textbook adoption committee, who orders equipment, who attends the science convention and comes back with new ideas. He is the person who suggests changes in the science curriculum and works to convince other staff members to join with him. These guidelines are written for the local leader in science education. More than any other individual, he will determine whether the guidelines are put to use or put to rest. The science leader will be interested in the entire book, but some of it may only be a review for him. He will have a philosophy of science teaching and will have set goals for his own instruction, if not for the entire school. Still, he will want to read Chapter 1 to see if there are new ideas or concerns that have not been given the attention that they deserve. He may encourage other teachers in the school system to read Chapter 1 and use it as a guide for working out a philosophy for their school and for setting goals that they hope to achieve. Processes of science, hierarchies, and conceptual schemes will be familiar terms to the leader in science education, so Chapter 2 may add little to ideas gleaned from previous professional reading. It may, however, provide some impetus for his school system to develop its *own* list of conceptual schemes around which the science program could be organized and to develop its *own* hierarchy of process skills which will be the framework for the science curriculum.

Chapter 3, which constitutes the heart of this document, will be the central concern of both the leader in science education and the classroom teacher. In Chapter 3 we have attempted to describe competencies that should be developed by students who study science. Every teacher should look at the entire list of objectives from kindergarten to grade 12 and examine more closely the objectives for two or three levels both preceding and succeeding theirs, for no teacher operates in isolation. What one is able to accomplish depends on what has gone before and what is to follow. Still, teachers in the primary grades will be most concerned with objectives for their own grade level, just as the physics teacher will be most concerned with what is to be done in his area of specialization.

No attempt has been made to specify the exact activities that must be carried out in a particular course or at a particular grade level. A pluralistic educational system that acknowledges unique concerns and needs of each community and each individual should be protected and encouraged. However, we live in a mobile society; and we believe that there are competencies that should be developed in every school system. We have tried to identify many of these competencies in general terms. It is left to local teachers to translate those competencies into specific objectives that will satisfy both the common needs in science education and specific concerns of the local community. Thus, we say that in the primary grades students should learn to classify objects on the basis of properties such as rough, smooth, small, large, same and different. Teachers must decide in their own situations whether this can best be done in kindergarten or grade 1 and whether this competency will best be achieved through experience with blocks of colored plastic and wood in special equipment kits, through examination of leaves and other natural objects collected by children, or by working with common objects found in the classroom. Although we mention that the student of physics should be able to demonstrate energy conservation using interactions which involve a change in energy forms, the physics teacher must decide how he can best develop that concept with his students, what examples of conservation are most likely to be meaningful and what evidence he will seek as assurance that the concept is understood.

We believe that every teacher of science should study the objectives for the course(s) he teaches. He should continue to develop the list by adding to it and by replacing our relatively general statements with more specific statements of what students should accomplish in his own course(s). The objectives in Chapter 3 will accomplish little so long as they remain in the bottom of the file cabinet or in the back of the teacher's mind. They are intended to be used in week to week planning and day to day teaching. We hope that this book will be torn apart literally; it has been designed to facilitate such dissection via loose leaf binding. *We would like local schools to make copies of pertinent objectives for each teacher.* We would like to go into classrooms and find that teachers have copies of the objectives in the notebook in which they keep the notes they use during class. We would like to see them marked, with new objectives added to the list. We would like to see that teachers have extended the development of the identified conceptual schemes. We would like to see activities, planned by the teacher to develop attitudes and values that have been too long neglected.

To many science teachers, the specification of performance objectives for a course, the organization of the science curriculum around conceptual schemes, the creation of classroom atmospheres conducive to appropriate attitude development and the development of hierarchies of process skills are new ideas. This may not be the case for students graduating from colleges today. These ideas are generally included in science methods courses; and students in those courses may be expected to write objectives, to identify conceptual schemes, to design strategies for value learning and, perhaps, even to develop a hierarchy of skills through task analysis.

We believe that these guidelines should be useful at the college level. Undergraduate students might be given the assignment of taking one conceptual scheme and, starting with suggested objectives which relate to it, plan a short segment of science instruction that would develop that major idea and promote the learning of those specific competencies and attitudes identified with the objectives. By engaging in this type of activity as an undergraduate and using a document that may serve as a guide to instruction after the student has joined the professional ranks, beginning teachers can develop planning strategies that will serve them throughout their teaching career.

We believe that the publication may serve a similar role in inservice progra[illegible] and graduate science methods courses. We believe that even experienced teachers can profit from activities similar to those outlined above.

HOW SHOULD THESE GUIDELINES BE USED? We have suggested some ways that this publication can be used as we have discussed individuals who will find it of interest. Here we want to be more specific. This publication contains *guidelines*, not dogma. No single group can provide a "how-to-do-it" manual to be followed by every classroom teacher within the state. There is no authority who should say, "These are the things that *must* be done in your classroom." We do not have the vision, and you wouldn't accept it if we did. But what strategy can be used by school personnel to implement the recommendations and develop curricula from these guidelines? We will suggest a plan.

Step 1: Institute a study of the local science curriculum. Although interested teachers may independently, or as a group, institute and accomplish changes in the school science program, a coordinated effort throughout the school system is more productive. Such efforts need the blessing of the administration. The first step in improving curriculum should therefore be to obtain the approval and official encouragement of the appropriate administrator.

Step 2: *Study these guidelines.* This can be done best by a small group of individuals within the school system who are interested in the science curriculum and familiar with the existing program. They should study the statement of philosophy and goals found in Chapter 1. Do they agree with the statement? How does it differ from their own philosophy? What goals can be identified in the existing science program? Is the present program a coordinated one that develops logically from kindergarten through the twelfth grade? Does the existing program satisfy the needs of *all* students served by the school system?

This group might prepare their own statement of philosophy and goals. This statement could be distributed to other science teachers within the system for comments, or it might be used as the topic for discussion in a school wide science meeting. Selected students, parents, and community leaders might also be asked to react to the paper to see if they agree with the stated purposes of science instruction. Until teachers within the system agree on the unique purposes and goals of science teaching in their schools, little change can be expected to occur.

Step 3: *Develop an articulated plan.* Once the general goals of science instruction have been identified, attention must be given to realizing these goals. Perhaps more people should be involved at this step. In particular, elementary and junior high teachers who are aware of special problems that may escape the attention of science specialists should have a part in making decisions. Are certain conceptual schemes better vehicles for organizing the instruction than others? What are the process skills, attitudes and values that should be included? Attention should be given to the objectives, conceptual schemes and processes outlined in this publication, and tentative decisions should be made concerning the categories of objectives that will be included at each grade level.

Step 4: *Select specific objectives.* Teachers at one level will not be greatly interested in what is to be done at remote levels, nor will teachers in one science field be vitally concerned about the details of instruction in other science fields; therefore, primary teachers, intermediate teachers, junior high teachers and senior high teachers might meet in separate groups to select, delete or add to the lists of objectives that have been suggested for each area.

Step 5: *Develop an implementation program.* Once general agreement has been reached concerning the objectives of the science curriculum, materials should be selected which will enable those objectives to be realized. Consideration must also be given to facilities and, perhaps, to inservice teacher education. What textbooks are available which are compatible with the planned objectives? What special equipment and supplies will be needed and what will they cost? Will some teachers need to develop new skills in order to teach science as it should be taught?

Guides are provided in Chapter 5 for evaluation of textbooks and science facilities. These should be of value as you deal with the above issues. Undoubtedly, compromises will be necessary. Attention must be given to getting the best science program possible with the money and personnel available.

Step 6: *Implement the program.* Individual teachers must eventually translate the objectives into classroom activities. Teachers must be encouraged to keep the objectives before them and to identify text material and activities appropriate to the objectives, so the objectives will not be permitted to become subservient to the textbook as a guide for instruction.

Step 7: *Continue the Implementation.* The coordinated science program that results from careful planning and diligent effort will quickly fade away unless continuing effort is made. Teachers die, retire or move to other schools. Others take their places. Each year teachers who join the school system will need orientation and help if they are to understand their responsibilities in teaching science. Some individual within the school system should have the responsibility for reviewing the science program with each new teacher. He should go over the science objectives for the courses for which the teacher is responsible. He should assist that teacher in translating those objectives into classroom activity.

Step 8: *Continue to study and revise.* No matter how well the initial effort is planned, it will have weaknesses. Many of these can be corrected as the implementors gain experience with the program. The implementation plans, therefore, must provide for continual feedback, restudy, revision and inservice training.

WILL IT WORK? In preparing this publication, The Indiana State Science Advisory Committee had the goal of inducing school personnel throughout the state of Indiana to reevaluate their science program, K–12, and to institute a coordinated program that is appropriate for the dynamic society of today and tommorrow. Will it be reached? We don't know. We do know that these guidelines are only the beginning; the real work must be done in the schools by the people who face students every day. The task is yours. We hope that the publication will help, that you will use it, or even abuse it; but, above all, we hope that this will be one curriculum guide that doesn't rest quietly in the back of the bottom file.

The Indiana State Science
Advisory Committee

ˆ.0 PHILOSOPHY AND GOALS FOR SCHOOL SCIENCE PROGRAMS

1.1 Philosophy of Science Experiences

Science and technology affect everyone's life in aesthetic as well as materialistic ways: thus they must be an integral part of the school curriculum. School science should help students comprehend how each science discipline contributes to the knowledge, the behaviors, the understandings and the predictive relationships that pervade the whole of science and the totality of human intelligence and behavior. This should occur in a success-expected sequenced set of operational objectives which can be evaluated, modified, and integrated in a continuous fashion.

Teachers must become as concerned with attitude and interest in science as they are with content. Teachers and students alike must be aware of the role of science in life style and the human condition. The sciencing students do must be highly individualized because of differences in abilities, goals and interests of the children. This changes the role of the teacher from one who presents demonstrations and imparts knowledge to one who helps students execute plans to the best of their abilities. The teacher should think of himself as a director of multi-level science activities in each classroom. The classroom atmosphere should be such that a teacher sees a child's confusion at some point in his project as a welcomed signal for opportunity to help.

These are Pupil Power guidelines: they provide practical guidance for developing self-motivating, scientifically literate, creative students capable of effective living.

1.2 Goals for School Science Programs [1]

1.21 *Rationale*

The goals of school science programs must be consistent with the overall goals of the educational system of which they are a part and must aid that system in realizing its goals. Even though much uncertainty presently exists concerning many of the more specific goals of the nation's schools, there are certain general goals which must underlie all school activities if the schools are to serve the social order in which they exist.These goals are: (1) to provide the student with the basic knowledge and skills essential for him to discover his most effective role in a dynamic society, (2) to provide him with adequate knowledge and experiences to understand this role, and (3) to develop the competencies necessary to properly execute this role in a manner which is satisfying to him and his associates and which will further human progress.

Although these goals have been basic to all educational efforts throughout history, educational programs and their specific goals have undergone and must continue to undergo changes; for these goals do presecibe human progress as one of their products. One of the products of this progress is a society which channels much of its labors toward its own self-improvement through education. Today's society demands that a fourth general goal be added to the three already stated. (4) To develop students who accept personal responsibility to continue their education throughout life. To accomplish this goal, school programs must provide relevant independent learning activities through which the student can enjoy the excitement of learning and be motivated and prepared for an adult life of continual self-improvement.

Our dynamic society demands that these four goals receive constant attention as school programs are evaluated and revised. From the abundance of information available, educators must select programs and materials which relate to these basic goals.

1.22 *Science Goals*

These general educational goals dictate that science programs must: (1) develop scientifically literate citizens who make wise choices about the particular environment they encounter, (2) provide the proper training for those with the aptitudes and interests to become scientists and technicians.

Both of these purposes demand that the student develop a comprehension of the conceptual patterns into which scientific knowledge has been organized. He must also develop an understanding of the universality of the cause and effect relationship, the processes man has employed to comprehend his natural environment and his relationship to it, the various mechanisms he has used to control it, and the adaptations he must make to it These understandings result from actively using the mental skills of sciencing and the manipulative skills needed to apply them. Some of these skills are making, recording and reporting accurately observations; sorting relevant data; thinking convergently and divergently to form hypotheses and generalizations; and making evaluative judgments to arrive at valid conclusions.

For a student to fully discover, understand and execute his role in a dynamic society, he must also develop certain attitudes, values and appriciations. Many of these can be nourished by properly planned science programs. Some of these involve the development of a respect for knowledge and understanding, an open-minded attitude, an intellectual curiosity, a respect for intellectual honesty, an objective additude, a realization of one's own competencies and limitations and a sense of responsibility. These attitudes and values will be established by programs which provide pleasurable experiences through which the student can discover the satisfaction derived from science learning. Science programs should also develop an appreciation for our scientific heritage and the contributors to that heritage; for the ever expanding knowledge bank which human endeavor, particularly the scientific enterprise, has produced: for the role of the pure scientist along with that of the practical inventor and technologist; for the potentials of science and its limitations; and for the aesthetic order and beauty in nature.

Science programs should be structured so these affective and cognitive skills do not find their sole application in the study of the scientific disciplines. Science programs can aid in developing citizens who strive to make sound decisions based on all available pertinent data and who continue their science and general education throughout life as they seek to improve their functions as members of society. Persons who conserve our natural and human resources should be another logical by-product of these programs.

Science programs necessarily become progressively more specialized in secondary and higher education, but at these levels the above goals remain apropos to programs for non-science students. Preservice and inservice programs for teachers of science in elementary and secondary schools must be designed to develop classroom practices which will promote these goals. In addition, these programs must provide the teacher with a realization of how he can manipulate the existing classroom environment to accomplish these goals.

These general goals provide direction for planning of school science programs. They also can help communicate to the general public what the schools are attempting to accomplish; however, to assure that these goals are realized, teachers and curriculum developers will need to reduce them to a series of sequentially stated instructional objectives. These objectives must be consistent with the learner's development and background and stated in terms which will allow the teacher to know when each has been realized.

[1] This statement of goals is an adaptation of a position paper of the Council of State Science Supervisiors on "Objectives of Science Programs," part of an unpublished document, *This We Believe*. It was adopted in roughly its present form by the Indiana State Science Advisory Committee in February, 1969 as "A Statement of Goals for Indiana School Science Programs" and since then, has received limited circulation under the subtitle: Project - D.U.E.

2.0 Important Themes in School Science Programs

The foregoing statement of goals for school science programs identifies several themes or threads that should permeate the entire K-12 science curriculum. These can be grouped into five main categories. These are: (1) the processes of sciencing, i.e. the mental transformational skills used in scientific investigations; (2) the conceptual schemes of science, i.e. the big ideas man uses to synthesize the multitude of facts he discovers about nature into a comprehendible body of knowledge; (3) the values and attitudes for living which are derived from science learning experiences; (4) the usable psycho-motor skills of sciencing; and (5) the subject matter of science, i.e. knowledge of the facts discovered by scientists which have been traditionally taught in school science instruction.

There has been much discussion about which of these major themes should receive the main emphasis in science curriculum design, i.e. toward which of these should the major impact of science instruction be directed. These Guidelines were built upon the philosophy that if a science program effectively serves today's youth, it must emphasize each of these themes. It must place each in the proper perspective since each has a unique contribution to make to the child's total education.

The manner in which this multi-emphasis approach may be achieved will be discussed in 3.23. This section discusses the nature of each theme with regard to its importance in science learnings.

2.10 The Processes of Sciencing

There are certain processes (mental techniques and skills) that characterize the thinking of a scientist. Although very few will become scientists, life in today's and tomorrow's society demands that each citizen comprehend the nature of scientific thought. Mastery of the processes of science can contribute to the total education of the child because of their high transferability. Sciencing (both natural and social) is more inductive or synthetic while the thinking required for most other school subjects, particularly mathematics and the language arts, is more deductive or analytical. Educational research indicates that inductive thought cannot be mastered by students being told or reading about the processes involved. They must have actual experience in using these skills. Adults who properly utilize the data the scientific enterprise provides must experience the techniques used in arriving at these data. This is necessary if they are to have some idea of the capabilities and limitations of science as well as the significance of and restrictions on its data. Additionally, in today's society, they must collect and process the data needed to make everyday decisions.

2.11 *The Process Hierarchy - Its Need and Description*

Even though the student must be a practitioner of science if he is to comprehend and master the processes of sciencing, the processes he is asked to master must be consistent with his mental growth and development. Although no teacher would ask a student to write a complex sentence before he can form the letters of the alphabet or to extract square roots before he can add two single digit numbers, it has not been uncommon to find examples in science instruction of comparably absurd assignments. Some students have been asked to perform complicated investigations before they have mastered making precise observations. Just as there are simpler skills to be mastered before students can accomplish the more complex ones in language and mathematics, there are simpler processes of sciencing to be mastered before the student can perform the total synthetical act. Since this inductive reasoning often involves abstract thought, total sciencing can be performed by only a few students before junior high school. On the other hand, to delay all sciencing until junior high school is just as unrealistic since there are simpler sciencing processes to be mastered before complex investigations and syntheses can be preformed.

In classroom instruction and curriculum development each process should be introduced as the student acquires some mastery of the prerequisite processes. This in turn, requires ordering the processes in a series which indicates those processes whose mastery is antecedent to the performing of other processes. Such an ordering is called a *process hierarchy*.

Considerable work in recent years has been devoted to the development of a valid hierarchy for the processes of sciencing. Much of the work of the Commission on Science Education of the American Association for the Advancement of Science in developing the elementary science program, *Science–A Process Approach*, involved validating one such hierarchy.[1,2] Although this research indicates that this hierarchy is a valid one, several problems arise in generalizing it to all K-12 science instruction. The three major ones are: (1) Is it the only valid hierarchy for the elementary grades? (2) Does it contain all the sciencing processes? (3) What other processes are required to extend it to include secondary programs and pre-school programs as well as to provide for disadvantaged students entering kindergarten or first grade? In an attempt to compensate for these possible deficiencies, an inferred hierarchy, drawn from several sources, has been employed in developing this publication. The processes were ordered by inference! It is the opinion of the committee that this hierarchy is fairly valid, and as such, should be tested.

2.12 *The Inferred Process Hierarchy*

This inferred hierarchy of processes is given in Chart 2.1. The more complex acts are at the top and their antecedent processes arranged in the lower levels of the scheme.

The inclusion of operational definitions of each process mentioned in this hierarchy might be a welcome addition to this publication for many readers. These definitions have not been included for three reasons: (1) their inclusion would considerably lengthen this section as well as the total publication; (2) most of these definitions can be found in current education and science education literature; and (3) the reader can easily develop his own operational definition for each process by referring to first and third column of the objective list in 3.30 (p.19 thru 110) and noting the objectives which call for utilization of the various processes.

Some duplications and overlaps must exist in this hierarchy. For example, one would be performing much the same type of transformations in ordering, equating and sequencing as in using space-time relationships, using numbers, and measuring. Such duplications are necessary to eliminate gaps in the complete coverage of the processes of sciencing.

Chart 2.1 THE INFERRED PROCESS HIERARCHY

Character Building, Acting on Conclusions
Synthesizing Results, Social Evaluating, Affective Evaluating
Performing Investigations
Recognizing Problems · Typing Problems, · Refining Problems, · Proposing Answers, · Designing Studies, · Formulating Statistical Models, · Cognitively Evaluating Alternatives
Experimenting, Synthesizing
Abstracting, · Formulating Models · Formulating Hypotheses, · Analyzing Systems, · Generalizing, · Interpreting Data, · Defining Operationally, · Translating
Testing, Manipulating Variables
Inferring, · Simulating, · Predicting, · Communicating, · Assimilating
Ordering, · Equating, · Sequencing, · Using Space/Time Relationships, · Using Numbers, · Measuring, · Classifying, · Recognizing Variables
Observing
Categorically Conceptualizing
Verbal Associating, Multiple Discriminating
Chaining
Stimulus-Response Connecting

Another type of duplication occurs which involves repeating similar processes at various levels of sophistication. The most prominent example is the series of processes involving the various forms of generalization, i.e. categorically conceptualizing, assimilating, generalizing, synthesizing, synthesizing results and character building. The complexity and abstractness of the entities to be linked increase from simple particular characteristics of concrete objects in categorical conceptualization to comprehensive abstract principles and values in character building. Other strands exist involving a similar duplication.

2.13 *Using a Process Hierarchy*

A Process Hierarchy might be operationally defined as: A sequence of specific mental skills used to transform information in the acts of learning and problem solving and ordered so the transformation utilized at any given performance level depends on some proficiency in most of the transformations listed in all levels below it.

This definition does not imply that a person who can perform complex mental processes will not also be performing lower level transformations. In fact, a sophisticated scientist often uses several low level transformations (such as discriminating or observing) when he encounters a new phenomenon prior to synthesizing it into a reorganized conceptural reference frame. Thus, some high school objectives may involve only low level transformations, but the high school science curriculum must not be over-loaded with such activities. These simpler processes are usually necessary inferences of higher level transformations. On the other hand, in introducing new phenomena such as electromagnetic waves, radioactivity or certain socio-interdependencies, objectives may need to be specifically stated in terms of a lower level process.

Although several students in a class may have progressed to near the same position in the hierarchy, not all the students in any class will be equally advanced. The teacher must therefore alter his objectives and strategies to allow for individual differences if he is to promote student mastery of antecedent processes before forcing the performance of more complex transformations.

On the other hand, it would be incorrect to assume that once a student has achieved proficiency in a series of processes, he should attack new problems using these processes in a neat sequential order. Quite the opposite is likely true. Although certain individuals may attack problems in an orderly manner, transposing one person's method on another completely ignores the psychology of individual differences. Any study of major scientific discoveries reveals that even two scientists differ considerably in their approach to scientific investigations. The hierarchy, therefore does not describe how a student should undertake the study of a science problem but merely identifies, particularly at the elementary and junior high levels, the kinds of activities the child is ready to attempt or should do for compensatory work.

2.20 The Conceptual Schemes of Science [3]

Man in his attempt to comprehend his environment has found it helpful to synthesize his knowledge into a few big ideas. These generalized ideas give him a framework from which to interpret new phenomena he encounters. Such ideas are often referred to as the *conceptual schemes of science*. To provide some comprehensible threads around which to organize the school science curriculum, scientists and science educators have attempted to identify the conceptual schemes which encompass the whole of science knowledge. The resulting sets have varied in number from about six to twelve.

Problems often arise in applying these sets to curriculum design and classroom programs. These problems arise from three main sources which are: (1) When these statements are few in number, they are often so generalized that many persons, even some scientists, have difficulty seeing the total encompassment of science in them. (2) Such comprehensive statements do not communicate effectively to all teachers, particularly elementary teachers whose background in science is often somewhat limited. (3) There are ideas concerning the interactions of scientific knowledge with other bodies of knowledge which should legitimately be included in the science curriculum but often are not covered by a set of conceptual schemes restricted to the structure of science.

Expanding the number of big ideas in the set may also present problems. First, the set becomes long and somewhat cumbersome to work with. Secondly, the generalization of the same fact, simple concept or principle may support two or more conceptual schemes. In fact, more than one of the "ordinary conditions" schemes may eventually be synthesized into a more comprehensive member of the set. On the other hand, such an expanded set has the advantage of improving communication and comprehension. To make these Guidelines as useful as possible to all schools and teachers in Indiana, an expanded set is utilized. The resulting set contains seventeen statements of major generalizations of scientific knowledge.

2.21 *Statement of the Conceptual Schemes*

Although a conceptual scheme is an idea which cannot be communicated by a summary word or phrase, each scheme has been given a title so the objectives in the next section can be coded to the schemes.

2.21-1 *Differences and Similarities of Objects.* There are differences and similarities in all objects (both living and non-living) in the neutral world. These differences and similarities can be used to develop classifications hierarchies which are useful in inferring and predicting the properties and characteristics of unfamiliar natural objects.

2.21-2 *Fundamental Structures.* All objects (both living and non-living) in the natural world can be analyzed in terms of their component parts and a hierarchy of systems around which these components are organized. The ultimate units of analysis are the fundamental particles which presumably have the same characteristics throughout the universe.

2.21-3 *Space/Time Reference Frames.* All natural objects exist in time and space. Their attributes and behavior can only be comprehended from the proper space-time reference frame.

2.21-4. *Force Fields.* All natural objects distort (or effect changes in) the space and time in which they exist. These distortions create forces around the object that affect the behavior of other objects entering these force fields. Descriptions of these effects are dependent on the space reference frame chosen.

2.21-5. *Constant Change.* All objects (both living and non-living) are in constant change. Descriptions of these changes are dependent upon the time reference frame chosen.

2.21-6. *Statistical Descriptions.* The qualities and behaviors of natural objects and their subunits can be described on a statistical basis. Communication of these properties to others requires the use of standard units.

2.21-7. *Differences and Similarities of Interactions.* There are differences and similarities in the interactions of natural objects and their subunits. The differences and similarities can be classified into categories which are useful in inferring and predicting events that occur during interactions.

2.21-8. *Action Forces.* Interactions occur only as a result of unbalanced forces.

2.21-9. *Matter Conservation. Under ordinary conditions,* interactions of natural objects or their subunits may involve matter transformations; but matter is neither created nor destroyed.

2.21-10. *Energy Forms.* There are many kinds of energy.

2.21-11. *Energy Exchange.* The interactions of natural objects or their sub-units involve the exchange of energy which may be transformed from one kind to another as well as transferred in kind.

2.21-12. *Energy Conservation. Under ordinary conditions,* during the interactions of natural objects, energy is neither created nor destroyed.

2.21-13. *Matter/Energy Conservation.* All interactions tend toward equilibrium in which energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations, matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

2.21-14. *Interdependency of Nature.* There is organization in the universe and therefore there is an interdependency among all natural objects and their subunits.

2.21-15. Generalized Perceptions. To comprehend his total environment and his interrelationships with it, man has developed mental constructs (concepts, principles, theories, and "natural laws") to interpret it. These constructs can exist only beause man believes nature is not capricious and sample observations can therefore be generalized. Since these are constructs of the human mind, they are subject to continual revision as new observations are made which are in conflict with them.

2.21-16. *Science and Technology.* To man, some of the most important interactions in nature are those which affect his general welfare and survival; thus, he continually strives to better comprehend and interpret the universe and his interactions with it in order to improve the quality of these interactions. This had led to man's technological (including medical) achievements and the continual modification of technological devices.

2.21-17. *Science and Society.* Important to man is his interaction with his fellow man. This interaction has led to the development of his communicative techniques and the humanities. These have created another class of interactions which can only be understood in terms of man's humanistic constructs and values and their interrelationships (confrontations) with the scientifically developed comprehension of the universe and its technological applications.

2.22 *Science Teaching and the Conceptual Schemes*

These seventeen generalizations can be used in organizing the K–12 science curriculum to give the processes of science direction. However, these generalizations are not ones which the student can learn and comprehend by committing them to verbal memory. He must synthesize them from his own encounters with his environment and/or science learning experiences. This is an ever-expanding process which begins with linking similar attributes (such as common colors and shapes) of concrete objects to form simple concepts (such as red or square). Simple concepts are chained to form principles and principles to form hypotheses, theories and "natural laws". Eventually these theories are connected as generalized conceptual schemes. It is only when the student has had enough encounters with nature to make these generalizations internally via his own mental operations that we can say he has truly learned the big ideas.

The need for direct experiences with the real world does not negate verbal learning and instruction in science programs. Often a student may have experienced enought environmental encounters to complete the required mental connection but his mind has not made the inductive linkage. At this point the teacher should enter with oral or written instruction (which might be either interrogative or declarative) to spark the needed creative linkage. The role of the teacher is therefore to arrange a proper mix of the various kinds of science learning experiences so the student can progress along this ladder of generalizing as rapidly as his mental ability and maturation will permit.

Testing for the learning of generalizations provides one of the paradoxes of science curriculum design. Since it is impossible to examine directly the internal connections that exist in the student's mind, we must look for external evidence that the internal transformation has occurred. A paradox exists as most of the overt evidence which the student can provide for direct examination involves his application or translation of the generalized idea to new phenomena which is a deductive or analytical process rather than an inductive or synthetic one. This however, is not unscientific since it is the approach taken by a creative scientist when he proposes a new theory or hypothesis to connect previously unrelated phenomena. He must then put the new theory to test. Testing involves applying it to a new set of circumstances and checking to determine if the theory predicts what occurs. Only after several tests have reinforced the theory does the scientific community begin to develop confidence in the theory. If they do not, the theory is rejected. Similarly, in testing to determine if the student has in fact made a generalization, we can have confidence he has made the proper mental linkages if he applies the new knowledge successfully to several new situations. If he cannot make these translations, we assume that he lacks the synthesis even though he may verbalize by rote recall.

2.30 The Values and Attitudes Derived from Science Learning Experiences

Instruction that does not relate to living and provide the learner with standards by which he can weigh his own behavior is of little worth to him. Although mastery of the processes of sciencing and comprehension of the conceptual scheme of science can provide the student valuable tools for critically evaluating his actions, surely some standards of behavior emerge from science learning experiences which can give direction to the student's present and future life. A close examination of science and sciencing reveals that not only do scientists and science teachers have moral standards, but the very progress of the scientific enterprise during the last four centuries is the result of an intrinsic value system. Scientists must accept this system and characterize it in their scientific work or scientific progress stops.

This system may not encompass the total set of values which man has derived from a study of the humanities. On the other hand, it has much in common with that set even though the values may be stated slightly differently. Seven such values were identified by the Educational Policies Commission in *Education and the Spirit of Science.*[4] This body was directing itself to a discussion of those values inherent to the spirt of science or rational thought which should pervade all of education. There may be other values, or at least attitudes, which science learning experiences can and should contributes to the student's standards for living. After reviewing the statement of goals (Sec. 1.22) and other sources, four more values or attitudes were identified.

2.31 *The Statement of Values and Attitudes*

The resulting eleven values and attitudes are listed below with a brief commentary on each.

2.31-1 *Longing to Know and Understand*

Science has developed due to man's continual desire to understand the world around him. Scientific progress results from this curiosity and the continual discovery of new problems needing solution during the investigation of original problems. Such a curiosity can aid each person as he seeks to fulfill his social role.

2.31-2 *Questioning of All Things*

Man's understanding of nature is of his own conception and may be limited in comprehensiveness by the reference frame of the observer. Certainty of conclusions is therefore replaced by probability. Although conscientious observers try to be as objective as possible in arriving at conclusions, later evidence often brings these conclusions into question; consequently, even many "self-evident" truths must be held as suspect. Thus, each person must advance his own conclusions open-mindedly with modesty and humility since they may contain similar uncertainties.

2.31-3 *Search for Data and Their Meaning*

The longing to know and understand is satisfied by interpreting the data one collects. Accurately collected data is of little value since as data it is merely unrealted discrete bits of information; however, such data is essential for the formation of generalizations which yield understanding. To connect this data into concepts, principles, theories and conceptual schemes demands the employing of the processes of sciencing by a creative, flexible, unbiased mind.

2.31-4 *Demand for Verification*

The hypothetical nature of theories and other generalizations suggests that they are subject to test. They must, in turn, be tested. Scientists do not merely accept the need for testing their conclusions; they actively search ways to make such tests. Such searching by each one to test his conclusions can give greater credibility to his call for honesty.

2.31-5 *Respect for Logic*

The validity of untested inferences and predictions can be judged in terms of the consistency of the logic used in deriving them and the relevancy and adequacy of the premises on which the logic is based. Although inferences and predictions must eventually be tested by collecting new data, there would be little scientific progress without using the rules of logic. Such objectivity is needed in solving all types of problems.

2.31-6 *Consideration of Premises*

In searching to understand nature, man must be careful not to draw conclusions that overextend the evidence. The observer must try to prevent his own predispositions from shaping his collection and interpretation of data. He must also be aware of the limitations that the state of the art of sciencing may place on the scope of his investigations. The interpretation of the data must not be extended to propose solutions to problems to which the data are irrelevant. One must therefore consider the capabilities and limitations of both himself and science as he seeks to be a responsible member of society.

2.31-7 *Consideration of Consequences*

If one holds a belief or takes action that does not consider implications or consequences, he is acting in partial ignorance. Although knowledge of consequences is always incomplete, a thinking person does not act or believe without attempting to project the effects of his action. He must evaluate all possible alternatives and pursue a course of action which will have the least possible harmful backwash. This evaluation must not be limited to personal and local consequences but must consider the total human race of which his is but a single member. This sense of responsibility should be inherent in all human thought.

2.31-8 *Respect for Order in Nature*

As man considers the effects of his actions on other humans, he is forced to consider an even wider circle of influence since there are inter-relationships linking all objects in nature. Although many of these inter-relations may be subtle, any careful study of nature will reveal them. Science learning experiences should do more than produce an awareness of this order in nature. They should nourish this awareness into an active respect.

2.31-9 *Demonstrating Confidence and Satisfaction*

For the individual to fulfill his social role, he must have pride in his work. He can do this best when he can experience success rather than failure. This does not mean that his efforts must always lead to success but that he directs his activities to this end. Science learning experiences should therefore be designed so that the student can attack life's problems with confidence and with a hope of achieving satisfactory results.

2.31-10 *Valuing Scientific Heritage*

Intellectually each generation stands on the shoulders of all preceding generations. The scientific enterprise and its technological applications illustrate this principle. Even though scientific knowledge and understanding is uncertain, an appreciation of the value system which characterizes scientific study and the tremendous labor it demands causes one to respect this knowledge. One should reject it only after assembling enough contradictory evidence to justify such action. Students should have science learning experiences from which they can develop this kind of respect for our scientific heritage.

2.31-11 *Developing a Commitment to Aesthetics in Nature*

Science learning experiences should cause the student to consider the consequences of his action on nature and to respect the order that exists in nature. Beyond this, he must have opportunities to become actively involved in maintaining this order.

2.32 *Limitation of Science Learning Experience in Teaching Values for Living*

Although these eleven values or attitudes can be gained or, at least, enhanced by properly directed science learning experiences, they do not comprise a total value system for living. Others will be added to these from a study of the humanities and from other institutions of which the student is a member such as the family and church. On the other hand, these eleven can both supplement and reinforce those obtained from other sources as well as provide some guiding principles for evaluating and organizing a total value system.

2.33 *Evaluating the Learning of Values and Attitudes*

There are many problems concerning how to teach for learning in the affective domain. Although teachers have always claimed that the development of attitudes, values and appreciations should be some of the most important outcomes of their instruction, true evaluation of these goals has seldom occurred. This failure most likely results from the absence of effective classroom measures for this type of learning. In the past, methods for evaluating such learning have received very little attention even in teacher training programs. However, as with all learning, if the behaviors can be identified which demonstrate that the desired learning has occurred, it is possible to construct a plan to evaluate it.

Identifying overt activities that provide evidence that values, attitudes and appreciations have been learned is more difficult than with most other types of learning. Psychomotor learning is probably the easiest to evaluate since the overt behavioral change is usually nearly identical to the desired learning. Evaluating learning in the cognitive domain is not as straightforward since the anticipated mental changes and the overt behavior evincing those changes are not identical. They become continually more divergent as one progresses from simple knowledge (or factual) learning to the more complex thought processes. This means that there is often a credibility gap between the measurement of learning and the actual learning. Although the testing instruments may validly indicate the examinee's ability to perform acts which should demonstrate the anticipated learning, he may be responding correctly for a completely different reason. This credibility gap is even greater when learning in the affective domain is evaluated. There may be other factors besides the student's internal value system causing him to display the overt behaviors which indicate he is characterizing the value. [5]

On the other hand, as discussed in 2.22, evaluation plans can be designed with a fairly high validity for measuring intellectual abilities and skills such as comprehending, applying, analyzing, synthesizing and evaluating. Such plans confront the student with situations which require using these kinds of thought. Evaluation in the affective domain, although admittedly less certain, should be very similar. It should evaluate the student in situations where he must apply values to determine his course of action. Since other motives (such as knowledge of the teacher's values) may cause the student to respond as a particular value would dictate, it is often necessary to evaluate the student under more relaxed conditions than for other types of learning.

2.34 *Teaching for Values and Attitudes*

As indicated above, one problem in evaluating learning in the affective domain is the identification of the overt behaviors which indicate this kind of learning. Teachers have often failed to identify those behaviors which characterize persons committed to desired values. They have also failed to design classroom strategies and learning situations through which students can either display or apply these values and attitudes. Perhaps even more critical is the failure of common evaluation systems to reward students who act positively in terms of desired values and attitudes. Many evaluation systems which test only for recall completely negate any positive attitudes that may have developed.

If values and attitudes are to be learned, positive behaviors must be identified. Then educational strategies must be designed not only to allow for the behaviors, but to actively encourage them. If the "questioning of all things" is a desirable value, then the classroom atmosphere must be such that the student can freely question and the evaluation system must reward him for this questioning. If he should have "respect for logic", then he must have an opportunity to think logically and be rewarded for doing so. If a driving "search for data and their meaning" is a desirable attitude, the student must be given opportunities to search, be encouraged to do so and be rewarded for searching. Each of the eleven values could be discussed in a similar manner; however, the important principle to be considered in teaching for value learning is that behaviors must be identified that evince value learning and instructional strategies designed to encourage and reward these behaviors.

2.40 Psycho-motor Skills in Science Learning Experiences

If a student is to be an actual practitioner of science, he will need to perform many manipulations with equipment and instruments. Although each investigation requires a unique assemblage of apparatus, there are several instruments and techniques which are common to several acts of sciencing. Most manipulative skills will demand some cognitive learning during the student's initial experience with them, but if they are to be useful to the student in varied activities, they need to be reduced to stimulus→response or chaining type reactions. These psychomotor skills include reading a multitude of measuirng insturments from the simple meterstick through thermometers, graduates and burets to balances, electrical meters, barometers and vernier scales, adjusting and focusing microscopes, mixing chemicals and manipulating a slide rule.

Acquisition of these psychomotor skills will facilitate the student in his sciencing. They may actually sharpen his psychomotor reflexes or transfer to real life activities, but it is unrealistic to consider these as the major goals for science learning. They are only tools which the student can use to achieve other objectives both in school and out. Even though the initial acquisition of the skill may require systematic instruction, this instruction should be considered only as a means to an end by both teacher and student.

2.50 The Subject Matter of Science

Since the major emphasis of this section has been on the processes, conceptual schemes and values and attitudes intrinsic to science, it might appear the importance of the subject matter of science is being reduced. It may be true that much past science teaching has overemphasized the regurgitation of "scientific facts" – often little more than isolated bits of data. Additionally "scientific knowledge" is exploding much too rapidly for any one person to catalog it totally. Conversely mental transformations must operate on data, generalizations must link facts, and values and attitudes result from interpretating data; therefore sciencing cannot occur in a vacuum. It must operate on something. This something is the subject matter of science courses with proper expansion and selection to include the student's total relevant physical and biological environment.

As can be seen by reading the objectives, these Guidelines do not slight science subject matter. Since very few factual details are retained by the learner, the appeal here is for school science programs which are directed toward helping the student discover, understand and execute his role in a dynamic society by using the processes of sciencing to arrive at generalizations which he can apply to real world problems after evaluating them by an organized value system. Only as science subject matter contributes to the education of this kind of productive individual does it have reason for being a part of the school curriculum.

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1. Walbesser, Henry, *A Model for the Evaluation of Curriculum*, Washington, D.C., American Association for the Advancement of Science, Miscellaneous Publications, 1967.
2. Americann Association for the Advancement Science, *Science—A Process Approach*, Parts A-G, New York, N.Y., Xerox Corporation, 1969-70.
3. The wording of several of the schemes (particularly 2.21-6 and 2.21-13) is close to that used in: National Science Teachers Association, *Theory into Action*, Washington, D.C., NSTA, 1964.
4. Education Policies Commission, *Education and the Spirit of Science*, Washington, D.C., National Education Association, 1966.
5. Eiss, Albert F., and Harbeck, Mary Blatt, *Behavioral Objectives in the Affective Domain*, Washington, D.C., NSSA-NTSA, 1969.

3.0 Performance Objectives for School Science Planning

3.10 The Role of Performance Objectives in Instructional Planning

It has been emphasized that instruction must be evaluated in terms of its outcomes, i.e. its benefits to the students. For this to be effectively accomplished, school systems, schools and teachers must clearly define:

1. Where they are going,
2. How they are going to get there,
3. How they are going to know when they have arrived.

3.11 *The Need of Specific Instructional Objectives*

Defining these points requires specific instructional objectives for each lesson. These objectives should identify those overt student behaviors which demonstrate that the desired learning has occurred. As schools are held more and more accountable for their programs, it is only as they plan and evaluate their programs in terms of specific instructional objectives that they can provide concrete evidence of their effectiveness.

If a general goal of science is to develop an understanding of the constant change which occurs in nature, what is it that the student can do to demonstrate this understanding? Although the understanding of this idea will become progressively more sophisticated as the student matures, there should be certain identifiable steps along the road to its eventual realization. Many texts use the principal of seasonal changes as a desirable second grade subconcept in this hierarchy. But it is too elusive to state the goal for a second grade unit as: The student should develop an understanding of seasonal change. Its attainment cannot be easily evaluated. Instructional objectives must deal with specific basic concepts which are prerequisite to the synthesis of this principle and for which specific overt behaviors can be identified.

What are the student behaviors that indicate student comprehension of seasonal changes? It is when he can state verbally that deciduous trees lose their leaves in the fall? Or that it is hot in the summer and cold in the winter? Or that many perennial flowers bloom in the spring? Comprehension of this principle involves the synthesis of these concepts with many others, but converting these questions into objective format would lack the specificity needed for effective evaluation. Consider an objective that says: The student should be able to recognize that certain trees lose their leaves in the fall. The behavior demonstrating this recognition should be identified. Is it identifying a picture of a fall scene? Or predicting the changes that will occur in a picture of a summer scene when autumn arrives? Or identifying trees that lose their leaves and those that don't. Or identifying from a selection of pictures or twigs, the season of the year during which the pictures were taken or the twigs were initially collected? Again, performing each of these acts can contribute to the recognition that certain trees lose their leaves in the fall, but an instructional objective needs to be more specific to be useful in evaluating instructional effectiveness.

One such objective might be: The student will, after observing several summer-autumn picture sequences of various trees, predict some easily observable characteristics that will be displayed by a given tree in the fall after viewing a picture of the same tree taken during the summer. These pictures may either be prepared prints or actual photographs taken either by the teacher or the class for this purpose. Those students who predict these changes with reasonable accuracy three out of four times will be considered to have accomplished this objective.

Many teachers have fears that stating objectives with this specificity will dehumanize instruction. While some of these fears may have foundation, many are more imaginary than real. Most good teachers already utilize unstated but mentally envisioned specific objectives in planning their teaching and testing. Their classroom activities and the testing programs would likely be more consistent if these objectives were clearly stated and available for their continual reference. Secondly, we have often failed, as mentioned in 2.22 and 2.33, to clearly identify and define those overt behaviors which demonstrate that the desired learning has occurred. If school programs are to be justified, this problem must be solved. Thirdly, some teachers feel that such objectives will constrict education to an assembly line approach. As has been emphasized, objectives must be personalized to help each student discover, understand and execute his role in a dynamic society. Specific instructional objectives will therefore aid teachers to more effectively fulfill their professional role.

It is only when instructional objectives have been clearly stated that teachers can know where they are going, how they are going to get there, and when they have arrived.

3.12 *A Word of Caution*

Some caution is needed in using specific instructional objectives. Their achievement must not become an end to itself but must remain as a step in an efficient means for accomplishing the purposes of education and the general goals of the curriculum area. Thus, the stated specific objectives must undergo continual review to determine their relevancy and adequacy for meeting students needs and educational goals. Plans for this kind of evaluation, in addition the usual evaluation of objective achievement, should be part of any curriculum improvement program.

3.13. *Performance Objectives In The Instructional Program*

Although the above precisely stated instructional objective is one which gives definite direction in planning classroom strategies, it would be unwise to use this specificity in a State publication. On the other hand, to outline only broad goals for the various grades and courses in the school science program would be of little value to Indiana schools and teachers. A State publication should be most useful if the objectives it contains are specific enough to provide school science programs direction but general enough to allow teachers and schools the flexibility and creativity necessary to serve their particular students.

Both the terms and their definitions used in discussing educational objectives have been subject to considerable controversy. To minimize this problem, the approach taken in these Guidelines was to identify levels of objectives which needed attention, assign each an appropriate descriptive term and use these terms consistently. The terms chosen were: *general educational purposes, goals, performance objectives* and *instructional objectives.*

The general educational purposes and goals used in this publication are stated in 1.2 and 2.0.

Although often used interchangeably with the terms: "behavioral objectives" and "instructional objectives," in this publication *performance objectives* refer to those objectives which identify the specific desired student behavioral act without specifying either the conditions under which it will occur (except when needed for clear communication of the act) or the criteria of acceptable performance.

Section 3.30 of these Guidelines contains a list of nearly 900 such objectives. The committee has identified these as common (even though not so stated) to most science programs or as desirable additions to present programs. Even with this massive number of assembled objectives, local schools should not consider this list either restrictive or prescriptive. Each school must review it and add or subtract objectives as the local situation demands. It is, however, the hope of the committee that this list may serve local schools and teachers as a base from which they may review their present program and gain direction in improving it. A more detailed discussion of the structure of this list is contained in 3.20.

The term *instructional objectives* refers to those objectives which not only identify the specific desired student behavioral act but also the conditions under which the performance of the act will be measured plus the criteria for acceptable performance of it. The objective in the fourth paragraph of 3.11 is of this type.

As already mentioned, it seems beyond the realm of a State Committee to develop instructional objectives for local classrooms. The conditions under which the measurable act is to be performed is, to a very great extent, determined by local conditions and facilities as well as by student interests. Although criteria of acceptable performance must be developed by testing in the local situation, they must be realistic in terms of the background and ability of the students. Conditions and criteria will therefore vary from school district to school district, usually from school to school, often from classroom to classroom, and in truly relevant programs, from pupil to pupil. The writing of instructional objectives must therefore be left to local teachers and curriculum planners. Many of the performance objectives (particularly at the upper grade levels) in the list in 3.30 can be expanded into an array of instructional objectives to develop the various competencies required for the student to demonstrate an acceptable performance of the specified act.

For each instructional objective, the teacher must develop one or more classroom strategies to lead to its achievement. These strategies should include activities and materials and must be planned in terms of available or obtainable resources.

3.20 The Format of the List of Performance Objectives in These Guidelines

The pattern used in organizing the list of performance objectives involves branched sequential subject matter strands coordinated with the processes, conceptual schemes, and attitudes by a parallel column structure. Each of these features is briefly discussed in the next three subsections.

3.21 *Strand Structure*

The more traditional subject matter areas of science are used as the categories or strands for sequencing the performance objectives. For the elementary and junior high-middle school, the objectives are organized into four strands. These are: living things, matter and energy, earth and space, and a general strand which cuts across all of the other three strands by including objectives which either are common to each or are process and skill objectives which support the sciencing objectives in each. Due to the pervading nature of this strand it is placed first in the presentation of the performance objectives in 3.30.

At the senior high level the performance objectives are branched into five strands to more closely fit the customary organization of the senior high science curriculum. These are: general, biology, chemistry, earth science and physics.

For a more detailed description of how the objectives in these strands should be employed in determining the content of various courses see 4.31 thru 4.33.

3.22 *A Continual Sequence With Breaks*

Although it seemed undesirable to specify grade level usage for the objectives, two concessions were made.

First, the list is organized into three separate lists: one for the Kindergarten and Elementary grades, one for the Middle School – Junior High years, and one for Senior High School. This categorization suggests the overlapping, nongraded nature of the list. In the senior high lists no attempt is made to distinguish objectives appropriate for introductory courses in the four disciplines from those appropriate for advanced courses. These decisions should be based on local conditions and student ability. (This point will also be more fully discussed in 4.33.)

The second concession was to indicate in each Elementary strand the objectives appropriate for the average student in any particular grade of a traditionally organized elementary school by inserting into the objective column, Levels One through Six notations. Due to the lack of uniformity in kindergarten programs, particularly in terms of science experiences, kindergarten and first grade are considered as one. Schools and teachers are cautioned not to consider these as prescriptive notations but as suggestive guides only. Students must begin working at their level of development and be allowed to progress as rapidly and as far as their maturation permits.

3.23 *The Parallel Columns and Their Use*

The lists of performance objectives are organized in four parallel columns. *Column 1 lists the processes* which the student would use in achieving the performance objective. *Column 2 indicates the conceptual scheme* with which the objective may be identified. *Column 3 states the performance objective. Column 4 gives the values and attitudes* that performance of the objective should help develop. Where more than one process, conceptual scheme, or value or attitude is involved, the ones felt to need the greatest emphasis are set in italics.

Columns 1,2 & 4 will be helpful to local school districts, schools, and particularly teachers as they implement these Guidelines, i.e. as they refine these performance objectives into instructional objectives, classroom strategies and evaluation procedures. *The processes* should help them *identify the type of science learning experiences* which will lead to the desired student performance. *The conceptual schemes* should help teachers *define a direction for these activities* and help them identify the emphasis for follow-up discussion and evaluation. The *values and attitudes* should help them *define the classroom atmosphere* most conducive to the achievement of the objective as well as provide additional direction for follow-up discussion and evaluation.

3.30 The List of Performance Objectives

On the following several pages are listed nearly 900 performance objectives which the committee hopes will aid the schools of this State as they attempt to improve their service to Indiana youth.

This list of objectives still needs refinement. Although it has been reviewed by several teachers throughout the State, insignificant, or inappropriate, or redundant or poorly worded objectives may remain. There may be gaps in the coverage of significant subject matter. Some of the sequencing may be inappropriate. The taxonomy of processes, conceptual schemes and values and attitudes may not always be entirely correct. The help of classroom teachers, science supervisors and researchers in science education is solicited to correct these possible flaws and to validate the hierarchy of processes, the set of conceptual schemes and the set of values and attitudes. It is hoped that such findings will be funnelled to the Curriculum Division of the Office of the State Superintendent of Public Instruction. With this help, it may be possible in three or four years to revise these Guidelines into a publication that can have even greater impact on school science programs in Indiana.

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
		Level One:	
Using Numbers, Observing	*Statistical Descriptions* Generalized Perceptions	1. identify sets of objects and events in terms of number of members.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying, Observing, Multiple Discriminating	Differences and Similarities of Objects	2. construct sets on the basis of properties such as: rough, small, large, same, different.	*Consideration of Premises*, Demonstrating Confidence and Satisfaction
Classifying, Observing, Multiple Discriminating	Differences and Similarities of Objects	3. identify and distinguish common colors and shades in terms of lighter than and darker than.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Observing, Multiple Discriminating	Fundamental Structures	4. identify when colors are mixed.	*Longing to Know and Understand*, Search for Data and Their Meaning
Using space/time relationships, Categorically conceptualizing, Verbally associating, Observing	Space/Time Reference Frames, Differences and Similarities of Objects	5. identify and name circle, square, rectangle, triangle, ellipse, cube, sphere, side, shape, large, big, small, wide, narrow, long, short, pyramid and ellipsoid.	*Search for Data and Their Meaning*, Demonstrating Confidence and Satisfaction
Classifying, Observing, Multiple Discriminating	Differences and Similarities of Objects	6. identify sounds on the basis of volume, pitch, and duration.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying, Observing, Multiple Discriminating	Differences and Similarities of Objects	7. identify and classify objects on the basis of taste such as sweet, sour, salty, etc.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Using space/time relationships, Observing, Communicating	*Space/Time Reference Frames*, Differences and Similarities of Interactions	8. identify right, left, up, down, forward, and backward and demonstrate the direction of movement.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Ordering, Measuring, Using space/time relationships	*Space/Time Reference Frames* Differences and Similarities of Objects	9. compare the length of two objects by matching them with a third object.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying, Observing, Multiple Discriminating	Differences and Similarities of Objects	10. use odor to distinguish and classify several objects.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Measuring, Using space/time relationships, Observing	*Statistical Descriptions*, Space/time Reference Frames, Differences and Similarities of Objects	11. demonstrate a unit of linear measure by using a stick or other arbitary length.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying Using space/time relationships, Observing	*Space/Time Reference Frames*, Differences and similarities of Objects	12. describe objects, lines, planes in terms of horizontal or vertical.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Observing, Equating	Differences and Similarities of Objects	13. use more than one sense to identify objects or changes.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Ordering, Using Numbers	Differences and Similarities of Objects	14. use numbers and their numerals to describe order or rank.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Measuring, Observing	Differences and Similarities of Objects	15. construct and/or use a simple balance.	Consideration of Premises
Ordering, Measuring	Differences and Similarities of Objects	16. order objects by weight by using a balance.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
		Level Two	
Communicating, Classifying, Measuring, Equating	Differences and Similarities of Objects or Differences and Similarities of Interactions	17. construct bar graphs to classify sets or objects and events.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Ordering, Using space/time relationships	*Differences and Similarities of Objects*, Space/Time Reference Frames, Constant Change, Generalized Perceptions	18. identify and order units of time: year month, day, week, hour, minute, second	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Communicating, Measuring, Equating	Differences and Similarities of Objects, or Differences and Similarities of Interactions	19. interpret simple graphs and make comparisons of the objects or events using data recorded on a graph.	Search for Data and their Meaning
Classifying, Using space/time relationships, Observing	*Space/Time Reference Frames*, Differences Similarities of Objects	20. identify, compare and classify objects using the concept of angles.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Using space/time relationships, Communicating, Using Numbers, Measuring	Space/Time Reference Frames	21. describe events in terms of time and date.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Using space/time relationships, Measuring, Communicating, Assimilating	Space/Time Reference Frames	22. describe past events in terms of time lapse.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Using Numbers, *Measuring*,	*Statistical Descriptions*	23. describe his observations in quantitative terms.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Inferring, Observing	Generalized Perceptions and others	24. distinguish observations from inferences.	*Demand for Verfication*, Questioning of All Things, Respect for Logic, Consideration of Premises
Classifying	Differences and Similarities of Objects	25. construct multistage classification of objects.	Longing to Know and Understand.

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Measuring, Using space/time relationships, Observing	Space/Time Reference Frames, Differences and Similarities of Objects, Statistical Descriptions	26. describe objects in terms of area by superposition of arbitrary units and standard units	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Communicating, Observing	Differences and Similarities of Objects	27. describe an object so a second person can identify the object in a collection of similar objects.	*Search for Data and their Meaning*, Respect for Logic, Demonstrating Confidence and Satisfaction
Communicating, and others	Generalized Perceptions. Differences and Similarities of Objects or Differences and Similarities of Interactions	Level Three 28. use a variety of communication skills such as oral and written language, manipulative skills, and art skills to inform other students of his findings.	*Search for Data and their Meaning*, Respect for Logic, Demonstrating Confidence and Satisfaction
Measuring, Using space/time relationships, Equating, Using Numbers, Communicating	*Statistical Descriptions, Space/Time Reference Frames*, Differences and Similarities of Objects	29. compare the lengths of various objects with standard units in the metric system (centimeter, decimeter, meter).	Search for Data and their Meaning
Measuring, Equating, Using Numbers, Communicating	*Statistical Descriptions, Space/Time Reference Frames*, Differences and Similarities of Objects	30. compare quantities of mass with standard units in the metric system (gram, kilogram).	Search for Data and their Meaning
Measuring, Using space/time relationships, Equating, Using Numbers, Communicating	*Statistical Descriptions, Space/Time Reference Frames*, Differences and Similarities of Objects	31. compare various areas of two dimensional shapes with standard units in the metric system (square meters, square decimeters, square centimeters).	Search for Data and their Meaning
Measuring, Using space/time relationships, Equating, Using Numbers, Communicating	*Statistical Descriptions, Space/Time Reference Frames*, Differences and Similarities of Objects	32. compare quantities of volume, both solids and liquids with standard units in the metric system (liters, milliliters, cubic centimeters, cubic meters).	Search for Data and their Meaning
Measuring	Statistical Descriptions	33. use the metric system to describe objects in terms of mass, length, area and volume.	*Search for Data and their Meaning*, Respect for Logic, Demonstrating Confidence and Satisfaction
		34. See Matter and Energy Objectives 37.	
		35. See Matter and Energy Objectives 39.	
Inferring, Simulating, Using space/time relationships	*Force Fields*, Space/Time Reference Frames, Generalized Perceptions	36. correctly use the term resistance to describe why simultaneously dropped objects of different shapes do not strike the floor at the same time and identify the differences between the objects.	Search for Data and their Meaning
Ordering, Measuring	Differences and Similarities of Objects	37. order containers on the basis of volume.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
		38. See Earth and Space Objective 1	
Using Space/Time relationships, Communicating, Equating	Space/Time Reference Frames	39. properly place objects according to directions: north, south, east and west.	Demonstrating confidence and Satisfaction.
Using Space/Time relationships, Sequencing, Assimilating	Space/Time Reference Frames	40. observe and identify movement with reference to a stable background.	*Respect for Logic*, Questioning of All Things, Consideration of Premises.
Testing, Inferring	Generalized Perceptions and others	41. demonstrate ability to make inferences and then support or reject each inference on the basis of additional observations.	*Demand for Verification,* Consideration of Premises, Questioning of All Things
Predicting, Communicating	Generalized Perceptions and others	42. demonstrate the ability to use graphs to interpret data by predicting, using extrapolation and interpolation.	*Demand for Verification,* Consideration of Premises, Questioning of All Things
Using space/ time relationships, Measuring, Simulating, Communicating	Space/Time Reference Frames	43. construct and interpret maps of classroom, school grounds, and other areas.	Demonstrating Confidence and Satisfaction, Consideration of Premises
Testing	*Generalized Perceptions* Differences and Similarities of Objects, or Differences and Similarities of Interactions, and others	44. test his predictions.	*Demand for Verification,* Questioning of All Things
		Level Four:	
Communicating, Simulating	Statistical Descriptions	45 construct a point or line graph which communicates observed data.	Search for Data and their Meaning
Interpreting Data, Recognizing variables, Manipulating Variables	Statistical Descriptions, Differences and Similarities of Interactions	46. discuss reasons for controlling variables.	*Questioning of All Things,* Search for Data and their Meaning
Recognizing Variables	Differences and Similarities of Interactions	47. identify and name variables related to an investigation.	Search for Data and their Meaning, Consideration of Premises
Interpreting Data, Inferring	Statistical Descriptions	48. identify data on a graph that support or do not support an inferred relationship between two variables.	Search for Data and their Meaning, Respect for Logic
Predicting	Generalized Perceptions	49. distinguish between predictions and guesses.	*Respect for Logic* Consideration of Premises
Interpreting data	Statistical Descriptions	50. construct graphs (including labels and scales for axes, etc.) to show the relationship between two variables	Search for Data and their Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Measuring, Interpreting data	Statistical Descriptions	51. demonstrate a procedure for making indirect measurements.	Search for Data and their meaning.
Defining operationally	*Generalized Perceptions*, Differences and Similarities of Objects	52. identify an object on the basis of an operational definition.	Search for Data and their Meaning.
Defining operationally	*Generalized Perceptions*, Differences and Similarities of Objects, or Differences and Similarities of Interactions	53. distinguish between operational and non-operational definitions.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Defining operationally	Generalized Perceptions, Science and Society	54. construct operational definitions.	Demonstrating Confidence and Satisfaction
Defining operationally, Manipulating variables	*Generalized Perceptions*, Differences and Similarities of Objects or Differences and Similarities of Interactions	55. demonstrate the use of an operational definition.	*Demand for Verification*, Demonstrating Confidence and Satisfaction
		Level Five:	
Manipulating variables	*Statistical Descriptions* Interdependency of Nature	56. identify and name the variables held constant, the manipulated variable and and the responding variable in an investigation.	*Search for Data and their Meaning*, Consideration of Premises
Measuring, Interpreting data	Statistical Descriptions	57. demonstrate methods for making indirect observations of length, width, volume, etc.	Search for Data and their Meaning
Using Numbers	Statistical Descriptions	58. apply a rule for writing decimal or whole numbers in scientific notation.	Demonstrating Confidence and Satisfaction
Interpreting data, using space/time relationships, *Formulating models*	*Space/Time Reference Frames*, Differences and Similarities of Interactions, Generalized Perceptions	59. construct vectors to represent relative motion.	Search for Data and their Meaning
Interpreting data	Statistical Descriptions	60. demonstrate procedures for determing the mean, median and range of a set of measurements or other appropriate data.	Search for Data and their Meaning
Formulating Hypotheses	Generalized Perceptions	61. distinguish between statements that are hypotheses and those that are not.	Longing to Know and Understand
Formulating Hypotheses, Interpreting data, Generalizing	*Generalized Perceptions*, Differences and Similarities of Objects or Differences and Similarities of Interactions	62. construct an hypothesis from a set of observations.	Search for Data and their Meaning
		Level Six:	
Interpreting data, Defining operationally	*Generalized Perceptions*, and others (Space/Time Reference Frames for example given)	63. apply a rule for calculating a quantity from two or more measurements (velocity from distance and time).	*Respect for Logic*,

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Predicting, Interpreting data, Translating	*Statistical Descriptions*, Generalized Perceptions, Differences & Similarities of Objects or Diferences and Similarities of Interactions	64. name the probability of the outcome of situations where the number is countable.	*Respect for Logic*, Search for Data and their Meaning, Consideration of Premises
Formulating Hypotheses, Experimenting, Interpreting data	*Generalized Perceptions*, Differences and Similarities of Objects or Differences and Similarities of Interactions	65. construct and demonstrate a test of hypotheses	*Respect for Logic*, Demand for Verification
Synthesizing, *Experimenting*	*Generalized Perceptions*, Differences and Similarities of Objects or Differences and Similarities of Interactions.	66. identify data collected from a test conducted by himself which support or do not support his hypothesis.	*Demand for Verification*, *Questioning of All Things*
Formulating models, Interpreting data	Generalized Perceptions	67. describe what a model is and describe how models can be useful in understanding various concepts in science.	Search for Data and their Meaning
Experimenting, etc.	Generalized Perceptions	68. construct a question to be answered, construct a test that will provide data, demonstrate the test and collect and interpret the needed data.	Longing to Know and Understand, Search for Data and their Meaning, Demand for Verification, Demonstrating Confidence and Satisfaction

3.31–L Elementary School Objectives – Living Things

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
		Level One:	
Classifying	Differences and Similarities of Objects	1. sort living things from non-living things.	*Consideration of Premises*, Demonstrating Confidence and Satisfaction, Respect for Order in Nature
Classifying	Differences and Similarities of Objects	2. distinguish between living and non-living things in an aquarium.	*Consideration of Premises*, Demonstrating confidence and Satisfaction, Respect for Order in Nature
Classifying	Differences and Similarities of Objects	3. sort plants from animals.	Consideration of Premises, Demonstrating Confidence and Satisfaction, *Respect for Order in Nature*
Communicating, Observing, Verbally associating	*Differences and Similarities of Objects*, Science and Society	4. describe orally a living or non-living object referring to several of its characteristics.	*Demonstrating Confidence and Satisfaction*, Consideration of Premises
Using space/ time relationships, Equating, Observing, Communicating	Space/ Time Reference Frames, Differences and Similarities of Objects	5. use two and three dimensional shapes and symmetry to describe shapes of plants and animals.	*Respect for Order in Nature*, Demonstrating Confidence and Satisfaction
Observing, Communicating	Differences and Similarities of Objects	6. identify and state variations in a set of similar living things.	Questioning of All Things, *Consideration of Premises*, Demonstrating Confidence and Satisfaction
Observing, Categorically conceptualizing, Multiple Discriminating	Space/Time Reference Frames, Differences and Similarities of Objects, Generalized Perceptions	7. identify some common plants found near the school	Demonstrating Confidence and Satisfaction
Classifying, Using space/ time relationships	Differences and Similarities of Objects, Constant Change, *Fundamental Structures*	8. distinguish between plants that loose their leaves in wi[illegible]er and those that do not.	*Demonstrating Confidence and Satisfaction*, Consideration of Premises Respect for Order in Nature
Communicating, Using space/ time relationships *Sequencing*	Constant Change	9. report the characteristics of the same tree at different times of the year (photographs, sketches, descriptions).	Respect for Order in Nature, Longing to know and Understand, Demonstrating Confidence and Satisfaction
Classifying	Differences and Similarities of Objects	10. sort leaves according to size, color, simple compound, deciduous or coniferous.	*Consideration of Premises* Demonstrating Confidence and Satisfaction
Classifying, *Sequencing*	*Differences and Similarities of Objects*, Science and Technology	11. identify and plant some seeds.	Search for Data and their Meaning, Respect for Order in Nature
Communicating, Measuring, Sequencing	*Constant Change*, *Statistical Descriptions*	12. observe, measure and record plant growth (see General 17 and 19).	*Search for Data and their Meaning*, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Measuring, Using space/ time relationships, Sequencing, Equating	*Interdependency of Nature,* Differences and Similarities of Interactions	13. identify the effects of water on plant growth.	*Search for Data and their Meaning,* Respect for Order in Nature
Using space/ time relationships, Sequencing, Equating	*Interdependency of Nature,* Force Fields, Energy Exchange	14. identify the effect of light on plant growth.	*Search for Data and their Meaning,* Respect for Order in Nature
Assimilating, Classifying	*Science and Technology, Differences and Similarities of Objects,* Interdependency of Nature	15. grow a plant from a bulb.	*Demonstrating Confidence And Satisfaction, Respect for Order in Nature,* Search for Data and their Meaning
Assimilating, Equating	*Science and Technology Differences and Similarities of Objects,* Interdependency of Nature	16. grow a new plant from a cutting.	*Demonstrating Confidence and Satisfaction, Respect for Order in Nature,* Search for Data and their Meaning
Observing, Equating, Inferring	*Matter Conservation* Differences and Similarities of Interactions, Interdependency of Nature, *Energy Forms*	17. identify the basic needs of a green plant.	*Respect for Order in Nature,* Search for Data and their Meaning
Classifying	Differences and Similarities of Objects	18. classify animals into various categories based on criteria which the student will select, such as: means of locomotions, body coverings, resemblance to parents, type of home, means of securing food, etc.	Longing to Know and Understand, *Consideration of Premises,* Demonstrating Confidence and Staisfaction
Communicating, Using space/ time relationships	*Space/Time Reference Frames,* Force Fields	19. describe the behaviors of birds, squirrels, other animals and insects he sees in the classroom and in his community enviornment.	*Consideration of Premises,* Demonstrating Confidence and Satisfaction
Assimilating	*Interdependency of Nature,* Matter Conservation	20. water and feed an animal on the basis of observations he has made of the animal.	*Respect for Order in Nature,* Demonstrating Confidence and Satisfaction
Classifying, Observing, *Assimilating*	Differences and Similarities of Objects, Matter Conservation, Energy Exchange	21. identify the basic needs of an animal.	Questioning of All Things, *Respect for Order in Nature,* Consideration of Consequences
		Level Two:	
Assimilating, Classifying, Sequencing	*Interdependency of Nature*	22. describe some of the interdependencies between animals and the environment.	*Respect for Order in Nature*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Observing, Classifying	*Differences and Similarities of Objects*	23. name ways through which seeds are dispersed.	Longing to Know and Understand, Respect for Order in Nature
Observing, Communicating, *Sequencing*, Using space/time relationships	*Constant Change*, Fundamental Structures	24. describe changes that occur in the appearance of an animal, a tree and a bird during the seasons of the year.	*Demonstrating Confidence and Satisfaction*, Longing to Know and Understand, Respect for Order in Nature
Observing, *Classifying*, Using space/time relationships	Differences and Similarities of Objects, Space/Time Reference Frames, Generalized Perceptions	25. name or identify some animals that have protective coloration.	Longing to Know and Understand, Respect for Order in Nature
Using space/time relationships, Sequencing, Classifying	*Differences and Similarities of Objects*, Constant Change, Generalized Perceptions	26. identify ways in which animals adapt to seasonal changes.	Respect for Order in Nature, Longing to Know and Understand
Classifying, Assimilating	*Differences and Similarities of Objects*, Science and Technology, Interdependency of Nature	27. identify foods he eats with the plant or animal from which they come.	Longing to Know and Understand, Consideration of Premises, *Developing a Commitment to Aesthetics in Nature*
Communicating, Using space/time relationships, Sequencing	*Interdependency of Nature*, Constant Changes, Differences and Similarities of Interactions.	28. describe several ways plants and animals respond to changes in their environment.	*Respect for Order in Nature*, Consideration of Consequences.
Classifying, Communicating Inferring	Differences and Similarities of Interactions, Space/Time Reference Frames, Force Fields, Science and Society	29. describe various ways by which living things protect themselves.	Respect for Order in Nature, Demonstrating Confidence and Satisfaction
Assimilating Using space/time relationships Classifying	*Interdependency of Nature*, Differences and Similarities of Interactions, Force Fields	30. identify several animals that live in social groups and describe their habits.	*Respect for Order in Nature*, Longing to Know and Understand
Classifying, Equating	*Differences and Similarities of Objects*, Interdependency of Nature	31. distinguish domestic and wild plants and animals by various ways.	*Longing to Know and Understand*, Consideration of Premises
Inferring, Using space/time relationships, Assimilating	*Interdependency of Nature*, *Action Forces*, Science and Technology	32. describe various ways plants and animals affect man's behavior.	*Respect for Order in Nature*, Longing to Know and Understand, Consideration of Consequences
Inferring, Using space/time relationships, Assimilating	*Interdependency of Nature*, *Action Forces*, Science and Technology	33. name various ways in which man affects the environment of plants and animals.	*Consideration of Consequences*, Longing to Know and Understand, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Observing, Classifying	Fundamental Structures	34. identify the basic parts of flowering plants (such as roots, stems and flowers).	Demonstrating Confidence and Satisfaction
Classifying	Differences and Similarities of Objects	35. identify and observe insects and spiders.	Longing to Know and Understand
Assimilating, Using space/time relationships	*Interdependency of Nature*, Generalized Perceptions, Differences and Similarities of Interactions Force Fields	36. describe how insects interrelate with plants.	*Respect for Order in Nature*, Longing to Know and Understand, Consideration of Consequences
Inferring, Communicating, Using space/time relationships	Force Fields, *Interdependency of Nature*, Generalized Perceptions	37. describe how some living things and the soil are interdependent.	*Consideration of Consequences*, Longing to Know and Understand, Respect for Order in Nature
Sequencing, Communicating, Observing	Constant Change, *Energy Exchange*, Energy Forms, *Matter Conservation*	38. describe a simple food chain.	*Consideration of Consequences*, Demonstrating Confidence and Satisfaction, Respect for Order in Nature
Measuring, *Communicating*	*Statistical Descriptions*, Constant Change	39. measure and record growth of plants, people and animals.	*Demonstrating Confidence and Satisfaction*, Search for Data and their Meaning
Measuring, Communicating	Statistical Descriptions	40. determine the actual size of a plant or animal when the unit of measurement or system is given.	*Demonstrating Confidence and Satisfaction*, Search for Data and Their Meaning
Measuring, *Communicating*	*Differences and Similarities of Objects*, Science and Technology	41 care for plants and animals on the basis of observation he has made in the classroom.	*Developing a Commitment to Aesthetics in Nature*, Consideration of Consesequences.
		Level Three:	
Measuring	Statistical Descriptions	42. measure and record the absorption of water by seeds and seedlings.	Search for Data and their Meaning
Testing, Recognizing Variables, Manipulating variables, Predicting	*Differences and Similarities of Interactions*, Space/Time Reference Frames, Generalized Perceptions	43. reduce a problem dealing with plants and animals to a single variable using the processes of observing, classifying, measuring, predicting, recording, testing.	*Search for Data and their Meaning*, Consideration of Premises
Classifying, Sequencing, Inferring	Differences and Similarities of Objects, Matter Conservation, Energy Exchange, Interdependency of Nature	44. recognize a mold, describe how it gets started and discuss its needs for growth.	Respect for Order in Nature, Longing to Know and Understand.
Inferring, Classifying, Assimilating	*Differences and Similarities of Objects*, Fundamental Structures, Force Fields	45. infer why different types of leaves are found in different types of environments.	*Longing to Know and Understand*, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Classifying, Using space/ time relation-ships	*Differences and Similar-ities of Objects*, Funda-mental Structures	46. sort seeds and plants on the basis of observable properties.	*Longing to Know and Under-stand*, Consideration of Premises, Demonstrating Confidence and Satisfaction
Inferring, Classifying	*Differences and Similar-ities of Objects*, Inter-dependency of Nature	47. describe different environments in which different animals may live.	*Consideration of Premises*, Respect for Order in Nature
Sequencing, *Inferring*, Interpreting data	*Interdependency of Nature*, Energy Forms, Matter Conservation	48. identify ways in which animals are dependent upon plants for food either directly or indirectly.	*Questioning of All Things*, Respect for Order in Nature
Sequencing, *Inferring*	Interdependency in Nature	49. describe how plant reproduction is affected by animals.	*Longing to Know and Under-stand*, Respect for Order in Nature
Inferring Classifying	*Interdependency in Nature* Differences and Similar-ities of Interactions	50. identify and describe ways that animals are dependent upon plants for more than just food.	*Longing to know and Under-stand*, Respect for Order in Nature
Classifyiing, Equating	*Differences and Similar-ities of Objects*, Funda-mental Structures, Constant Change	51. identify examples of vegetative repro-duction on the basis of observable criteria, i.e. cuttings, tubers, bulbs.	*Demonstrating Confidence and Satisfaction*, Longing to Know and Understand
Communicating, Classifying	*Differences and Similar-ities of Objects*, Generalized Perceptions	52. describe from observation an asexual form of reproduction such as in molds, yeasts, etc.	Longing to Know and Under-stand
Communicating, Sequencing, Using space/ time relation-ships	Constant Change	53. describe orally the characteristics of a living object as it grows and changes from one stage to another.	*Longing to Know and Under-stand*, Respect for Order in Nature
Using space/ time relation-ships, Classifying, *Ordering*	Constant Change, Differences and Similar-ities of Objects, Inter-dependency of Nature	54. identify differences in the life spans of various plants.	*Demonstrating Confidence and Satisfaction*, Respect for Order in Nature
Communicating, Sequencing, Using space/ time relation-ships	*Constant Change*, Interdependency of Nature	55. describe several plant and animal life cycles and give examples.	*Longing to Know and Under-stand*, Respect for Order in Nature
Predicting, Classifying	*Differences and Similar-ities of Objects*, Funda-mental Structures	56. predict how many first leaves a plant from a dicot or monocot seed will have.	Respect for Logic, Consid-eration of Premises, Longing to Know and Under-stand
Testing	*Differences and Similar-ities of Objects*, Funda-mental Structures	57. plant various kinds of seeds to test his predictions about these seeds.	*Demand for Verification*, Respect for Order in Nature
Predicting, *Testing*	Science and Technology, Differences and Similar-ities of Interactions	58. describe several activities which he thinks will make his heart beat faster and check his predictions.	*Demand for Verification*, Consideration of Premises, Consideration of Conse-quences

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Generalizing, Equating, Sequencing	*Space/Time Reference Frames*, Differences and Similarities of Objects, Fundamental Structures	59. describe the similarities of a fertilized egg to a plant seed.	*Respect for Order in Nature*, Consideration of Premises
Inferring, Assimilating	*Differences and Similarities of Interactions*, Interdependency of Nature, Science and Technology	60. distinguish between some wise and unwise use of plant and animal life.	*Consideration of Consequences*, Developing a Commitment to Aesthetics in Nature
Communicating, *Inferring*, Assimilating	*Science and Technology*, Interdependency of Nature Science and Soceity	61. state a rule for why various plants and animals are protected by law.	*Consideration of Consequences*, Developing A Commitment to Aesthetics in Nature
Communicating, Simulating, Classifying, Using space/ time relationships, Sequencing	*Space/Time Reference Frames*, *Fundamental Structures*, Differences and Similarities of Objects	Level Four: 62. describe ways in which animals may move from place to place.	*Longing to Know and Understand*, *Demonstrating Confidence and Satisfaction*
Classifying *Assimilating*	*Fundamental Structures*, *Interdependency of Nature*, Differences and Similarities of Interactions, Matter Conservation, Energy Forms	63. name parts of plants used by man.	*Search for Data and their Meaning*, Consideration of Consequences, Respect for Order in Nature
Generalizing, Classifying, Assimilating	Energy Exchange, Differences and Similarities of Objects, *Interdependency of Nature*	64. identify animals which are predominantly carnivorous, herbivorous, or omnivorous	Respect for Order in Nature, Demonstrating Confidence and Satisfaction
Classifying, Assimilating	*Differences and Similarities of Objects*, Fundamental Structures	65. identify hearing mechanism of several animals such as a frog, a grasshopper, bird, fish and compare these with that of a human.	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Classifying, Observing	Fundamental Structures	66. identify and describe the main characteristics of insects.	Longing to Know and Understand
Classifying, Assimilating	*Differences and Similarities of Objects*, *Fundamental Structures*, Generalized Perceptions	67. distinguish between vertebrate and invertebrate animals from appropriate pictures, models or preserved specimens.	Longing to Know and Understand, *Consideration of Premises*
Classifying, Assimilating	*Differences and Similarities of Objects*, Fundamental Structures	68. match plants or animals with the method in which they reproduce through the use of pictures, preserved or live specimens and models.	Longing to Know and Understand, Consideration of Premises
Inferring, Assimilating, Using space/ time relationships, Sequencing	*Force Fields*, Differences and Similarities of Objects, Interdependency of Nature	69. identify the role of each type of individual found in one of the social animal colonies.	*Respect for Order in Nature*, Longing to Know and Understand

Processes	Conceptual Scheme	OBJECTIVE: Dependent upon ability and past experience, the student will:	Values and Attitudes
Using space/ time relationships, *Assimilating*	*Constant Change*, Differerences and Similarities of of Objects, Interdependency of Nature	70. describe plant and animal adaptations to seasonal change in terms of migration, hibernation, etc.	*Respect for Order in Nature* Longing to Know and Understand.
Inferring, Assimilating	Force Fields	71. infer ways in which the organism may react or respond to protect itself given a specific danger.	Long to Know and Understand
Predicting, *Testing*, Assimilating, Classifying	*Differences and Similarities of Objects*, Science and Technology	72. identify areas of the school ground in which various plants could grow and attempt to propagate plants in these areas.	Developing a Commitment to Aesthetics in Nature
Simulating, Interpreting data	*Interdependency of Nature* Energy Exchange	73. construct a microhabitat and observe the interrelationships of the various organisms.	*Respect for Order in Nature*. Longing to Know and Understand.
Defining operationally, Classifying	*Fundamental Structures*, Differences and Similarities of Objects	74. identify the cell as the basic structural unit of all living things.	*Longing to Know and Understand*, Consideration of Premises
Interpreting data, Classifying Observing	*Fundamental Structures*, Interdependency of Nature	75. order and describe the structural units of living organisms (cell, tissue, organ, system, organisms).	*Longing to Know and Understand*, Respect for Order in Nature
Simulating, Communicating	*Fundamental Structures*, Interdependency of Nature	76. construct models of organisms and their substructures to show interrelationships between structure and the total organism.	Longing to Know and Understand, Demonstrating Confidence and Satisfaction
Interpreting data, Recognizing variables, Measuring	*Energy Exchange*, Energy Forms, Force Fields	77. record data and describe how a plant responds to light.	*Search for Data and their Meaning*, *Demand for Verification*, Respect for Order in Nature
Interpreting data, Defining operationally	*Differences and Similarities of Interactions*, Interdependency of Nature	78. identify photosynthesis as the vital process whereby energy is converted by plants into a form that can be used by all living things.	*Longing to Know and Understand*, Respect for Order in Nature
Defining operationally, Interpreting data, Using space/time relationships	*Constant Change*, Space/ Time Reference Frames	Level Five: 79. describe the concept of growth as it applies to organisms by using data.	Search for Data and their Meaning
Classifying, Observing	*Differences and Similarities of Objects*, Fundamental Structures	80. name some unicellular plants and animals and discuss the similarities and differences of these.	*Longing to Know and Understand*, Demand for Verification
Classifying, Observing Assimilating	*Differences and Similarities of Objects*, Fundamental Structures	81. identify the major characteristics of each of the five classes of vertebrates.	Longing to Know and Understand

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Assimilating, Classifying, Recognizing variables, Using space/time relationships	*Differences and Similarities of Objects*, Generalized Perceptions	82. identify five different biomes in which plants or animals may live.	Longing to Know and Understand, *Respect for Order in Nature*
Assimilating, Recognizing variables	*Science and Technology*, Interdependency of Nature	83. describe various ways that man may alter the environment so plants can grow in ordinarily unsuitable habitats.	Search for Data and their Meaning, Valuing Scientific Heritage, Consideration of Consequences
Assimilating	*Force Fields*, Interdependency of Nature	84. identify and demonstrate ways in which plants and animals compete for basic needs in their environment.	Search Data and their Meaning, Consideration of Consequences.
Assimilating	*Interdependency of Nature*, Science and Technology	85. discuss plants or animals that have been introduced by man in new habitats and describe both desirable and detrimental effects of this introduction.	Consideration of Consequences
Recognizing variables, Inferring	*Force Fields*, Constant Change, Interdependency of Nature	86. infer plant and animal adaptations that would be desirable under various environmental conditions.	*Consideration of Consequences*, Search for Data and their Meaning
Manipulating variables, Interpreting data	*Science and Technology*, Differences and Similarities of Objects	87. describe how man uses genetic factors for the breeding of plants and animals for his own benefits.	Valuing Scientific Heritage
Predicting, Classifying	*Differences and Similarities of Objects*, Fundamental Structures, Generalized Perceptions	88. predict the number of cotyledons that will be produced by various seeds and describe the structure in the plants that produce these seeds.	*Search for Data and their Meaning*, Respect for Order in Nature
Generalizing, *Classifying*	*Interdependency of Nature*, Differences and Similarities of Objects, Generalized Perceptions	89. discuss three major ways different plants obtain nourishment.	*Search for Data and their Meaning*, Respect for Order in Nature
Interpreting data, Ordering	*Differences and Similarities of Objects*, Fundamental Structures, Constant Change	90. order plant reproductive systems on the basis of complexity.	Search for Data and their Meaning
Interpreting data	Constant Change	91. name specific plants and animals that have become extinct in this century.	Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and attitudes
Interpreting data, Formulating Hypothesis, Manipulating variables	*Force Fields*, Interdependency of Nature, Science and Technology	92. name and identify endangered plants and animals and describe ways in which habitats may be maintained and developed so the species may continue natural reproduction and replenishment.	*Developing a Commitment to Aesthetics in Nature*, Consideration of Consequences
Interpreting data, Analyzing systems	*Interdependency of Nature*, Science and Technology	93. list several ways that man can conserve natural resources and identify places in the community where conservation practices might be applied.	*Consideration of Consequences*, Respect for Order in Nature
Communicating, Assimilating	Science and Technology Science and Society	94. identify individuals who pioneered discoveries in the life sciences and briefly discuss the importance of their discoveries.	Valuing Scientific Heritage
Interpreting data, Sequencing	*Differences and Similarities of Interactions*, Constand Change, Interdependency of Nature	Level Six: 95. identify stimuli in an environment and the response of living things to these stimuli.	Search for Data and their Meaning
Interpreting data, Defining operationally, Recognizing variables	Differences and Similarities of Objects	96. describe a typical life cycle of a chordate and compare it with the life cycle of another animal group such as insects, sponges, etc.	Questioning of All Things. Search for Data and their Meaning, Respect for Order in Nature
Analyzing systems Interpreting data, Defining operationally	*Interdependency of Nature*, Force Fields	97. identify the niche that a plant or animal occupies in its habitat.	*Respect for Order in Nature*, Search for Data and their Meaning
Translating, Cognitively evaluating alternatives	*Interdependency of Nature*, Differences and Similarities of Interactions, Matter Conservation, Science and Technology	98. identify incidents of natural resources misuse within his community and propose several solutions.	Consideration of Consequences
Acting on Conclusions	*Science and Technology* Science and Society	99. develop a plan to implement the solutions he selects to to correct natural resource misuse and begin to implement his plan.	Developing a Commitment to Aesthetics in Nature
Generalizing	Interdependency of Nature, Matter Conservation	100. describe the dependency of living cells upon water.	Search for Data and their Meaning, Respect for Order in Nature
Formulating Models, Analyzing systems	*Interdependency of Nature*, Constant Change, Generalized Perceptions	101. construct a diagram or model to illustrate various cycles involving living things such as water, carbon, nitrogen, and oxygen cycles.	*Respect for Order in Nature*, Search for Data and their Meaning, Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Formulating models, Analyzing systems	*Matter Conservation, Energy Exchange*, Interdependency of Nature, Generalized Perceptions	102. construct a diagram or model to show that a plant is a food factory.	*Search for Data and their Meaning*, Respect for Order In Nature
Analyzing systems, Formulating models, Generalizing	*Interdependency of Science and Technology, Force Fields*, Matter Conservation, Energy Exchange	103. describe how man is totally dependent on living things, soil, water, air, and mineral resources for all his needs.	*Consideration of Consequences*, Respect for Order in Nature
Analyzing Systems, Formulating models	*Interdependency of Science and Technology*, Force Fields, Matter Conservation, Energy Exchange	104. describe how knowledge of plant nutrition has had both desirable and undesirable effects.	*Consideration of Consequences.* Respect for Order in Nature.
Synthesizing	*Interdependency of Nature, Science and Technology*, Force Fields, Matter Conservation, Energy Exchange	105. propose and discuss ways to increase man's food supply without producing serious adverse environmental conditions.	*Consideration of Consequences*, Developing a Commitment to Aesthetics in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
		Level One:	
Observing, Multiple Discriminating	Differences and Similarities of Objects	1. identify vibrating objects as producers of sound.	Search for Data and their Meaning
Classifying, *Simulating*	Differences and Similarities of Objects	2. identify sounds and their sources	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Observing, Classifying, Multiple Discriminating	Differences and Similarities of Objects	3. describe how sounds differ.	Search for Data and their Meaning
Observing, Classifying, Ordering	Differences and Similarities of Objects	4. name various things through which sound can travel	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Classifying Assimilating	Differences and Similarities of Objects	5. identify different sources of light	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Sequencing, Classifying, Assimilating, Using space/time relationships	*Interdependency of Nature* Science and Technology, Differences and Similarities of Objects, Space/Time Reference Frames	6. name and identify several uses for light.	*Respect for Order in Nature*, Respect for Logic, Demonstrating Confidence and Satisfaction
Measuring Using space/time relationships	*Space/Time Reference Frames*, Constant Change, Statistical Descriptions	7. measure length and angle of shadows.	*Search for Data and Their Meaning*, Demonstrating Confidence and Satisfaction
Measuring, Using space/time relationships, Sequencing	*Statistical Descriptions* Space/Time Reference Frames, Constant Change	8. clock the time lapses as shadows change.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying Categorically conceptualizing	*Differences and Similarities of Objects*, Force Fields	9. sort things attracted to a magnet from those not attracted to a magnet	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction.
Communicating, *Equating*, Classifying, Using space/time relationships	*Force Fields*, Space/Time Reference Frames, General Perceptions, Differences and Similarities of Objects	10. describe a magnet in terms of function.	Longing to Know and Understand
Observing	*Science and Technology*, Force Fields	11. name several ways in which magnets are used in everyday life.	*Search for Data and Their Meaning*, Demonstrating Confidence and Satisfaction
Classifying Equating	*Differences and Similarities of Objects*	12. identify solids, liquids and gases.	Search for Data and their Meaning, Respect for Order in Nature
Classifying, Equating, Observing	Differences and Similarities of Objects	13. label each example, from provided specimen, according to its state and identify the distinguishing characteristics of each specimen.	Demonstrating Confidence and Satisfaction, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Inferring, Classifying, Using space/ time relationships	*Differences and Similarities of Objects*, Space/ Time Reference Frames, Force Fields	14. correctly infer which objects will float and which will sink after observing and manipulating various objects.	*Consideration of Premises*, Respect for Logic
Communicating, Using space/ time relationships	*Space/Time Reference Frames*	15. record changes of positions of an object in a variety of ways (photographs, drawings, verbal descriptions).	*Search for Data and Their Meaning*, Demonstrating Confidence and Satisfaction
Inferring, Equating, Testing	*Differences and Similarities of Objects, Differences and Similarities of Interactions*, Action Forces	16. manipulate objects such as spring type toys on the basis of observation of relationships.	*Consideration of Premises*, Respect for Order in Nature
Inferring, Classifying, Assimilating	*Energy Forms*, Differences and Similarities of Interactions, Generalized Perceptions	17. identify energy as the cause of movement of both mechanical and living things.	*Longing to Know and Understand*, Respect for Order in Nature
Classifying, Assimilating, Using space/ time relationships, *Inferring*	*Energy Forms*, Differences and Similarities of Interactions, Generalized Perceptions	18. identify moving things as a form of kinetic energy. 19. See General Objective 28..	*Longing to Know and Understand*, Respect for Order in Nature
Assimilating, Simulating, Using space/ time relationships, Classifying	*Science and Technology*, Differences and Similarities of Interactions, Space/Time Reference Frames	20. describe various ways that wheels are used by man and construct models illustrating some of these ways.	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Assimilating, Classifying	*Differences and Similarities of Objects*, Energy Exchange	21. describe objects in terms of hotter than or colder than his hand.	Longing to Know and Understand, Demonstrating Confidence and Satisfaction
Assimilating, Classifying	*Science and Technology*, Differences and Similarities of Interactions, Energy Forms	22. name various ways in which we use heat.	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Assimilating, Classifying, Observing	Energy Forms	23. identify electricity as a form of energy.	*Longing to Know and Understand*
Simulating, Assimilating	*Science and Technology*, Differences and Similarities of Interactions	24. identify various ways that man utilizes electricity.	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
		Level Two:	
Simulating, Assimilating, Using space/time relationships, Classifying	*Differences and Similarities of Objects*, Space/ Time Reference Frames, Generalized Perceptions	25. demonstrate that some matter cannot be seen.	*Demand for Verification, Consideration of Premises*
Assimilating, Sequencing, Classifying	*Science and Technology*, Action Forces, Differences and Similarities of Inter-	26. identify some ways air pressure can be used by man.	*Longing to Know and Understand*, Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Assimilating Observing, Classifying	*Energy Forms*, Differences and Similarities of Objects	27. identify heat as a form of energy.	Longing to Know and Understand
Assimilating, Using space/ time relation-ships, Classifying	Differences and Similar-ities of Interactions, Energy Exchange, Energy Forms	28. identify heat as being the energy that can change solid to liquid.	*Longing to Know and Understand*, Consideration of Premises
Simulating, Inferring Using space/ time relation-ships	Differences and Similar-ities of Interactions, Energy Exchange, Energy Forms, Science and Technology	29. describe and demonstrate how a solid substance can change to a liquid and vice-versa.	*Longing to Know and Under stand*, Respect for Logic, Demonstrating Confidence and Satisfaction
Assimilating, Classifying	Differences and Similar-ities of Interactions, Energy Exchange, Energy Forms,	30. describe the change in state and give reasons for the change, after observing a situation suitable for evaporation.	Longing to Know and Understand, Respect for Logic, Demonstrating Confidence and Satisfaction
Measuring Using Numbers, Simulating	Statistical Descriptions, Science and Technology	31. construct and crudely calibrate a thermometer.	*Search for Data and their Meaning*, Consideration of Premises
Measuring, Using Numbers	*Statistical Descriptions* Generalized Perceptions	32. demonstrate the ability to read a standard thermometer.	Search for Data and their Meaning
Communicating, Using Numbers, Using space/ time relation-ships, Measuring	*Statistical Descriptions* Generalized Perceptions	33. record thermometer readings after mixing water of different temperatures.	Search for Data and their Meaning
Classifying, Observing	Differences and Similar-ities of Objects, Force Fields	34. classify objects on the basis of those that will float in water and/or other liquids and those that will not float.	Search for Data and their Meaning, Longing to Know and Understand
Simulating, Sequencing, Classifying	Energy Forms, Generalized Perceptions, Differences and Similarities of Interactions	35. demonstrate sound as a form of energy.	*Longing to Know and Understand.* Consideration of Premises
Assimilating	*Energy Forms*, Inter-dependency of Nature	36. identify the sun as the basic source of energy.	*Developing a commitment to Aesthetics in Nature.* Longing to Know and Under-stand, Questioning of All Things
Assimilating, Sequencing, Using space/ time relation ships	*Action Forces, Funda-mental Structures*, Differences and Similar-ities of Objects, Differ-ences and Similarities of Interactions	37. identify the parts of the body that push and enable various animals to change their position.	Longing to Know and Understand, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Assimilating, Classifying	*Energy Forms*, Differences and Similarities of Interactions, Generalized Perceptions	38. identify movement of muscles as the result of energy input.	*Longing to Know and Understand*, Consideration of Premises
Testing, Inferring, Using space/ time relationships, Communicating	*Action Forces*, Space/Time Reference Frames, Generalized Perceptions	39. demonstrate how a push or pull in a given direction will effect a change in position of an animal or object.	Longing to Know and Understand, Demonstrating Confidence and Satisfaction
Testing, Predicting, Using space/ time relationships	*Action Forces*, Generalized Perceptions, Differences, and Similarities of Interactions	40. demonstrate how a push or pull will cause a moving object to change speed or direction.	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Classifying	*Differences and Similarities of Interactions*, Force Fields	41. identify instances where friction is present.	*Consideration of Premises*, Demonstrating Confidence and Satisfaction
Classifying	*Differences and Similarities of Interactions*,	42. create situations illustrating both sliding and rolling friction.	*Considerations of Premises*, Demonstrating Confidence and Satisfaction
Inferring, *Simulating*,	Differences and Similarities of Interactions, Energy Exchange, Energy Forms, Generalized Perceptions, Science and Technology	43. identify the relationships between friction and heat from various observations.	*Search for Data and their Meaning*, Consideration of Premises, Consideration of Consequences
Testing, *Predicting*, Using space/ time relationships	*Science and Technology* Energy Exchange	44. demonstrate how a simple machine can increase the ability to do heavy work.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying Assimilating	*Differences and Similarities of Objects*, Differences and Similarities of Interactions, Action Forces, Science and Technology	45. sort simple machines by function.	*Demonstrating Confidence and Satisfaction*, Longing to Know and Understand
Classifying, Assimilating Using space/ time relationships	*Energy Forms*, Energy Exchange, Science and Technology	46. identify various common chemical reactions in which energy is released (fire, and mixing a weak base with a weak acid such as baking soda and vinegar).	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Classifying,	*Differences and Similarities of Interactions*, Energy Forms, Energy Exchange	47. identify the form(s) of energy being used when given a picture, working model or other visual stimulus.	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Assimilating, Classifying	*Energy Forms*, Differences and Similarities of Interactions, *Energy Exchange*, Science and Technology	48. name or identify various sources of energy and give examples of objects that use each.	Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Testing, Using space/time relationships, *Predicting*, Measuring	*Constant Change*, Space/ Time Reference Frames, Statistical Descriptions	49. check predictions on the length and angle of shadows.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
		Level Three:	
Predicting Recognizing variables	*Action Forces*, Differences and Similarities of Interactions	50. describe how speed can be increased or decreased through the use of unbalanced forces.	*Respect for Order in Nature*, Consideration of Premises, Valuing Scientific Heritage
Predicting, Generalizing	*Differences and Similarities of Interactions*, Energy Exchange, Energy Conservation	51. infer what he thinks the temperature of mixes of hot and cold water will be.	*Respect for Order in Nature*, Consideration of Premises
Inferring, Assimilating, Classifying	Differences and Similarities of Interactions, Energy Exchange, Generalized Perceptions	52. infer what he thinks will happen when certain objects are placed in water and/or other liquids of known temperature.	*Consideration of Premises*, Demonstrating Confidence and Satisfaction
Classifying	*Differences and Similarities of Interactions*, Differences and Similarities of Objects	53. distinguish between physical and chemical changes when presented a series of changes.	Longing to Know and Understand, *Consideration of Premises*, Demonstrating Confidence and Satisfaction
Testing, Inferring	*Differences and Similarities of Interactions*, Energy Exchange, Science and Technology	54. infer and test how changes in heat (both addition and subtraction of heat) would affect objects such as raisins, chocolate bar, spoonful of sugar, cake batter or other common household materials.	*Respect for Logic*, Consideration of Premises, Demonstrating Confidence and Satisfaction
Measuring, Using space/ time relationships	*Statistical Descriptions*, Force Fields, Generalized Perceptions	55. weigh water displaced by various objects dropped into the water.	*Search for Data and their Meaning*, Respect for Order in Nature, Demonstrating Confidence and Satisfaction
Sequencing, Using space/ time relationships	Space/Time Reference Frames	56. describe how an impulse travels along a spring (loosely stretched slinky)	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction
Testing, Predicting, Using space/ time relationships	*Differences and Similarities of Interactions*, Space/Time Reference Frames	57. demonstrate how shaking a spring or rubber hose with varying speed and stroke will cause it to vibrate with different amplitudes and frequencies.	*Consideration of Premises*, Demonstrating Confidence and Satisfaction
Testing, *Inferring*	*Differences and Similarities of Interactions*, Generalized Perceptions	58. infer and test what will happen when he plucks a rubber band stretched to varying lengths.	*Search for Data and their Meaning*, Consideration of Premises
Testing, *Inferring*	*Differences and Similarities of Interactions*, Generalized Perceptions	59. infer and test what will happen when he taps glasses containing various amounts of liquid in terms of variations in the sound produced.	*Search for Data and their Meaning*, Consideration of Premises
Sequencing, Using space/ time relationships	*Space/Time Reference Frames*, Force Fields	60. describe how water waves spread across the surface of a body (tank) of water	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Testing, Assimilating	*Force Fields*, Differences and Similarities of Interactions	61. construct an electromagnet.	*Longing to Know and Understand*, Demand for Verification
Translating	*Fundamental Structures*, Differences and Similarities of Interactions, Science and Technology	62. construct a toy of his own design and identify the simple machines incorporated in it.	Demonstrating Confidence and Satisfaction
Translating, Testing	*Energy Exchange*, Energy Exchange, Energy Forms, Science and Technology	63. construct a system whereby electrical energy can be transferred into light and/or sound.	*Longing to Know and Understand*, Consideration of Premises
Assimilating, Observing, Classifying	Fundamental Structures	64. identify sunlight as being composed of many colors.	Longing to Know and Understand, Search for Data and their Meaning
Simulating, *Observing*	Fundamental Structures, Force Fields	65. demonstrate that sunlight is composed of many colors.	Longing to Know and Understand.
Measuring, Using space/ time relationships	*Statistical Descriptions*, Constant change	66. clock the time lapses as oxygen is consumed by an enclosed candle.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Inferring, Testing	*Differences and Similarities of Interactions*, Statistical Descriptions, Constant Change	67. infer how long he thinks a candle will burn when a jar is placed over it and test his inferences.	*Consideration of Premises*, Demand for Verification, Search for Data and their Meaning.
Inferring, Assimilating	*Differences and Similarities of Interactions*, Energy Exchange, Energy Forms, Science and Technology	68. infer what could happen if old rags or newspapers were left in a pile near a window through which the sun can shine.	Consideration of Consequences
Predicting, Classifying	*Differences and Similarities of Interactions*, *Science and Technology*	69. list precautions that must be followed when using electricity, combustible substances, fire, household substances and medicines.	Consideration of Consequences
		Level Four:	
Testing, Classifying	*Differences and Similarities of Interactions*, *Force Fields*	70. construct a test to determine the the presence of magnetic force.	Demonstrating Confidence and Satisfaction
Assimilating, Inferring	*Force Fields*, Differences and Similarities of Interactions	71. identify friction as a force.	*Search for Data and their Meaning*, Respect for Logic
Interpreting data, Classifying	Force Fields, Science and Technology	72. demonstrate how friction can be either a help or hinderance.	*Search for Data and their Meaning*, Consideration of Consequences
Interpreting data, Generalizing	*Differences and Similarities of Interactions*, *Statistical Descriptions*, Action Forces	73. demonstrate that objects at rest tend to remain at rest and objects in motion tend to remain in the same state of motion.	Search for Data and their Meaning
Translating	Differences and Similarities of Interactions, Science and Technology	74. relate this to what happens to him when a car in which he is riding suddenly changes speed or direction.	Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Interpreting data, Recognizing variables, Testing, Generalizing	*Differences and Similarities of Interactions,* Force Fields, Action Forces, Generalized Perceptions	75. demonstrate that more massive objects are harder to start in motion and harder to stop.	Search for Data and their Meaning, Respect for Logic, *Demand for Verification*
Predicting, Testing, Recognizing variables	*Action Forces,* Force Fields, Differences and Similarities of interactions, Generalized perceptions	76. describe or demonstrate ways to change the speed of an object.	*Respect for Logic,* Search for Data and their Meaning, Demand for Verification
Classifying, Measuring	*Differences and Similarities of Objects,* Energy Exchange	77. order various substances according to their kindling points.	*Search for Data and their Meaning,*Demonstrating Confidence and Satisfaction
Simulating, Assimilating, Using space/ time relationships	*Differences and Similarities of Interactions*	78. demonstrate the effect of addition or subtraction of heat on various solid materials (include demonstrations that involve both like and unlike materials).	*Search for Data and their Meaning,* Demonstrating Confidence and Satisfaction
Measuring, Using Numbers	*Energy Exchange, Energy Forms,* Generalized Perceptions	79. record changes in the temperature of matter during a change of phase (solid to liquid to gas and reverse).	*Search for Data and their Meaning.* Questioning of All Things
Assimilating, Classifying	*Differences and Similarities of Interacitons*	80. distinguish between common chemical and physical changes.	Search for Data and their Meaning
Assimilating Classifying,	*Differences and Similarities of Interactions*	81. identify examples of physical and chemical changes constantly taking place.	*Search for Data and their Meaning,* Demonstrating Confidence and Satisfaction
Manipulating variables, Testing	*Energy Forms, Action Forces, Science and Technology,* Energy Exchange	82. demonstrate or construct a system to show that sources of energy other than muscle power might be used to operate machines.	*Demonstrating Confidence and Satisfaction,* Demand for Verification
Analyzing systems	*Fundamental Structures,* Science and Technology	83. identify the simple machines that compose a complex machine.	*Longing to Know and Understand*
Simulating, Inferring, Measuring	*Differences and Similarities of Objects, Differences and Similarities of Interactions,* Force Fields Action Forces	84. demonstrate the compressibility of gases and the mobility of fluids and gases.	*Questioning of All Things,* Demonstrating Confidence and Satisfaction
Translating, Analyzing systems	*Action Forces, Science and Technology,* Differences and Similarities of Interactions	85. construct a working model to show how moving gases and liquids can be used to do work. Level Five:	*Demonstrating Confidence and Satisfaction,* Demand for Verification
Translating, Interpreting data	*Differences and Similarities of Objects, Differences and Similarities of Interactions, Force Fields, Action Forces*	86. demonstrate various methods of producing electric charge and describe various ways of producing electric current.	*Demonstrating Confidence and Satisfaction*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Testing, Interpreting data	*Force Fields* , Statistical Descriptions	87. construct an electromagnet and devise a test to determine the strength of the magnet.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Manipulating variables, Interpreting data	*Science and Technology,* Force Fields, Statistical Descriptions	88. identify variables that can be altered to increase or decrease the strength of an electromagnet.	Search for Data and their Meaning, Respect for Logic
Analyzing systems, Defining operationally, Manipulating variables	Differences and Similarities of Interactions, Fundamental Structures, Force Fields	89. construct simple electric circuits and show the advantages and disadvantages of parallel and and series circuitry.	*Questioning of All Things,* Search for Data and their Meaning
Defining operationally, Classifying	*Differences and Similarities of Objects, Fundamental Structures*	90. define the terms: elements, compounds and mixtures.	*Longing to Know and Understand,* Respect for Order in Nature
Testing, *Translating*	*Differences and Similarities of Objects, Funda mental Structures*	91. devise a test for distinguishing between mixtures and compounds or elements.	Search for Data and their Meaning
Defining operationally, Generalizing, Interpreting data	*Differences and Similarities of Interactions,* Matter Conservation, Generalized Perceptions	92. describe the attributes of chemical change.	Search for Data and their Meaning
Defining operationally, Classifying, Measuring	*Differences and Similarities of Interactions,* Matter Conservation	93. describe oxidation and give examples of rapid and slow oxidation.	*Search for Data and their Meaning,* Respect for Order in Nature.
Defining operationally, Classifying	*Differences and Similarities of Objects,* Generalized Perceptions	94. distinguish between acids and bases using litmus or other indicator papers.	*Search for Data and their Meaning,* Respect for Order in Nature
Defining operationally, Classifying	*Differences and Similarities of Objects,* Generalized Perceptions	95. describe some properties of acids and bases.	*Search for Data and their Meaning,* Respect for Order in Nature
Categorically conceptualizing Verbally associating	*Fundamental Structures*	96. describe the relationship between molecules and atoms.	Demonstrating Confidence and Satisfaction
Assimilating	*Science and Technology Science and Society*	97. name possible peaceful uses of atomic energy.	Consideration of Consequences, Consideration of Premises
Analyzing systems	*Fundamental Structures,* Generalized Perceptions	98. use the concept of molecules as one possible explanation of the behavior of matter in its three states.	*Respect for Logic,* Search for Data and their Meaning
Formulating Hypotheses, Experimenting, Interpreting data	*Action Forces,* Differences and Similarities of Interactions, Generalized Perceptions	99. demonstrate that to every force exerted there is an equal and opposite reactive force.	*Questioning of All Things,* Search for Data and their Meaning, Consideration of Premises

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Testing, Interpreting data	*Energy Exchange, Energy Forms*, Generalized Perceptions	100. demonstrate ways in which mechanical kinetic energy can be converted to heat.	*Search for Data and their Meaning*
Defining operationally, Interpreting data	Differences and Similarities of Objects, Differences and Similarities of Interactions	101 define transparent, translucent, opaque and reflective.	Demonstrating Confidence and Satisfaction
Analyzing systems, Testing	Space/Time Reference Frames, *Differences and Similarities of Interactions*	102. demonstrate that light travels in a straight line except when passing from one medium to another.	*Demand for Verification* Search for Data and their Meaning
Interpreting data, Generalizing	*Differences and Similarities of Interactions, Force Fields*	103. describe the path of light at a reflective surface.	*Search for Data and their Meaning*, Respect for Order in Nature
		Level Six:	
Defining operationally, Interpreting data, Recognizing variables	*Generalized Perceptions*, Energy Forms	104. distinguish between heat and temperature.	*Search for Data and their Meaning*, Demand for Verification
Analyzing systems, Defining operationally, Interpreting data	*Statistical Descriptions* Generalized Perceptions	105. identify and demonstrate temperature conditions necessary for heat exchange between objects.	*Search for Data and their Meaning, Consideration of Premises*, Respect for Order in Nature
Testing, Predicting, Assimilating	*Energy Exchange, Statistical Descriptions*	106. construct a system to demonstrate that heat can be transferred.	*Consideration of Premises*, Respect for Logic, Respect for Order in Nature
Formulating models	*Differences and Similarities of Interactions, Energy Exchange*, Generalized perceptions	107. describe the process of heat transfer by conduction, convection and radiation.	*Search for Data and their Meaning*
Testing, Inferring, Assimilating	*Statistical Descriptions*, Energy Forms	108. construct a test to demonstrate that heat can be measured.	Search for Data and their Meaning, Consideration of Premises
Simulating	*Energy Exchange*, Energy Forms	109. construct a test to demonstrate how light from the sun is converted into heat on the earth.	Search for Data and their Meaning, Demonstrating Confidence and Satisfaction
Translating	*Science and Technology*, Energy Exchange, Energy Forms	110. describe by writing a paper or constructing a model how the sun's energy may be utilized more efficiently.	Questioning of All Things. Demonstrating Confidence and Satisfaction
Experimenting, Synthesizing, Translating	*Differences and Similarities of Interactions*, Generalized Perceptions	111. construct a test to distinguish electrical conductors from non-conductors and after performing the test many times, predict items which will be conductors or non-conductors.	*Demand for Verification Respect for Logic*

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Defining operationally, Interpreting data, Recognizing variables	*Generalized Perceptions*, Differences and Similarities of Objects	112. distinguish between density and mass (or weight).	*Search for Data and their Meaning, Respect for Logic, Consideration of Premises*, Questioning of All Things
Recognizing variables, Inferring	*Differences and Similarities of Objects*, Generalized Perceptions	113. infer why certain objects will float in one liquid and sink in another.	Search for Data and their Meaning, Respect for Logic, Respect for Order in Nature
Formulating Hypotheses, Manipulating variables, Interpreting data	*Generalized Perceptions, Differences and Similarities of Objects*, Statistical Descriptions	114. construct a hypothesis to explain why various objects float with varying fractions of their volumes below the liquid surface.	*Search for Data and their Meaning*, Respect for Logic, Respect for Order in Nature
Analyzing systems, Interpreting data	Differences and Similarities of Objects	115. construct a classification system whereby items can be identified on the basis of their observable properties, when given a number of common household substances.	*Consideration of Premises* Search for Data and their Meaning
Translating, Experimenting	*Fundamental Structures*, Force Fields, Generalized Perceptions	116. demonstrate ways of separating white light into colors.	*Demand for Verification*, Consideration of Premises
Analyzing systems	Fundamental Structures	117. describe how man perceives color.	Longing to Know and Understand
Formulating Hypotheses, Translating	*Science and Technology*, Differences and Similarities of Interactions	118. state and apply a rule concerning color mixing of light.	*Respect for Logic*, Demonstrating Confidence and Satisfaction
Using space/time relationships, Analyzing systems	*Differences and Similarities of Objects, Differences and Similarities of Interactions*, Force Fields	119. distinguish between convex and concave lens by comparing the path of light as it passes through them.	Search for Data and their Meaning
Using space/time relationships, Analyzing systems	*Differences and Similarities of Objects, Differences and Similarities of Interactions*, Force Fields	120. distinguish between convex and concave mirrors by comparing their effect on the path of light.	Search for Data and their Meaning
Assimilating, Communicating	*Science and Society* Generalized Perceptions	121. report on one or more of the early attempts to measure the speed of light.	Valuing Scientific Heritage
Translating, Interpreting data	*Generalized Perceptions*, Differences and Similarities of Objects, Energy Forms	122. compare the path of radiowaves with the path of light from source to sensor.	*Search for Data and their Meaning*, Respect for Logic
Manipulating variables, Interpreting data	*Energy Exchange, Energy Forms, Force Fields*, Generalized Perceptions	123. demonstrate how potential gravitational energy can be added to an object.	Search for Data and their Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Defining operationally, Manipulating variables	*Differences and Similarities of Interactions*, Action Forces, Energy Forms	124. identify work as being dependent on the force applied and the distance an object is moved.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Analyzing systems, Experimenting, Translating	*Differences and Similarities of Interactions, Action Forces*, Energy Conservation	125. construct a system showing the relationship between lever arms, force applied and resistance overcome and apply this relationship to both lever systems and wheel and axle systems.	*Respect for Logic*, Search for Data and their Meaning
Analyzing systems, Experimenting	*Action Forces, Differences and Similarities of Interactions*, Energy Conservation	126. construct a pulley system showing the relationship between lifting strands, the force applied and weight lifted.	*Search for Data and their Meaning*, Respect for Logic
Assimilating	*Science and Technology* Energy Forms, Energy Exchange	127. name some ways man has found to use sound energy for his benefit.	Demonstrating Confidence and Satisfaction
Interpreting data	*Statistical Descriptions*, Space/Time Reference Frames	128. calculate the speed of sound in air from collected data.	Search for Data and their Meaning, Respect for Logic
Experimenting	*Force Fields*, Differences and Similarities of Interactions	129. demonstrate that sound cannot be transmitted without the presence of matter.	*Questioning of All Things*, Search for Data and their Meaning
Analyzing systems, Interpreting data	*Differences and Similarities of Interactions, Force Fields*	130. distinguish between the states of matter in terms of their ability to transmit sound using criteria he selects.	*Search for Data and their Meaning*, Questioning of All Things
Abstracting, Manipulating variables, Formulating Hypotheses	*Statistical Descriptions, Differences and Similarities of Interactions*	131. identify frequency and wavelength as two of the variables in wave motion and relate them mathematically to the speed of wave transmission.	Search for Data and their Meaning
Analyzing systems, Formulating models, Manipulating variables	*Differences and Similarities of Interactions, Force Fields*, Generalized Perceptions	132. demonstrate the relationship between vibrational amplitude of sound producers and the loudness of the sound and infer related behaviors in transmitting media.	*Search for Data and their Meaning*, Consideration of Premises
Manipulating variables, Interpreting data	Differences and Similarities of Interactions, Science and Technology Energy Exchange	133. distinguish between surfaces that are good sound reflectors and those are not and apply the collected data to the problem of acoustic design.	*Search for Data and their Meaning*, Consideration of Consequences
Formulating Hypotheses, Interpreting data	Force Fields, Differences and Similarities of Interactions, Generalized Perceptions	134. demonstrate sympathetic vibrations and construct an hypothesis to explain them.	*Questioning of All Things*, Respect for Logic

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Defining operationally	*Differences and Similarities of Interactions,* Interdependency of Nature	135. distinguish between music and noise in terms of wave patterns.	*Consideration of Consequences,* Respect for Order in Nature
Anaylzing systems, Translating	*Science and Technology* Differences and Similarities of Interactions, Force Fields	136. demonstrate that a resonance chamber alters the quality and volume of sound and relate these properties to the construction of musical instruments.	*Longing to Know and Understand,* Demonstrating Confidence and Satisfaction
Manipulating variables, Formulating Hypotheses	*Differences and Similarities of Interactions,* Generalized Perceptions	137. order various dissimilar vibration in terms of the sound they produce and infer a reason for that order.	Search for Data and their Meaning
Formulating Hypotheses, Experimenting	*Differences and Similarities of Interactions,* Generalized Perceptions	138. order an assortment of various similar vibrators in terms of pitch of the sound they produce and construct a testable hypothesis to explain the order.	*Search for Data and their Meaning, Respect for Logic, Demand for Verification*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
		Level One:	
Using space/ time relationships, Multiple Discriminating, Verbally associating	Space/Time Reference Frames	1. distinguish among north and south and east and west.	Demonstrating Confidence and Satisfaction
Using space/ time relationships, Simulating, Observing, Communicating	*Space/Time Reference Frames*, Differences and Similarities of Interactions	2. demonstrate how shadows are formed and how they can be changed.	*Longing to Know and understand*, Demonstrating Confidence and Satisfaction
Using space/ time relationships, Equating	*Space/Time Reference Frames*, Differences and Similarities of Objects	3. identify the shape of the earth.	Longing to Know and Understand.
Assimilating, Verbally associating	Space/Time Reference Frames	4. identify the earth as man's home.	Longing to Know and Understand
Assimilating	*Interdependency of Nature*, Science and Society	5. demonstrate concern for the environment by activities which reduce the litter in the community (as well as areas where he goes for recreational activities).	*Developing a Commitment to Aesthetics in Nature*, Demonstrating Confidence and Satisfaction
Classifying, Using space/ time relationships, Observing	*Energy Exchange*, Force Fields, Interdependency of Nature	6. identify the sun as a light source.	*Longing to Know and Understand*, Respect for Order in Nature
Categorically conceptualizing, Multiple Discriminating	Science and Technology, Science and Society	7. describe vicarious experiences related to space exploration.	Valuing Scientific Heritage
Observing Classifying	*Space/Time Reference Frames*, Constant Change	8. describe the differences between day and night.	*Longing to Know and Understand*, Consideration of Consequences
Using space/ time relationships, Communicating Simulating	*Space/Time Reference Frames, Constant Change, Differences and Similarities* of Interactions	9. demonstrate the cause of night and day.	*Respect for Order in Nature*, Search for Data and their Meaning
Using space/ time relationships, Sequencing, Observing	Space/Time Reference Frames, Constant Change, Differences and Similarities of Interactions	10. illustrate the approximate position of the sun at different times of the day.	*Respect for Order in Nature*, Search for Data and their Meaning
Communicating, Measuring	*Statistical Descriptions*, Constant Change, Science and Technology	11. observe, measure and record temperature.	Search for Data and their Meaning, Demonstrating Confidence and Satisfaction
Communicating, Sequencing	*Differences and Similarities of Objects, Constant Change*	12. observe and record changes in cloud cover.	*Longing to Know and Understand*, Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Communicating, Measuring, Using space/ time relationships	*Statistical Descriptions, Constant Change,* Science and Technology	13. observe, measure and record the moisture that falls from the clouds.	*Search for Data and their Meaning,* Demonstrating Confidence and Satisfaction
Communicating, Using space/ time relationships	*Constant Change,* Space/ Time Reference Frames, Science and Technology	14. observe and record changes in wind direction and velocity.	*Search for Data and their Meaning,* Demonstrating Confidence and Satisfaction
Recognizing variables, Communicating, Measuring, Sequencing	*Constant Change,* Statistical Descriptions, Science and Technology	15. observe, measure and record changes in weather over a period of time.	*Search for Data and their Meaning,* Longing to Know and Understand
Classifying, Observing, Sequencing	*Constant Change,* Differences and Similarities of Interactions	16. describe local seasonal changes.	*Respect for Order in Nature,* Search for Data and their Meaning
		Level Two:	
Using space/ time relationships, Observing	*Force Fields,* Differences and Similarities of Interactions	17. identify the effects of gravity on objects.	*Longing to Know and Understand,* Respect for Order in Nature
Simulating, Using space/ time relationships	*Space/Time Reference Frames*	18. describe the major features of the earth's surface.	*Longing to Know and Understand,* Valuing Scientific Heritage
Using space/ time relationships, Equating	Space/Time Reference Frames	19. locate on a globe or an appropriate map approximately where he lives.	Demonstrating Confidence and Satisfaction, Search for Data and their Meaning
Using space/ time relationships, Simulating	*Space/Time Reference Frames,* Constant Change	20. describe or demonstrate why the moon appears to change shape.	Search for Data and their Meaning
Using space/ time relationships, Simulating	*Space/Time Referance Frames,* Constant Change	21. demonstrate the movement of the earth with respect to rotation and revolution around the sun.	Search for Data and their Meaning
Classifying Assimilating	Differences and Similarities of Interactions	22. identify several different types of weather.	Search for Data and their Meaning
Classifying, Using space/ time relationships, Assimilating	*Fundamental Structures,* Space/Time Reference Frames, Interdependency of Nature	23. identify various types of climate.	Longing to Know and Understand
Assimilating, Equating, Classifying	Differences and Similarities of Objects	24. describe how fog and clouds are similar.	Longing to Know and Understand

Elem. — Ear & sp. 2

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Inferring, Sequencing, Using space/ time relationships	Force Fields, Constant Change, Interdependency of Nature	25, explain why we have rain and and describe the relationship between the clouds and rain.	*Respect for Order in Nature*, Search for Data and their Meaning.
Classifying, Ordering	*Differences and Similarities of Objects*, Fundamental Structures	26. identify soil and distinguish between various types of soil such as rocky, sandy, clay, etc.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Using space/ time relationships, Interpreting data, Sequencing, Assimilating	*Space/Time Reference Frames*, Constant Change	Level Three: 27. describe some effects of wind and water on soil.	*Consideration of Consequences*, Respect for Order in Nature
Sequencing, Observing, Using space/ time relationships	*Interdependency of Nature*, Force Fields, Constant Change	28. describe the effects of plants and animals on the development of soil.	*Longing to Know and Understand*, Respect for Order in Nature
Classifying, Observing, Using space/ time relationships	*Differences and Similarities of* Objects Space/ Time Reference Frames, Constant Change	29. identify some characteristics of fossils.	Longing to Know and Understand, Valuing Scientific Heritage
Ordering, Communicating, Using space/ time relationships	*Space/Time Reference Frames*, Differences and Similarities of Objects, Constant Change, Statistical Descriptions	30. construct a crude model of the solar system.	*Search for Data and their Meaning*, Respect for Order in Nature
Using space/ time relationships, *Communicating*, Interpreting data	*Space/Time Reference Frames*, Constant Change, Statistical Descriptions	31. demonstrate the movement of the moon with respect to the earth and the sun.	*Search for Data and their Meaning*, Respect for Order in Nature
Using space/ time relationships	Space/Time Reference Frames	32. explain why the stars look so small.	Consideration of Premises
Using space/time relationships, Classifying, Using Numbers	*Space/Time Reference Frames*, Science and Society	33. identify a few of the major constellations using a map of the sky.	*Respect for Order in Nature*, Valuing Scientific Heritage
Communicating, Using space/time relationships, Interpreting data	*Space/Time Reference Frames*, ,Constant Change	34. demonstrate how the earth's inclination determine the seasons.	*Longing to Know and Understand*, Respect for Order in Nature
Sequencing, Using space/time relationships, Inferring	*Space/Time Reference Frames*, Constant Change, Interdependency of Nature	35. describe how clouds and fog are formed and dissipated.	*Longing to Know and Understand*, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Communicating	*Science and Technology*, Science and Society	36. name several sources from which he could get information about the weather.	Consideration of Premises, Respect for Logic, Demonstrating Confidence and Satisfaction
Assimilating Classifying, Communicating	*Interdependency of Nature*, Science and Technology, Science and Society	37. list some ways man uses weather predictions to make decisions about his planned activities.	Respect for Order in Nature
Using space/time relationships, Measuring	*Space/Time Reference Frames*, Force Fields, Differences and Similarities of Objects	38. demonstrate the use of a compass to find directions.	Demonstrating Confidence and Satisfaction
		Level Four:	
Assimilating, Using space/time relationships, Ordering	*Fundamental Structures* Differences and Similarities of Objects, Space/Time Reference Frames	39. describe the relationship of our solar system to the universe.	*Longing to Know and Understand*, Consideration of Premises
Predicting, Assimilating	*Force Fields*, Differences and Similarities of Interactions	40. predict the deviation that a bullet or thrown ball will make from its line of flight and defend his prediction.	*Respect for Logic, Search for Data and their Meaning*
Testing, Inferring	Force Fields, *Differences and Similarities of Interactions*	41. demonstrate that a central force is required to keep an object moving in a circle.	*Demand for Verification*, Search for Data and their Meaning
Inferring, Simulating	*Force Fields*, Generalized Perceptions	42. describe why the moon and artificial satellites stay in orbit.	Questioning of All Things, Respect for Logic, Search for Data and their Meaning
Inferring, Simulating	*Force Fields*, Generalized Perceptions	43. describe why planets and certain other members of our solar system stay in their orbits.	*Questioning of All Things* Search for Data and their Meaning, Consideration of Premises
Analyzing systems, Interpreting data, Using space/time relationships, Recognizing variables	Space/Time Reference Frames	44. describe why the relative position of the stars seems to be constant on earth.	*Respect for Logic*, Search for Data and their Meaning
Using space/time relationships, Communicating	Space/Time Reference Frames	45. identify several of the major constellations using a star map.	Demonstrating Confidence and Satisfaction
		Level Five:	
Interpreting data, Classifying	Differences and Similarities of Objects	46. construct a classification key to identify a small group of common minerals.	Search for Data and their Meaning
Assimilating, Sequencing	*Constant Change, Differences and Similarities of Interactions*, Interdependency of Nature	47. name and identify the major causes of erosion.	*Search for Data and their Meaning*, Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Classifying	*Differences and Similarities of Objects,* Constant Change, Generalized Perceptions	48. name and identify various common sedimentary rocks.	Search for Data and their Meaning
Interpreting data, Inferring, Using space/time relationships	*Constant Change,* Matter Conservation, Generalized Perceptions	49. construct a simple description of the rock cycle.	*Respect for Order in Nature* Questioning of All Things
Classifying	*Differences and Similarities of Objects,* Constant Change, Generalized Perceptions	50. name typical igneous and metamorphic rocks.	Search for Data and their Meaning
Formulating Hypotheses, Interpreting data, Defining operationally	*Constant Change,* Generalized Perceptions	51. describe and demonstrate how various sedimentary rocks are formed.	*Search for Data and their Meaning,* Respect for Logic, Respect for Order in Nature
Interpreting data, Communicating	*Space/Time Reference Frames,* Action Forces	52. interpret the basic data recorded on a weather map.	Demonstrating Confidence and Satisfaction
Classifying, Using space/time relationships, Assimilating	*Fundamental Structures,* Interdependency of Nature, Space/Time Reference Frames	53. identify various zones found on the earth such as desert, swamps, etc.	Longing to Know and Understand, Respect for Order in Nature
Interpreting data	Constant Change, Differences and Similarities of Interactions	54. identify changes that are continually taking place on the earth's surface.	*Search for Data and their Meaning,* Respect for Order in Nature
Analyzing systems, Classifying	*Differences and Similarities of Objects, Constant Change*	55. distinguish between fossils that are imprints and those that are part of the actual organism.	Longing to Know and Understand
Interpreting data	*Space/Time Reference Frames,* Constant Change, Differences and Similarities of Objects	56. describe evidence of past continental glaciation and identify any local glacial features.	Search for Data and their Meaning
Classifying	*Differences and Similarities of Objects.* Constant change	57. identify similarities and differences in fossil specimens and group the specimens on the basis of similarities and differences that he selects.	Longing to Know and Understand
Analyzing systems	*Differences and Similarities of Objects,* Fundamental Structures	58. infer characteristics of the living plant or animal when given fossil specimens.	*Respect for Order in Nature,* Respect for Logic
Analyzing systems	*Interdependency of Nature,* Matter Conservation, Energy Exchange	Level Six: 59. describe how man is dependent upon the soil.	*Consideration of Consequences,* Respect for Order in Nature
Interpreting data, Inferring	*Constant Change,* Generalized Perceptions	60. infer some of the major events in the geological history of an area from a study of its topographic features and other data.	*Search for Data and their Meaning,* Questioning of All Things

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Generalizing, Inferring	Generalized Perceptions	61. describe how we are able to infer a partial history of the earth from the fossil record.	Search for data and their Meaning
Analyzing systems, Simulating	*Constant Change,* Matter Conservation, Generalized Perceptions	62. describe the water cycle in meteorologic terms.	*Search for Data and their Meaning,* Consideration of Consequences, Respect for Order in Nature
Analyzing systems, Abstracting	*Constant Change,* Interdependency of Nature, Generalized Perceptions	63. relate the movement of air masses to heat exchange.	*Search for Data and their Meaning,* Respect for Order in Nature
Anaylzing systems, Interpreting data	*Differences and Similarities of Interactions, Constant Change,* Force Fields, Interdependency of Nature	64. record changes in barometric pressure and identify some relationships between these changes and changes in weather patterns.	*Search for Data and their Meaning,* Respect for Logic, Respect for Order in Nature
Analyzing systems, Translating	*Force Fields, Constant Change,* Differences and Similarities of Interactions, Generalized Perceptions	65. identify some ways that gravity is the moving force in various natural phenomena (water movement, land movement, air movement).	*Respect for Logic,* Respect for Order in Nature
Analyzing systems, Translating	*Differences and Similarities of Interactions, Science and Technology*	66. discuss the similarities and differences of man living on the earth and living on a satellite orbiting the earth.	*Consideration of Consequences,* Respect for Logic
Interpreting data, Measuring	*Space/Time Reference Frames,* Statistical Descriptions	67. describe some indirect methods that have been used to determine the shape of the earth.	*Consideration of Premises,* Search for Data and their Meaning
Defining operationally, Assimilating, Using space/time relationships	*Space/Time Reference Frames,* Statistical Descriptions	68. discuss the concept light year and the reason for using this method of measurement in astronomy.	*Demonstrating Confidence and Satisfaction,* Longing to Know and Understand
Observing, Measuring	Science and Technology	69. name the instruments that a scientist might use in exploring the solar system and describe the basic use of each.	Longing to Know and Understand
Analyzing systems, Generalizing	*Differences and Similarities of Objects, Differences and Similiarities of Interactions,* Interdependency of Nature	70. describe the conditions necessary for life and discuss why life as we know it probably could not exist on other planets of our solar system.	*Consideration of Premises,* Questioning of All Things
Interpreting data	*Space/Time Reference Frames, Statistical Descriptions*	71. calculate and graph the time required for sunlight to reach the planets in the solar system.	Respect for Logic
Cognitively evaluating alternatives, Manipulating variables, Synthesizing	*Space/Time Reference Frames,* Statistical Descriptions	72. construct inferences concerning the present feasibility of interplanetary travel	*Questioning of All Things,* Respect for Logic

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Generalizing, Measuring	Space/Time Reference Frames, Statistical Descriptions	1. give examples of how each of the five senses can be used as instruments with which man can observe, measure and understand the universe.	Consideration of Premises, Valuing Scientific Heritage
Measuring, Communicating	Statistical Descriptions	2. identify the characteristics of a good measurement system including: units, reference to standard, and limitations of scale.	*Consideration of Premises,* Search for Data and their Meaning
Measuring, Communicating	Statistical Descriptions	3. zero an instrument of measurement and read a scale to the nearest appropriate unit.	*Consideration of Premises,* Search for Data and their Meaning
Measuring, Communicating	Statistical Descriptions	4. demonstrate skill in development of units of measurement and standards of measurements.	*Consideration of Premises,* Search for Data and their Meaning
Communicating, Manipulating variables, Recognizing variables	Generalized Perceptions, Science and Technology	5. demonstrate the ability to carry out an independent activity from printed or oral directions.	*Demonstrating Confidence and Satisfaction,* Demand for Verification, Questioning of All Things
Measuring, Communicating	Statistical Descriptions	6. demonstrate the ability to comprehend the meaning of questions and to respond appropriately.	*Demonstrating Confidence and Satisfaction,* Consideration of Premises, Search for Data and their Meaning
Measuring, Communicating	Statistical Descriptions	7. demonstrate skill in using a meter stick and metric units including the millimeter, centimeter, and meter in measurement of distance and in reporting the answer to an accuracy of ± 0.2 cm.	*Demonstrating Confidence and Satisfaction,* Consideration of Premises, Respect for Logic
Measuring, Communicating	Statistical Descriptions	8. demonstrate skill in using a pan balance to measure mass in units including the gram and kilogram and in reporting the answer to an accuracy of ± 0.5 grams.	*Demonstrating Confidence* and Satisfaction, Consideration of Premises, Respect for Logic
Measuring, Communicating	Statistical Descriptions	9. demonstrate skill in using a a thermometer by recording temperatures in correct units to an accuracy of ± 0.5 degrees.	*Demonstrating Confidence and Satisfaction,* Consideration of Premises, Respect for Logic
Chaining, Manipulating variables, Observing	Space/Time Reference Frames, Science and Technology	10. demonstrate the ability to properly use, handle, and care for microscope.	*Demonstrating Confidence and Satisfaction,* Longing to Know and Understand
Manipulating variables, Chaining, Observing	Space/Time Reference Frames, Science and Technology	11. mount a slide on the stage of a microscope and focus the scope using both low and high power objectives.	*Demonstrating Confidence and Satisfaction,* Longing to Know and Understand

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Manipulating variables. Chaining, Observing	Space/Time Reference Frames, Science and Technology	12. adjust the lighting and magnification of a microscope for appropriate study of the material.	*Demonstrating Confidence and Satisfaction*, Longing to Know and Understand
Recognizing variables, Communicating	*Statistical Descriptions*, Space/Time Reference Frames	13. demonstrate the ability to properly identify information and construct a data table.	*Search for Data and their Meaning*, Consideration of Premises, Demonstrating Confidence and Satisfaction
Interpreting data, Communicating	*Statistical Descriptions*, Generalized Perceptions	14. demonstrate the ability to interpret information from a data table.	*Search for Data and their Meaning*, Consideration of Premises, Demonstrating Confidence and Satisfaction
Communicating, Recognizing variables	*Statistical Descriptions*, Space/Time Reference Frames	15. demonstrate the ability to record information by by constructing a graph using data containing two variables.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction, Consideration of Premises
Interpreting data, Communicating	*Statistical Descriptions*, Generalized Perceptions	16. demonstrate the ability to interpret information presented to him in a graphic form.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction, Consideration of Premises
Analyzing systems, Testing	*Fundamental Structures*, Interdependency of Nature	17. demonstrate a method for analysis of a system by identifying sources of the problem and describe a method to test for each problem identified, e.g. a light bulb that will not glow.	*Demonstrating Confidence and Satisfaction*, Respect for Logic
Recognizing variables, Generalizing, Defining operationally, Communicating	*Constant Change*, Generalized Perceptions	18. state a definition of "variable" which includes the concept of change.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Analyzing systems, Generalizing, Defining operationally, Communicating	*Fundamental Structures*, Interdependency of Nature	19. state a definition of "control" being certain to include the concept of experimental design.	*Consideration of Premises*, Valuing Scientific Heritage, Respect for Logic
Generalizing, Defining operationally, Communicating	*Generalized Perceptions* Differences and Similarities of Objects, Differences and Similarities of Interactions	20. state a definition of hypothesis being certain that the response indicates a tentative answer to a question that can be tested by experimentation.	Valuing Scientific Heritage, Demonstrating Confidence and Satisfaction
Experimenting, Formulating Hypotheses, Analyzing systems	Generalized Perceptions	21. demonstrate the ability to design and carry out a simple experiment.	*Respect for Logic*, Demonstrating Confidence and Satisfaction, Valuing Scientific Heritage

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Formulating models, Translating	Generalized Perceptions	22. demonstrate a skill by building a model based on observable characteristics and use the model to predict future observations.	*Search for Data and their Meaning*, Consideration of Premises, Demonstrating Confidence and Satisfaction
Generalizing, Interpreting data	Differences and Similarities of Interactions	23. state the procedures to when chemicals are spilled in the laboratory.	Consideration of Consequences
Generalizing, Interpreting data	Differences and Similarities of Interactions	24. state the procedures to follow when an accidental fire breaks out in the laboratory.	Consideration of Consequences
Translating, Interpreting data, Communicating	*Science and Society*, Science and Technology	25. select and order items (pictures, news releases, advertisements, etc.) from the news media to illustrate the effect of science and technology on a selected area of his life.	*Valuing Scientifc Heritage*, Consideration of Consequences
Analyzing systems, Interpreting data, Communicating, Affective and Social Evaluating	*Science and Society*, Science and Technology	26. analyze a current article from popular periodic literature (newspaper, or popular magazine) as to it's probable scientific creditability and predict some of the possible effects of the phenomena reported on contemporary life.	*Respect for Logic*, Consideration of Premises, Consideration of Consequences
Communicating, Translating	*Science and Technology*, Generalized Perceptions	27. identify periodicals which he could read to keep abreast of of important and significant scientific and technological advances.	*Longing to Know and Understand*, Valuing Scientific Heritage, Search for Data and their Meaning
Character Building, Affective and Social Evaluating	*Generalized Perceptions*, Science and Technology, Differences and Similarities of Interactions	28. peruse scientific (not highly technical) literature in his leisure time reading.	*Longing to Know and Understand*, Valuing Scientific Heritage, Demand for Verification, Respect for Logic, Consideration of Premises
Communicating, Translating	Science and Technology, Generalized Perceptions	29. identify reference works which he can use to investigate scientific and technological topics.	Longing to Know and Understand, Valuing Scientific Heritage, Search for Data and their Meaning
Analyzing systems, Interpreting data, Affective and Social Evaluating	*Science and Society*, Science and Technology	30. analyze a book on a scientific or technical subject as to important ideas presented and their relationship to society.	*Respect for Logic*, Consideration of Premises, Consideration of Consequences

3.32-L Jr. Hi./Mid. Sch. Objectives – Area: Living Things

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Defining operationally	*Fundamental Structures,* Interdependency of Nature	1. order the components of an organism ranging from cells to systems in terms of complexity.	*Respect for Order in Nature* Longing to Know and Understand, Search for Data and their Meaning
Defining operationally, Formulating Hypotheses, Classifying	*Differences and Similarities of Objects*	2. identify from an assortment of items those that are living and defend his classification.	*Longing to Know and Understand,* Respect for Order in Nature
Defining operationally, Formulating Hypotheses, Classifying	*Differences and Similarities of Objects*	3. from an assortment of macroorganisms select those that are plants and those that are animals and defend his classification.	*Longing to Know and Understand* Respect for Order in Nature
Recognizing variables, Generalizing, Classifying	*Differences and Similarities of Objects* Generalized Perceptions	4. make a comparison of plant and animal cells.	*Search for Data and their Meaning,* Respect for Order in Nature
Analyzing systems, Generalizing	Constant Change	5. list the essential life activities that are carried on by every living cell.	*Search for Data and their Meaning,* Respect for Order in Nature.
Using space/time relationships, Observing	*Constant Change,* Differences and Similarities of Objects	6. give a brief explanation of what transpires in the nuclear material of a cell during cell division.	Longing to Know and Understand, Respect for Order in Nature
Predicting		7. predict from observations the typical growth pattern for humans and other organisms.	Respect for Order in Nature
Analyzing systems	*Differences and Similarities of Interactions*	8. name the three common methods by which plants may secure food and identify plants which employ each of these methods.	Longing to Know and Understand, Consideration of Consequences, Respect for Order in Nature
Synthesizing, Analyzing systems, Formulating models	*Interdependency of Nature,* Science and Technology	9. discuss or write a paper on how plants and animals depend upon each other.	Developing a Commitment to Aesthetics in Nature
Defining operationally	*Interdependency of Nature,* Science and Technology, Force Fields	10. define "weed" and explain how weeds can be undesirable.	Consideration of Consequences
Proposing answers, Cognitively evaluating alternatives, Affective and Social Evaluating	*Interdependency of Nature,* Science and Technology, Science and Society, Force Fields	11. identify means of weed control other than chemicals	Developing a Commitment to Aesthetics in Nature, Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Formulating models, Translating	*Interdependency of Nature* Science and Technology	12. construct demonstrations or models of various methods that may be used to conserve top soil and explain under what conditions each might be used.	*Developing a Commitment to Aesthetics in Nature*, Valuing Scientific Heritage
Analyzing systems, Synthesizing, Communicating	*Interdependency of Nature*, Science and Technology, Force Fields	13. list the chief enemies, natural and man-made, of plants and describe methods that might control these enemies.	*Consideration of Consequences*, Developing a Commitment to Aesthetics in Nature
Recognizing variables	*Constant Change*, Statistical Descriptions, Science and Technology	14. explain how stronger muscles may be developed and cite examples to illustrate.	*Consideration of Consequences*, Demand for Verification
Formulating Hypotheses	Force Fields, *Interdependency of Nature*, Science and Technology, Science and Society	15. produce a list of factors that would influence the development of his physical, mental, emotional, social and moral resources.	Longing to Know and Understand
Classifying, Recognizing variables	Differences and Similarities of Objects	16. classify an assortment of plants and/or animals, preserved specimens of plants and/or animals, or pictures of plants and/or animals into two or more categories and defend his classification system.	*Respect for Order in Nature*, Search for Data and their Meaning
Classifying, Manipulating variables	Differences and Similarities of Objects, Generalized Perceptions	17. order as to the complexity of the organism an assortment of plants and/or animals, preserved specimens of plants and/or animals or pictures of plants and/or animals, which have been classified into two or more categories.	*Search for Data and their Meaning*, Respect for Order in Nature, Longing to Know and Understand
Classifying, Defining operationally	*Differences and Similarities of Objects*, Generalized Perceptions	18. identify from an assortment of specimens, living or preserved, or pictures, those that would fit each of the following: Spermatophyte, gymnosperm, monocot, dicot, pteridophyte, bryophyte, and thallophyte.	Respect for Logic, Valuing Scientific Heritage
Formulating models, Translating Communicating	*Matter Conservation*, Energy Forms, *Interdependency of Nature*, Generalized Perceptions	19. draw a diagram showing the nitrogen cycle and be able to explain various steps of it.	*Developing a Commitment to Aesthetics in Nature*, Respect for Order in Nature, Search for Data and their Meaning, Consideration of Consequences
Formulating models, Experimenting, Synthesizing, Communicating	*Matter Conservation*, Energy Forms, Inter dependency of Nature, Generalized Perceptions	20. construct a terrarium and use it to explain the carbon and water cycles.	*Developing a Commitment to Aesthetics in Nature*, Respect for Order in Nature, Search for Data and their Meaning, Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Analyzing systems, Cognitively evaluating alternatives, Affective and Social Evaluating	*Interdependency of Nature* Science and Technology, Science and Society Constant Change	21. cite examples of how man has affected nature and predict some consequence if he continues on his present course.	*Consideration of Consequences*, Developing a Commitment to Aesthetics in Nature
Manipulating variables, Generalizing, Communicating	Science and Technology	22. write a paper explaining how man cares for and improves the plants and animals which are necessary for his existence.	*Consideration of Premises*, Valuing Scientific Heritage, Consideration of Consequences
Formulating models, Formulating Hypotheses, Translating, Communicating	*Interdependency of Nature*, Science and Technology	23. identify and illustrate how fish and other wildlife provide valuable resources and beneficial acts.	*Developing a Commitment to Aesthetics in Nature*, Consideration of Premises, Consideration of Consequences
Defining operationally, Generalizing, Classifying, Communicating	*Differences and Similarities of Interactions*, Generalized Perceptions	24. demonstrate various ways by which plants may reproduce such as seeds, spores, cuttings, etc.	*Search for Data and their Meaning*, Respect for Order in Nature
Formulating models	Statistical Descriptions, Differences and Similarities of Interactions, *Generalized Perceptions*	25. construct a model to demonstrate how traits are passed from parent to offspring.	Respect for Order in Nature, Search for Data and their Meaning
Analyzing systems, Generalizing, Using space/time relationships, Communicating	*Space/Time Reference Frames*, Constant Change	26. draw a diagram illustrating alternation of generations in higher plants.	*Respect for Order in Nature*, Search for Data and their Meaning
Defining operationally, Communicating, Cognitively evaluating alternatives	*Differences and Similarities of Objects*, Space/Time Reference Frames	27. discuss various means of asexual reproduction and how asexual reproduction is of value to man and the organism.	*Search for Data and their Meaning*, Consideration of Consequences
Communicating, Classifying	*Constant Change*, Differences and Similarities of Objects, Generalized Perceptions	28. draw, or by other means produce a visual illustration that will show the life cycle of various animals such as: a fish, a frog, a robin, a rabbit, etc.	*Respect for Order in Nature*, Search for Data and their Meaning, Valuing Scientific Heritage
Defining Operationally, Interpreting data Communicating	Interdependency of Nature, *Generalized Perceptions*, Differences and Similarities of Interactions	29. write a paper or discuss the different forms of pollination.	Respect for Order in Nature, Search for Data and their Meaning
Classifying	Differences and Similarities of Objects, Constant Change	30. list the plants that are in his yard or the school ground and identify them as to annual, biennial, or perennial.	Longing to Know and Understand, Search for Data and their Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Recognizing variables, Interpreting data	*Differences and Similarities of Interactions*, Differences and Similarities of Objects, Generalized Perceptions	31. label on a map some of the major biomes of the world.	*Developing a Commitment to Aesthetics in Nature*, Longing to Know and Understand, Search for Data and their Meaning
Analyzing systems	Interdependency of Nature, Space/Time Reference Frames	32. report on the plant and animal life of a selected biome.	Developing a Commitment to Aesthetics in Nature
Experimenting, Formulating Hypotheses, Manipulating Variables	*Force Fields*, Constant Change, Statistical Descriptions, Action Forces	33. develop an experiment that will show how a plant may adapt to environmental changes such as change in direction of light source, change in position, gravity, etc.	*Longing to Know and Understand*, Search for Data and their Meaning, Consideration of Premises
Proposing Answers, Cognitively Evaluating Alternatives	*Interdependency of Nature*	34. predict the adaptation that a hypothetical animal (given characteristics) will make in a hypothetical biome (given characteristics) and defend his predictions.	*Respect for Logic*, Developing A Commitment to Aesthetics in Nature
Proposing Answers, Cognitively Evaluating Alternatives	*Interdependency of Nature*, Constant Change, Force Fields	35. predict how various plants and animals might react under given conditions and defend his predictions	*Developing a Commitment to Aesthetics in Nature*, Respect for Logic, Consideration of Premises, Consideration of Consequences

3.32 – M & E Jr. Hi./Mid. Sch. Objectives – Matter and Energy

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Communicating, Generalizing	*Differences and Similarities of Objects*, Space/Time Reference Frames, Force Fields	1. illustrate the basic properties of all matter (mass and space occupancy).	Demand for Verification, Demonstrating Confidence and Satisfaction
Communicating, Generalizing, Defining operationally	Differences and Similarities of Objects	2. define element, compound and mixture, and state properties that distinguish them from one another.	*Consideration of Premises*
Formulating models, Translating, Cognitively evaluating alternatives	*Fundamental Structures*, Differences and Similarities of Objects, Generalized Perceptions	3. construct and defend a model of matter which will explain specified properties and interactions of matter.	*Search for Data and their Meaning*, Consideration of Premises
Formulating models, Translating, Cognitively evaluating alternatives	Generalized Perceptions, Differences and Similarities of Objects, Fundamental Structures	4. modify an established model of matter to incorporate new phenomena.	*Questioning of All Things*, Search for Data and Their Meaning, Consideration of Premises
Formulating models	*Force Fields*, Space/Time Reference Frames, Differences and Similarities of Objects, Fundamental Structures, Statistical Descriptions	5. construct a model of matter that explains particle formation, particle combination in definite ratio, particle cohesiveness and particle movement.	*Search for Data and their Meaning*, Consideration of Premises
Classifying	*Differences and Similarities of Objects*, Space/Time Reference Frames	6. identify the natural elements and those that are man-made when given a periodic table.	*Respect for Logic*, Search for Data and their Meaning, Respect for Order in Nature
Interpreting data, Recognizing variables	*Differences and Similarities of Objects*, Differences and Similarities of Interactions	7. compare and contrast properties of various elements.	*Search for Data and their Meaning*, Consideration of Premises, Respect for Order in Nature
Testing, Communicating	Differences and Similarities of Objects	8. demonstrate the use of spectroscopy or a flame test to identify specific elements.	*Search for Data and their Meaning*
Classifying, Interpreting data, Communicating	Differences and Similarities of Objects	9. use a periodic table and show how to find atomic weight, atomic number, common combining numbers and distinguish between metals and nonmetals.	*Respect for Order in Nature*
Categorically conceptualizing	Fundamental Structures	10. name the three fundamental particles in an atom.	*Respect for Order in Nature*
Classifying, Observing, Interpreting data Defining operationally	*Differences and Similarities of Objects*	11. distinguish between the physical and chemical properties of a given substance.	Search for Data and their Meaning, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Formulating models	Generalized Perceptions, Statistical Descriptions Energy Forms	12. construct a model of matter that explains simple chemical reactions and electrolysis.	*Search for Data and their Meaning*, Questioning of All Things, Consideration of Premises
Categorically conceptualizing	Differences and Similarities of Objects	13. name the result of an atom gaining or losing electrons.	*Demonstrating Confidence and Satisfaction*
Categorically conceptualizing	Differences and Similarities of Objects	14. give the name of the same element having different numbers of neutrons.	*Demonstrating Confidence and Satisfaction*
Generalizing, Formulating Hypotheses, Analyzing systems	Matter Conservation, Energy Conservation, Matter/Energy Conservation	15. state the Laws of Conservation of Matter and Energy and identify some of the exceptions that are known today.	*Valuing Scientific Heritage*, Respect for Order in Nature, Search for Data and their Meaning
Communicating	Matter Conservation	16. write an abbreviated statement of the reaction either in words or symbols if given a simple chemical reaction.	*Demonstrating Confidence and Satisfaction*
Experimenting, Formulating Hypotheses, Manipulating variables, Defining operationally	*Action Forces*, Energy Forms, Interdependency of Nature	17. design and perform an experiment to demonstrate that energy is necessary to bring about physical and chemical changes.	Demand for Verification, Demonstrating Confidence and Satisfaction
Experimenting, Formulating Hypotheses, Defining operationally	*Differences and Similarities of Interactions*, Matter Conservation	18. design and perform an experiment to illustrate that substances lose individual identity in chemical change.	*Longing to Know and Understand*, Demand for Verification
Defining operationally, Communicating	*Differences and Similarities of Objects*, Force Fields, Constant Change, Science and Technology	19. write a paper concerning the phenomena of natural radioactivity and include some of its possible applications.	*Consideration of Consequences*, Questioning of All Things, Search for Data and their meaning, Demonstrating Confidence and Satisfaction
Defining operationally, Communicating	*Differences and Similarities of Objects*. Force Fields, Constant Change, Science and Technology	20. write a paper or discuss several potential uses of atomic energy.	*Consideration of Consequences*, Questioning of All Things, Search for Data and their Meaning
Formulating Hypotheses, Analyzing systems	*Energy Forms*, Matter/Energy Conservation	21. set up a demonstration which will show that combustion is a source of heat energy which can be transferred through radiation, convection and conduction.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Formulating models, Translating, Cognitively evaluatiing alternatives	*Energy Forms*, Generalized Perceptions	22. construct a model for heat that explains heat transfer and expansion.	*Search for Data and their Meaning*, Consideration of Premises

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Abstracting, Formulating Hypotheses, Experimenting Synthesizing	*Energy Forms,* Action *Forces, Interdependency* of Nature	23. design and perform experiments which show that energy transfer and/or transformation are an integral part of any chemical reaction.	*Demand for Verification,* Consideration of Premises
Analyzing systems, Defining operationally, Formulating Hypotheses	*Energy Forms,* Differences and Similarities of Interactions	24. set up a demonstration that will show that various forms of energy can be released through oxidation.	Demand for Verification
Defining operationally, Communicating	*Science and Technology*	25. write a paper or discuss synthetic materials that man is now capable of making and is using in his everyday living.	*Consideration of Premises*
Formulating models, Communicating	*Energy Forms,* Interdependency of Nature, Science and Technology	26. construct a chart indicating the nutrients needed by man and indicate the function of each.	*Consideration of Premises,* Search for Data and their Meaning, Respect for Order in Nature
Analyzing systems	*Energy Forms,* Matter Conservation, Matter/ Energy Conservation, Science and Technology	27. identify major organs of the human body that are involved in converting food to energy and state the function of each	Respect for Order in Nature, Longing to Know and Understand
Analyzing systems, Abstracting	*Science and Technology,* Constant Change, Energy Forms	28. explain why rest is needed and and what takes place while the body is at rest.	*Respect for Order in Nature,* Consideration of Consequences
Interpreting data, Defining operationally, Recognizing variables	*Space/Time Reference Frames,* Statistical Descriptions	29. interpret collected data concerning an object moving with nonuniform speed to develop an operational definition of acceleration.	Search for Data and their Meaning
Analyzing systems, Interpreting data, Formulating statistical models	*Action Forces,* Statistical Descriptions, Generalized Perceptions	30. identify from observations and collected data those variables which influence the acceleration of an object and state identified relationships in mathematical ratios.	*Search for Data and their Meaning,* Consideration of Premises, Valuing Scientific Heritage
Defining operationally, Generalizing, Interpreting data, Recognizing variables	Space/Time Reference Frames, *Force Fields,* Differences and Similarities of Interactions, Generalized Perceptions	31. define momentum in operational terms and identify it as one of the important qualities of motion to consider in collisions and explosions.	*Search for Data and their Meaning,* Consideration of Premises, Respect for Order in Nature
Synthesizing, Manipulating variables, Interpreting data	*Space/time Reference Frames,* Differences and Similarities of Interactions, Statistical Descriptions	32. formulate a rule describing momentum relationships involved in simple collisions and explosions after observing several such events.	*Search for Data and their Meaning,* Respect for Logic Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Classifying, Defining operationally	*Differences and Similarities of Interactions,* Energy Forms, Generalized Perceptions	33. explain the difference between kinetic and potential energy and give several examples of each.	Respect for Order in Nature
Defining operationally	*Differences and Similarities of Interactions,* Action Forces	34. identify when work has been done given various situations.	*Search for Data and their Meaning,* Consideration of Premises, Demonstrating Confidence and Satisfaction
Manipulating variables, Defining operationally	*Energy Exchange,* Science and Technology, Energy Conservation	35. perform a demonstration showing how simple machines are used to produce a mechanical advantage.	Developing a Commitment to Aesthetics in Nature, Respect for Order in Nature, Consideration of Premises
Synthesizing, Manipulating variables, Defining operationally, Formulating statistical models	*Energy Exchange,* Generalized Perceptions, Statistical Descriptions, Space/Time Reference Frames	36. describe the mathematical nature of the relationship between kinetic energy and velocity from the operational definition of work and the force-acceleration relationship.	*Respect for Logic,* Valuing Scientific Heritage
Analyzing systems, Cognitively evaluating alternatives, Affective and Social Evaluating	*Science and Technology,* Differences and Similarities of Interactions, Space/Time Reference Frames	37. apply the principles of conservation of momentum and energy to describe various events that occur in an automobile collision and relate these to various safety features being built into modern automobiles.	*Consideration of Consequences,* Respect for Logic
Analyzing systems, Defining operationally	*Differences and Similarities of Interactions*	38. analyze various situations and explain which type of resistance must be overcome to do work in each situation.	*Search for Data and their Meaning*
Classifying, Simulating	Energy Forms	39. list various forms of energy and give an example of work done by each.	Demonstrating Confidence and Satisfaction
Formulating Hypotheses, Experimenting, Synthesizing	*Force Fields,* Differences and Similarities of Interactions	40. design and perform an experiment that will show relationship between electricity and magnetism.	*Search for Data and their Meaning,* Demand for Verification
Formulating models, Interpreting data	*Differences and Similarities of Interactions,* Force Fields, Generalized Perceptions	41. construct a model for sound to explain its propagation, reflection, beats sympathetic vibrations, etc.	*Search for Data and their Meaning,* Respect for Order in Nature, Consideration of Premises

Processes	Conceptual Schemes	OBJECTIVES: Dependent on ability and past experience, the student will:	Values and Attitudes
Translating	*Differences and Similarities of Interactions*, Force Fields, Generalized Perceptions	42. use his model for sound to explain other behaviors of sound such as: sound deadening, the Doppler effect, overtones, etc.	*Questioning of All Things*, Respect for Logic
Interpreting data, Defining operationally, Formulating Hypotheses	*Statistical Descriptions*, Science and Technology, Science and Society	43. state the rules relating the music scale to frequency ratios and apply these rules to explain chording, harmony, rhythm, and other principals of musical scoring.	*Respect for Order in Nature*, Demonstrating Confidence and Satisfaction, Longing to Know and Understand
Analyzing systems, Defining operationally, Using space/time relationships	*Force Fields*, Differences and Similarities of Interactions, Generalized Perceptions	44. design a demonstration to illustrate the various interactions of light with matter such as transparencies, translucencies, refractions and reflections.	Search for Data and their Meaning
Simulating, Communicating	Space/Time Reference Frames	45. use ray diagrams to describe the interactions of light with matter.	Demonstrating Confidence and Satisfaction
Formulating models, Cognitively evaluating alternatives	*Differences and Similarities of Interactions*, Force Fields, Generalized Perceptions	46. construct a model for light that explains some of its interactions with matter.	*Search for Data and their Meaning*, Respect for Order in Nature, Consideration of Premises
Experimenting, Translating	*Differences and Similarities of Interactions*, Force Fields, Generalized Perceptions	47. use his model of light to predict its interaction with an untested matter form or configuration and design and perform an experiment to test these predictions.	*Demand for Verification*, Questioning of All Things
Generalizing, Classifying	*Force Fields*, Science and Technology, Energy Forms	48. name the source of all forms of energy except nuclear energy and list those forms that come directly from the source and those forms which come indirectly from the source.	*Respect for Order in Nature*, Developing a Commitment to Aesthetics in Nature
Formulating Hypotheses, Cognitively evaluating alternatives	Energy Forms	49. design an experiment illustrating how energy is transformed from one form to another.	*Consideration of Premises*, Consideration of Consequences
Analyzing systems, Synthesizing	*Matter/Energy Conservation*, Science and Technology	50. describe and illustrate methods that man can use to conserve heat energy.	*Consideration of Consequences*, Consideration of Premises, Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Interpreting data, Inferring	*Differences and Similarities of Objects*, Generalized Perceptions	1. describe the type and origin of the bedrock in his own locale, in his State and in the world.	*Search for Data and their Meaning*, Valuing Scientific Heritage, Demonstrating Confidence and Satisfaction
Analyzing systems, Communicating	*Constant Change*, Generalized Perceptions, Statistical Descriptions	2. cite evidence for the generally accepted appropriate age of various bedrock.	*Search for Data and their Meaning*, Questioning of All Things, Valuing Scientific Heritage
Interpreting data, Communicating	*Constant Change*, Statistical Descriptions	3. construct a model to explain why rocks of different ages are exposed in Indiana and surrounding states.	*Search for Data and their Meaning*, Valuing Scientific Heritage, Respect for Order in Nature
Interpreting data	Space/Time Reference Frames, Science and Technology	4. identify and locate on a map some rock and mineral deposits of interest to man.	Search for Data and their Meaning
Classifying, *Generalizing*	*Interdependency of Nature*, Differences and Similarities of Objects, Space/Time Reference Frames	5. correlate geological history of a region with diagrams and/or observations of geological formations.	*Search for Data and their Meaning*, Respect for Order in Nature
Classifying	Differences and Similarities of Objects	6. identify common types of fossils found in Indiana and in the locale.	Longing to know and Understand
Interpreting data, Generalizing, Simulating	*Constant Change*, Difference and Similarities of Objects	7. write a paper or construct a model to indicate the effect of glaciation on the topography of Indiana and adjacent states.	Search for Data and their Meaning, Respect for Logic
Defining operationally, Interpreting data	Generalized Perceptions, Force Fields	8. define "lithosphere" and cite evidence indicating that it is stratified.	Search for Data and their Meaning
Recognizing variables, Defining operationally	*Differences and Similarities of Objects*, Force Fields, Generalized Perceptions	9. name and characterize the layers of the atmosphere.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Interpreting data, Analyzing systems, Communicating	Generalized Perceptions	10. describe and/or illustrate formations such as shelves and mountain ranges either in an ocean or lake floor.	Search for Data and their Meaning
Analyzing systems	*Constant Change*, Action Forces	11. identify the natural phenomena that bring about major earth changes.	*Search for Data and their Meaning*, Respect for Logic
Experimenting, Synthesizing	Constant Change	12. from observations of simple experiments, identify and briefly explain mechanisms by which minerals are changed in the formation of soil.	*Developing A Commitment to Aesthetics in Nature*,
Classifying	Differences and Similarities of Objects	13. list the components of the solar system in addition to the planets.	Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Interferring	*Space/Time Reference Frames*, Generalized Perceptions, Science and Society	14. give a possible explanation of origin of the solar system.	Demonstrating Confidence and Satisfaction Longing to Know and Understand
Communicating, Assimilating	*Generalized Perceptions*, Science and Society	15. list three persons who have made major contributions to astronomy and give a brief description of their work.	Valuing Scientific Heritage
Formulating models, Experimenting, Synthesizing, Communicating	*Matter Conservation*, Energy Forms, Interdependency of Nature, Generalized Perceptions	16. set up a demonstration of and explain the water cycle.	Developing a Commitment to Aesthetics in Nature, Respect for Order in Nature, Search for Data and their Meaning, Consideration of Consequences
Recognizing problems, Proposing answers, Cognitively evaluating alternatives	Science and Technology, Interdependency of Nature, Constant Change	17. discuss some of the things that he can do to help control pollution of the soil, air and water in his community.	*Consideration of Consequences*, Developing a Commitment to Aesthetics in Nature
Recognizing problems, Proposing answers, Cognitievely evaluating alternatives	*Science and Technology*, Interdependency of Nature, Constant Change	18. identify misuses of land areas within his school district and suggest possible corrective steps.	*Consideration of Consequences*, Developing a Commitment to Aesthetics in Nature
Interpreting data	Matter Conservation	19. make lists of natural materials that are renewable and nonrenewable.	Consideration of Premises, Consideration of Consequences
Analyzing systems, Formulating Hypotheses	Interdependency of Nature	20. identify some of the adaptations man must make when he leaves the earth and enters space.	Consideration of Premises, Consideration of Consequences
Analyzing systems, Formulating Hypotheses	Interdependency of Nature	21. identify some of the adaptations man must make when he leaves land and enters the hydrosphere.	Consideration of Premises, Consideration of Consequences
Simulating, Defining operationally	Generalized Perceptions	22. construct a model microclimate.	Demonstrating Confidence and Satisfaction
Measuring, Communicating	Statistical Descriptions	23. demonstrate proficiency in use of various weather instruments such as thermometer, barometer, hydrometer, rain gauge, wind vane.	Demonstration Confidence and Satisfaction
Interpreting data, Generalizing	*Statistical Descriptions*, Constant Change, Force Fields	24. make a list of the various instruments that are used to produce long range weather forecasts and explain what information is gained from the use of each instrument.	Search for Data and their Meaning, Consideration of Premises

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Analyzing systems, Translating	*Interdependency of Nature*, Science and Technology	25. discuss or write a paper on the part climate plays in determining the life pattern of living things in a given area.	*Consideration of Premises*, Developing A Commitment to Aesthetics in Nature, Consideration of Consequences
Recognizing Problems, Cognitively Evaluating Alternatives	*Science and Technology*, Interdependency of Nature	26. infer some effects various weather and climatic conditions may have on man's physical and emotional behavior.	Consideration of Premises, *Consideration of Consequences*, Respect for Order in Nature
Defining operationally, Equating, Recognizing variables	Differences and Similarities of Objects, Space/Time Reference Frames	27. compare our sun to other stars.	Respect for Order in Nature, Search for Data and their Meaning
Assimilating	Space/Time Reference Frames, Differences and Similarities of Objects, Statistical Descriptions	28. list the outstanding characteristics of each of the planets in our solar system.	*Demonstrating Confidence and Satisfaction*, Valuing Scientific Heritage
Translating, Interpreting data, Generalizing	*Force Fields*, Generalized Perceptions	29. discuss the basic ideas of Newton's Laws of Motion and Gravitation and demonstrate how they affect him.	*Valuing Scientific Heritage*, Respect for Order in Nature
Synthesizing	Interdependency of Nature	30. give examples of how man is dependent upon soil, directly or indirectly, for his food, clothing and shelter.	Respect for Order in Nature
Proposing answers, Interpreting data, Cognitively evaluating alternatives, Affective and Social Evaluating	Science and Technology	31. look at pictures of various landscapes and prescribe possible uses for the land from the data available in the pictures.	*Developing a Commitment to Aesthetics in Nature*, Consideration of Consequences, Consideration of Premises
Analyzing systems, Formulating Hypotheses, Experimenting	Differences and similarities of Interactions, Matter Conservation	32. construct a demonstration showing possible methods that would help to control the runoff of a given watershed.	*Consideration of Premises*, Demonstrating Confidence and Satisfaction
Analyzing systems, Affective and Social Evaluating, Interpreting data	Science and Technology, Science and Society	33. discuss his need for state parks, national parks, forests, water areas, historical sites, camping areas, nature sanctuaries and arboretums; and tell where each of these can be found in or near his community.	Developing a Commitment to Aesthetics in Nature
Analyzing systems	Matter/Energy Conservation	34. discuss the conditions that must be met to place an object into orbit.	Search for Data and their Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Formulating models	*Energy Forms*, Matter/ Energy Conservation	35. explain how radiation is produced by the sun.	Search for Data and their Meaning
Categorically Conceptualizing, Communicating	Differences and Similarities of Objects	36. name and differentiate the basic types of optical telescopes and cite the location of an example of each.	Longing to Know and Understand, Demonstrating Confidence and Satisfaction, Valuing Scientific Heritage
Analyzing systems, Generalizing	Differences and Similarities of Objects	37. discuss how and why an astronomer uses a radio telescope, radar and lasers.	Valuing Scientific Heritage
Communicating, Measuring	*Constant Change, Differences and Similarities of Objects*	38. use a simple spectroscope and/or a camera to record and report celestial phenomena.	Longing to Know and Understand
Communicating, Assimilating	Generalized Perceptions, Science and Society	39. identify some major contributions to our present understanding of the solar system and discuss briefly their contribution.	Valuing Scientific Heritage

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Using Numbers	*Statistical Descriptions*	1. add, subtract, multiply and divide (in base 10) numbers up to three digits.	Demonstrating Confidence and Satisfaction, Respect for Logic
Inferring, Using Numbers	*Statistical Descriptions*	2. estimate the result of calculations performed on appropriate measurements.	Demonstrating Confidence and Satisfaction, Respect for Logic
Communicating	*Statistical Descriptions,* Generalized Perceptions	3. translate a word description of a mathematical relationship into a mathematical sentence.	*Demonstrating Confidence and Satisfaction,* Respect for Logic
Communicating	*Statistical Descriptions,* Generalized Perceptions	4. translate a mathematical equation into words.	Demonstrating Confidence and Satisfaction, Respect for Logic
Simulating, Using Numbers	*Statistical Descriptions*	5. calculate with a slide rule, correctly placing the decimal point in the answer, arithmetic problems such as: (a) multiplying whole and decimal numbers, (b) dividing whole and decimal numbers, (c) doing a series of such multiplications and divisions (in any order) and (d) finding the square and square root of any number.	*Demonstrating Confidence and Satisfaction*
Measuring, Using *space/time relationships, Classifying,* Categorically conceptualizing	*Statistical Descriptions*	6. state whether a given metric measurement is a measurement of mass, volume, or length.	*Consideration of Premises, Demonstrating Confidence and Satisfaction*
Analyzing systems, Measuring	*Statistical Descriptions,* Generalized Perceptions	7. measure and record all the dimensions of a solid using the appropriate metric scale indicating the uncertainty of the measurement.	*Consideration of Consequences, Questioning Of All Things,* Search for Data and their Meaning
Interpreting data, Measuring	*Statistical Descriptions* Generalized Perceptions	8. record measurements using scientific notation (powers of 10).	*Demonstrating Confidence and Satisfaction,* Respect for Logic
Interpreting data, Using Numbers	*Statistical Descriptions,* Generalized Perceptions	9. add, subtract, multiply, divide and find powers and roots of data recorded in scientific notation.	*Respect for Logic, Consideration of Premises*
Interpreting data, Measuring	*Statistical Descriptions,* Generalized Perceptions	10. calculate surface area and volume of solids indicating the uncertainty of the result.	*Respect for Logic, Consideration of Premises, Search for Data and their Meaning*
Measuring, Communicating	*Statistical Descriptions,* Generalized Perceptions	11. use correct units with both measured and calculated quantities.	*Search for Data and their Meaning, Consideration of Premises*

Processing	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Generalizing, Communicating	*Statistical Descriptions*, Generalized Perceptions, Science and Society	12. defend the need for standardized units of measurement.	*Search for Data and their Meaning*, Respect for Logic, Consideration of Premises
Interpreting data, Measuring	*Statistical Descriptions*, Generalized Perceptions	13. convert units within a measurement system such as MKS (meter, kilogram, second).	*Respect for Logic*, Search for Data and their Meaning
Analyzing systems, *Interpreting data*, Measuring, Communicating	*Statistical Descriptions*, Generalized Perceptions, Science and Society	14. convert units in the MKS (meter, Kilogram, second) system to units in the cgs (centimeter, gram, second) system and vice versa.	*Longing to Know and Understand*, *Search for Data and their Meaning*, Consideration of Consequences
Interpreting data, Ordering, Equating	*Statistical Descriptions*, Generalized Perceptions, Science and Society	15. approximate "order of magnitude" for a given measurement in other units (e.g. given the measurement of 1 X 10^{13} A° the student should indicate that this is 10^5 cm., 10^3 m., 1 km. and is about .6 of a mile).	*Longing to Know and Understand*, *Search for Data and their Meaning*, Consideration of Consequences.
Interpreting data, *Measuring*	*Statistical Descriptions*, Generalized Perceptions	16. name and apply a rule about significance of figures to identify those numerals which should be retained in a measurement or a calculation involving results of any measurement.	*Consideration of Premises*, *Search for Data and their Meaning*, *Respect for Logic*
Analyzing systems, *Measuring*, Using space/time realtionships	*Statistical Descriptions*, Generalized Perceptions	17. measure and record time in standardized units indicating the uncertainty of the measurement.	*Consideration of Premises*, *Search for Data and their Meaning*, Respect for Logic
Analyzing systems, Translating	*Generalized Perceptions*, *Science and Society*, *Statistical Descriptions*	18. differentiate magnitudes of time intervals and suggest historical and practical reason for their use.	*Valuing Scientific Heritage*
Analyzing systems, Measuring	*Statistical Descriptions*, Generalized Perceptions	19. determine and record the temperature of a liquid indicating the uncertainty of the measurement.	*Consideration of Premises*, *Search for Data and their Meaning*
Analyzing systems, *Formulating models*	*Differences and Similarities of Interactions*, *Energy Forms*, *Generalized Perceptions*	20. construct a demonstration to distinguish between heat and temperature.	*Longing to Know and Understand*, *Search for Data and their Meaning*, *Respect for Logic*
Formulating statistical models, Experimenting	*Statistical Descriptions*, *Interdependency of Nature*, *Generalized Perceptions*, Differences and Similarities of Interactions, Matter Conservation, Energy Conservation	21. from the initial pressure, volume and temperature for a sample of an ideal gas and two of these after the conditions have been changed, calculate the unknown.	*Search Data and their Meaning*, Respect for Logic, Valuing Scientific Heritage
Verbally associating	Science and Technology	22. Identify all common laboratory apparatus by name.	Demonstrating Confidence and Satisfaction

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Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Psycho-motor skills, Assimilating	*Statistical Descriptions*	23. use a double pan or triple beam balance to determine the mass of a sample of any solid or liquid taking proper precaution so that the balance is not damaged, none of the sample is lost, and the sample is not contaminated. In addition, the value reported should indicate the uncertainty of the measurement and be correct within the limits of the precision of the balance used.	Demonstrating Confidence and and Satisfaction, Consideration of Consequences
Psycho-motor skills		24, insert a glass tube into a rubber stopper demonstrating ability to use a lubricant and protect himself from from possible injury by broken glass.	Demonstrating Confidence and Satisfaction, Consideration of Consequences
Psycho-motor skills	Differences and Similarities of Interactions	25. heat a liquid in a test tube to boiling without any overflow of the liquid.	Demonstrating Confidence and Satisfaction, Consideration of Consequences.
Interpreting data, Measuring, Using space/ time relationships.	*Statistical Descriptions*, Generalized Perceptions	26. read the volume of a liquid in a graduated cylinder and/or a buret and record the measurements indicating its uncertainty.	*Consideration of Premises, Respect for Logic*, Search for Data and their Meaning
Psycho-motor skills	Differences and Similarities of Interactions	27. decant the liquid from over a solid material without a measurable loss of any of the solid.	Demonstrating Confidence and Satisfaction, Consideration of Consequences.
Psycho-motor skills, Measuring	Statistical Descriptions	28. use a bulb and pipette to transfer a specified quantity of liquid from a stock bottle to a beaker with an accuracy of ±0.1 ml.	Demonstrating Confidence and Satisfaction, Consideration of Consequences
Psycho-motor skills, Recognizing variables, Measuring	Statistical Descriptions	29. properly clean, rinse, fill and use a buret, pipette, etc.	Demonstrating Confidence and Satisfaction, Consideration of Consequences
Psycho-motor skills, Manipulating variables	Differences and Similarities of Interactions, Energy Exchange	30. light a bunsen burner and adjust the flame appropriately to efficiently achieve the desired use.	Demonstrating Confidence and Satisfaction, Consideration of Consequences
Analyzing systems, Psycho-motor skills, Translating	*Statistical Descriptions*, Generalized Perceptions	31. use a mercury barometer to measure atmospheric pressure to the nearest millimeter of Hg, convert the reading to normal units of pressure and correctly describe a rationale for accepting this length of a column of Hg as a measure of atmospheric pressure.	*Search for Data and their Meaning, Respect for Logic*, Valuing Scientific Heritage
Translating	*Statistical Descriptions*	32. demonstrate a safe and appropriately accurate procedure for preparing a prescribed volume of a specific concentration of a solution from a stock solution of an acid or base.	Demonstrating Confidence and Satisfaction, Consideration of Consequences

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Translating	*Statistical Descriptions*	33. prepare a solution of specified volume and concentration from a solid.	Demonstrating Confidence and Satisfaction, Consideration of Consequences.
Translating	Science and Technology	34. construct an electrical circuit consisting of a power supply (or chemical cell) a switch, a resistance (or chemical cell), a volt meter and an ammeter and determine the voltage and current in the circuit.	Demonstrating Confidence and Satisfaction, Consideration of Consequences
Classifying, Observing and others	*Differences and Similarities of Objects*, Generalized Perceptions	35. identify those observations that are necessary and sufficient to identify an object or class of objects uniquely.	*Search for Data and their Meaning*, *Respect for Logic*, Consideration of Premises, Demonstrating Confidence and Satisfaction
Interpreting data	*Statistical Descriptions*, Differences and Similarities of Objects, Generalized Perceptions	36. find the density of a given sample of a solid, liquid or gas.	*Search for Data and their Meaning*
Defining operationally	*Differences and Similarities of Objects*, *Statistical Descriptions*, Generalized Perceptions	37. describe properties (e.g. density, melting point, boiling point, heat of fusion, heat of vaporization, specific heat, solubility) that may provide information on which the identity of a substance may be based.	*Search for Data and their Meaning*, Consideration of Premises, Demonstrating Confidence and Satisfaction
Defining operationally, *Testing*	*Differences and Similarities of Objects*, *Differences and Similarities of Interactions*, Fundamental Structures	38. describe a test which would help determine whether a sample of a material that appears to be uniform in composition is a single substance (a free element or compound) or a mixture.	*Search for Data and their Meaning*, Demand for Verification
Communicating	Differences and Similarities of Objects, Differences and Similarities of Interactions, Statistical Descriptions, Generalized Perceptions	39. use a standard reference to locate information such as: (a) the density of an element or compound, (c) the specific heat of an element or compound, (d) the heat of formation of a compound and (e) the vapor pressure of water as a function of temperature.	*Valuing Scientific Heritage* Demonstrating Confidence and Satisfaction
Simulating, *Communicating*	*Generalized Perceptions*, *Fundamental Structures*, Statistical Descriptions	40. write the correct formula from the name of any compound commonly used in the course.	Demonstrating Confidence and Satisfaction, Search for Data and their Meaning, Valuing Scientific Heritage
Translating, Communicating	*Generalized Perceptions*, Fundamental Structures, Statistical Descriptions	41. translate a chemical equation into an ordinary English sentence.	Demonstrating Confidence and Satisfaction, Search for Data and their Meaning, Valuing Scientific Heritage
Translating, *Interpreting data*, Communicating	*Generalized Perceptions*, Fundamental Structures, Statistical Descriptions	42. translate a word description of a chemical reaction into a chemical equation.	Demonstrating Confidence and Satisfaction, Search for Data and their Meaning, Valuing Scientific Heritage

Processes	Conceptual	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Interpreting data, Communicating	*Statistical Descriptions*	43. construct a table of data from a graph of the data.	*Search for Data and their Meaning*
Manipulating variables, Interpreting data	*Statistical Descriptions, Generalized Perceptions*	44. from experimental data for some variable which is a function of another variable, establish a suitable scale, locate points on a graph for each ordered pair and draw a "best fit" curve for the data.	Search for Data and their Meaning, Respect for Logic, Consideration of Premises
Assimilating, Communicating	*Statistical Descriptions,* Generalized Perceptions, Differences and Similarities of Interactions	45. construct a short word statement to describe what a table or graph communicates about the responses of one variable to the manipulated variable.	*Demonstrating Confidence and Satisfaction*, Search for Data and their Meaning
Formulating statistical models, Communicating	*Statistical Descriptions, Generalized Perceptions,* Differences and Similarities of Interactions	46. construct a mathematical statement to describe what a straight line graph communicates	*Respect for Logic, Search for Data and their Meaning*
Predicting	*Statistical Descriptions, Generalized Perceptions,* Differences and Similarities of Interactions	47. apply rules for interpolation or extrapolation to predict from a graph.	*Respect for Logic,* Consideration of Premises, Search for Data and their Meaning
Interpreting data, Communicating	*Statistical Descriptions,* Generalized Perceptions	48. construct a frequency distribution for a set of observations.	*Respect for Logic, Search for Data and their Meaning*
Inferring, Observing	*Generalized Perceptions,* Science and Society	49. distinguish between observations and inferences from a list containing examples of both.	*Consideration of Premises, Demand for Verification*
Inferring	Generalized Perceptions	50. construct inferences that are consistent with the data obtained by indirect measurement or observation.	*Consideration of Premises, Questioning of All Things, Longing to Know and Understand*
Analyzing systems, Inferring	*Generalized Perceptions, Science and Society*	51. distinguish between inferences that account for all observations and inferences that do not.	*Consideration of Premises, Questioning of All Things*
Recognizing variables	*Generalized Perceptions, Statistical Descriptions*	52. identify and name the variable that should be held constant, the one that should be manipulated and the one that will respond to that manipulation in a test of an hypothesis.	*Search for Data and their Meaning*, Respect for Logic, Consideration of Premises,
Recognizing problems	*Generalized Perceptions*	53. identify one or more unexpected events (1) in a structured situation, (2) in an open or less structured situation.	*Questioning of All Things*
Refining problems, Typing problems	*Generalized Perceptions, Science and Society*	54. select a problem for study according to the following criteria: (1) the utilization of previous findings from various sources such as teacher, text, research reports, etc. (2) the judgment of the feasibility of the problem, (3) the problem's interest and value to him.	*Longing to Know and Understand, Questioning of All Things*, Search for Data and Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Refining problems	*Generalized Perceptions*	55. state the problem to be researched in researchable terms.	*Search for Data and their Meaning, Respect for Logic, Consideration of Premises*
Refining problems	*Generalized Perceptions*	56. identify the elements of a problem on which a hypothesis could be based.	*Respect for Logic, Consideration of Premises*
Proposing answers	*Generalized Perceptions*	57. generate hypotheses about the critical element in the problem.	*Consideration of Premises, Respect for Logic*
Cognitively evaluating alternatives	*Generalized Perceptions*	58. clarify the statement of the hypotheses to: (1) eliminate duplication, (2) determine which hypotheses are testable and (3) determine the relevance of each hypothesis to the problem.	*Consideration of Premises, Respect for Logic*, Demand for Verification
Designing studies	*Generalized Perceptions*	59. plan to test hypotheses on the basis of: (1) identifying all the variables possible, (2) selecting a variable to be studied, (3) establishing a proper control, (4) planning for replication, (5) planning systematic observation of descriptive data, (6) identifying sources of error such as measurement, computations tools, instrumentation, etc. and (7) planning a system for processing the data to make it ready for interpretation.	*Consideration of Premises*, Search for Data and their Meaning
Performing investigations	Generalized Perceptions	60. execute the plan of investigation by (1) collecting, organizing and analyzing data, (2) presenting findings, (3) using tools properly, (4) recording data accurately indicating the degree of uncertainty, (5) reviewing tools and procedures used and (6) revising procedures where indicated by results.	*Search for Data and their Meaning, Consideration of Premises, Demand for Verification*
Synthesizing results, Social evaluating, Affective evaluating	*Generalized Perceptions, Science and Society*	61. interpret data or findings by (1) identifying the assumptions he has used in the study, (2) employing reasonings skills (both deductive and inductive), (3) using various means of presenting data to bring out different features, (4) examining collected data to determine its relevance to both the problem and the hypothesis at hand and to other problems, (5) identifying conflicts and discrepancies in data, (6) drawing tentative conclusions and (7) avoiding overgeneralizations of the results without unduely withholding judgment by restricting interpretation to those permissable from the data.	*Consideration of Premises, Search for Data and their Meaning, Demand for Verification, Respect for Logic*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Synthesizing results, Cognitively evaluating alternatives	*Generalized Perceptions, Science and Society*	62. synthesize knowledge gained from an investigation by (1) relating findings to various personal interests and to the world at large, (2) correlating findings and making interpretations from several experiments, (3) applying knowledge gained to new situations, (4) recognizing new problems, (5) using theories, theoretical constructs and models as a means of relating and organizing new knowledge, (6) recognizing that evidence for or against a given theory may be inconclusive, (7) recognizing that a theory may or may not be testable at the time of formation and (8) recognizing that several theories may be useful as each can make its own unique contribution to understanding the problem.	*Demand for Verification, Consideration of Consequences, Questioning of All Things, Respect for Logic, Consideration of Premises*
Cognitively evaluating alternatives, Social evaluating, Affective evaluating	*Interdependency of Nature, Science and Technology, Science and Society*	63. discuss the ethical responsibility on the part of an industry or a public agency and the kind of scientific information that should be supplied to the public in order to meet their responsibilities for situations such as the following: (a) a company plans to market a new laundry product, (b) a company has applied for a license to test a new drug on human subjects, (c) a company or public utility has purchased land in a wilderness area for the purpose of constructing a new plant, (d) a company has purchased urban property for the purpose of constructing a new plant, (e) a company plans to market a new agricultural product, (f) a company plans to market a new packaging material and (g) there are plans to add chemicals to the city water supply.	*Consideration of Consequences, Developing A Commitment to Aesthetics in Nature*
Cognitively evaluating alternatives, Social Evaluating, Affective evaluating	*Interdependency of Nature, Science and Technology, Science and Society*	64. discuss the ethical responsibility on the part of the public and the mechanism by which those responsibilities can be fulfilled in situations such as those described above.	*Consideration of Consequences, Developing A Commitment to Aesthetics in Nature*
Cognitively evaluating alternatives, Social evaluating, Affective evaluating	*Interdependency of Nature, Science and Technology, Science and Society*	65. evaluate reports of a current social issue of the nature suggested above to determine whether the industry, the public or both have fulfilled their respective ethical responsibilities.	*Consideration of Consequences, Developing A Commitment to Aesthetics in Nature*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Acting on conclusions	*Science and Society*	66. after (and only after) satisfying the above objective, propose a course of action that will assure that the ethical responsibilities of both industry and the public are fulfilled.	Respect for Order in Nature
Synthesizing	*Science and Society*	67. provide at least one historical example to show the influence that scientific development has had on social thought and/or action.	*Valuing Scientific Heritage*
Synthesizing	Science and Society	68. provide at least one historical example to show the influence (either positive or negative) that society as a whole has had on scientific development.	Valuing Scientific Heritage
Character building	*Generalized Perceptions*, Science and TEchnology, Science and Society	69. demonstrate a concern or an intellectual interest in scientific development by any combination of activities such as the following: (a) reading science related books or articles which are not required reading, (b) participating in science fairs or development of nature trails, (c) visiting a science museum or science lecture and (d) applying scientific thought to a real problem facing him.	*Longing to Know and Understand*, Valuing Scientific Heritage, Demand for Verification Respect for Logic, Consideration of Premises

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Analyzing systems	Fundamental Structures	1. Identify by name and function the major structures that constitute plant cells (cell wall, cell membrane, nucleus, chloroplast, vacuole, mitochondria, ribosome, endoplasmic reticulum).	*Search for Data and their Meaning*, Longing to Know and Understand, Respect for Order in Nature
Analyzing systems	Fundamental Structures	2. identify by name and function the major structures that constitute animal cells (cell membrane, nucleus, vacuoles, mitochondria, ribosomes, endoplasmic reticulum, centrisome).	*Search for Data and their Meaning*, Longing to Know and Understand, Respect for Order in Nature
Observing	Fundamental Structures, Space/Time Reference	3. prepare a slide of living or preserved cells and identify the parts visible with both low and high magnification.	*Demand for Verification*, Demonstrating Confidence and Satisfaction
Synthesizing, Analyzing systems	*Force Fields*, Fundamental Structures, Interdependency of Nature	4. relate the structure and function of the highly specialized cells: a. muscle cells, b. nerve cells, c. epidermal cells in leaves, d. red blood cells, e. white blood cells, f. xylem cells, g. others as suitable.	*Search for Data and their Meaning*, Respect for Order in in Nature
Synthesizing, Analyzing systems	Force Fields, Fundamental Structures, Interdependency of Nature	5. describe the functions of various tissues such as: a. wet membrane — lungs, b. islets of Langerhans — pancreas, c. epidermis — skin of mammal, d. xylem — roots, stems, leaves, e. meristem — plants, f. others as desired.	*Search for Data and their Meaning*, Respect for Logic, Respect for Order in Nature
Synthesizing, Analyzing systems	*Fundamental Structures*, Differences and Similarities of Objects, Force Fields, Interdependency of Nature	6. describe the complementarity of the structure and the function of organs using examples such as: a. heart — circulation of earthworm, grasshopper, and human, b. brain — nervous system of humans, c. liver — digestive system of a mammal, d. uterus — reproduction of humans, e. intestine — digestion of earthworm, grasshopper, and human, f. ovary and testes — reproduction of frog, fish, birds, g. leaf — photosynthesis in producers.	*Search for Data and their Meaning*, Respect for Logic, respect for Order in Nature
Synthesizing, Analyzing systems	*Fundamental Structures*, Differences and Similarities of Objects, Force Fields, Interdependency of Nature	7. describe the major parts of various systems and relate how these structures contribute to the well being of the total organism. Use examples such as the following: a. roots — corn plant, b. circulatory — frog, c. Skeletal — insect, d. skeletal — mammal, e. nervous — human, f. endocrine — human, g. digestion — cow, h. excretion — human, i. transport — woody plant.	*Search for Data and their Meaning*, Respect for Logic, Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Designing studies, Performing investigations, Cognitively evaluating alternatives	*Differences and Similarities of Objects, Differences and Similarities of Interactions,* Energy Exchange	8. compare and contrast the nutritional patterns of organisms using examples such as: a. algae cells, b. paramecia, c. fungus — mold or toadstool, d. earthworm, e. grasshopper. f. tree, g. man, h. parasitic organisms. i. symbiotic organisms.	*Questioning of All Things,* Search for Data and their Meaning
Formulating models, Synthesizing, Experimenting	*Differences and Similarities of Interactions,* Differences and Similarities of Objects, Energy Exchange, Generalized Perceptions	9. identify the major roles of enzymes as they occur in organic reactions.	*Search for Data and their Meaning,* Respect for Order in Nature, Demand for Verification
Analyzing systems	*Differences and Similarities of Interactions,* Energy Exchange, Interdependency of Nature, Generalized Perceptions	10. describe in a given organism the mechanical and chemical processes that change food in its large particle form to the small particle form that is able to diffuse into living cells.	*Questioning of All Things,* Respect for Order in Nature
Formulating models, Synthesizing, Experimenting	*Differences and Similarities of Interactions,* Matter Conservation, Generalized Perceptions, Science and Technology	11. demonstrate, by laboratory procedures if practical, the control of diffusion of a material in solution and relate this action to life situations such as: a. well water contamination. b. improper use of fertilizer, c. drinking sea water, d. alcohol consumption, e. irrigation in areas where water has been used several times — such as Imperial Valley, California.	*Search for Data and their Meaning, Consideration of Consequences,* Consideration of Premises
Cognitively evaluating alternatives, Analyzing systems, Abstracting	*Differences and Similarities of Objects,* Space/Time Reference Frames, Generalized Perceptions	12. describe supporting and conflicting evidence of the hypothesis; the larger the size of the mature organism the more complex its systems, using situations such as: a. circulation in the earthworm and a chordate, b. gas exchange processes in the paramecium, the insects, and a mammal, c. reproduction of the paramecium and a rotifer, d. circulation of transport in a sponge and a mouse.	*Demand for Verification,* Questioning of All Things, Consideration of Premises
Designing studies, Performing investigations, Synthesizing results	*Differences and Similarities of Objects, Differences and Similarities of Interactions, Constant Change, Interdependency of Nature*	13. describe the stimulus-response mechanisms in various organisms such as: a. paramecia, b. euglena, c. planaria, d. earthworm, e. insects, f. human.	*Search for Data and their Meaning,* Respect for Order in Nature
Designing studies, Performing investigations	*Differences and Similarities of Interactions, Statistical Descriptions,* Force Fields, Interdependency of Nature	14. design and perform a demonstration to show the effect of tropisms such as: geotropism, hydrotropism, heliotropism, etc.	*Search for Data and their Meaning,* Respect for Order in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Designing studies, Performing investigations, Synthesizing results, Refining problems	*Differences and Similarities of Interactions, Statistical Descriptions,* Interdependency of Nature, Generalized Perceptions	15. design, perform, and report the results of a controlled experiment to demonstrate the effect on living organisms of varying amounts of the following items such as: water, nitrogen, calcium, phosphorous. light, and heat. Use various kinds of plants, fruit flies, other insects, or small water animals.	*Search for Data and their Meaning,* Consideration of Consequences. Respect for Order of Nature
Formulating models	*Generalized Perceptions, Interdependency of Nature,* Matter/Energy Conservation, Differences and Similarities of Interactions	16. relate the role of endocrine secretions to homeostasis.	*Search for Data and their Meaning,* Respect for Order in Nature
Analyzing systems, Synthesizing, Experimenting	*Energy Exchange, Energy Forms,* Differences and Similarities of Interactions	17. describe these aspects of respiration: a. distinguish between aerobic and anerobic respiration to the effeciency of energy release and the products formed, b. relate respiration to energy in all living things, c. describe the basic chemical changes which occur when sugar is burned and identify the role of each organ or organelle involved.	*Search for Data and their Meaning,* Respect for Order in Nature
Analyzing Systems, Synthesizing or *Designing studies* and *Performing investigations*	*Differences and Similarities of Interactions, Differences and Similarities of Objects,* Fundamental Structures, Space/ Time Reference Frames, Force Fields	18. describe the action of ciliated or flagelleted motion as it occurs in: a. single celled organisms, b. sessile water animals, c. special tissues in complex organisms, e. g. frog epithelium, oviduct, trachael epithelium.	*Search for Data and their Meaning,* Respect for Order in Nature
Analyzing systems, Formulating models or *Designing studies* and *Performing investigations*	*Differences and Similarities of Interactions, Fundamental Structures, Differences and Similarities of Objects*	19. describe how movement is achieved by muscular contraction in organisms where action involves internal or external skeletons; the action against material or opposing muscles using examples such as: mammalian movement, insect movement, round worm or earthworm movement, peristalsis.	*Search for Data and their Meaning,* Demand for Verification, Respect for Order in Nature
Analyzing systems or Typing problems, Designing studies and *Synthesizing results*	*Matter Conservation, Differences and Similarities of Interactions, Fundamental Structures*	20. describe the excretion function by identifying the material secreted, the source of the material, and the disposition of the materials in such organs as: a. intestines of earthworm, insect, and mammals, b. lungs of reptiles, birds, and mammals, c. gills of fishes, d. kidneys of vertebrates, e. nephrons of the earthworm, f. cell membrane of the paramecium.	*Search for Data and their Meaning, Respect for Order in Nature, Consideration of Consequences*
Analyzing systems	*Differences and Similarities of Objects, Fundamental Structures, Differences and Similarities of Interactions,* Constant Change	21. identify and contrast the sequence of events in the mitosis of plant and animal cells.	*Questioning of All Things, Respect for Order in Nature,* Search for Data and their Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Designing studies, Performing investigations, Recognizing problems, Typing problems, Refining problems	*Differences and Similarities of Objects, Fundamental Structures,* Differences and Similarities of Interactions, Constant Change, Interdependency of Nature	22. describe and contrast fertilization in various organisms such as: a. mold (Rhizopus), b. algae (Spirogyria, Oedogonium), c. a flowering plant, d. a frog (external fertilization), e. a mammal (internal fertilization).	*Questioning of All Things, Respect for Order in Nature,* Search for Data and their Meaning
Designing studies, Performing investigations, Synthesizing results	Differences and Similarities of Objects, Fundamental Structures, Constant Change, Interdependency of Nature	23. describe the various processes by which asexual reproduction may occur and cite examples to illustrate: a. fission, b. budding, c. regeneration, d. layering, e. fragmentation, f. sporulation.	*Questioning of All Things Demand for Verification,* Respect for Order in Nature
Interpreting data	*Differences and Similarities of Objects, Fundamental Structures,* Generalized Perceptions	24. diagram an atom or an ion given the appripriate data.	Search for Data and their Meaning, Respect for Order in Nature
Interpreting data	Differences and Similarities of Objects, Differences and Similarities of Interactions, Fundamental Structures, Force Fields, Generalized Perceptions	25. contrast covalent, hydrogen and ionic bonding.	Search for Data and their Meaning, Consideration of Premises, Respect for Order in Nature
Analyzing systems, Formulating models	Differences and Similarities of Interactions, Fundamental Structures, Action Forces, Interdependency of Nature	26. contrast the ionization and dissociaof ionic and electron sharing compounds in water solution.	*Search for Data and their Meaning,* Consideration of Premises
Analyzing systems, Recognizing variables, Formulating models	Differences and Similarities of Objects, Differences and Similarities of Interactions, Fundamental Structures, Action Forces	27. relate pH scale to acidity and alkalinity.	*Search for Data and their Meaning*
Analyzing systems, Formulating models, Defining operationally	*Differences and Similarities of Objects, Differences and Similarities of Interactions, Fundamental Structures*	28. recognize generalized structural formulas and component parts of common chemical substances referred to in biology such as: a. amino acids, b. proteins, c. fatty acids, d. glycerol, e. carbohydrates, f. water, g. carbon dioxide, h. molecular oxygen.	*Search for Data and their Meaning,* Respect for Order in Nature
Designing studies, Performing Investigations	*Differences and Similarities of Interactions,* Action Forces, Interdependency of Nature	29. relate the role of the enzymes in a total process such as photosynthesis.	*Search for Data and their Meaning,*
Defining operationally, Classifying	Fundamental Structures, Differences and Similarities of Objects, Generalized Perceptions	30. identify the three basic structural units of nucleic acids: phosphate group, sugar group, and base group. Compare the structure of DNA and RNA.	Search for Data and their Meaning

Process	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Synthesizing, Interpreting data	*Fundamental Structures*, Force Fields, Generalized Perceptions	31. describe, by diagrams or models, the process of DNA replication.	*Respect for Order in Nature*, Respect for Logic
Analyzing systems, Formulating models	*Fundamental Structures*, Interdependency of Nature, Generalized Perceptions	32. by diagrams or models show how a given sequence of amino acids in protein synthesis is determined by the chromosomes (DNA).	*Respect for Order in Nature*, Respect for Logic
Interpreting data, Formulating models	*Interdependency of Nature, Energy Conservation*, Matter Conservation, Science and Technology	33. construct a food web diagram that illustrates the dependence of the high level consumers on the low level consumers and producers from a given list of organisms found in a community.	*Respect for Order in Nature*, Search for Data and their Meaning, Consideration of Consequences
Analyzing systems, Interpreting data	*Energy Exchange, Interdependency of Nature*, Energy Conservation, Science and Technology	34. trace the transfer of energy from one form to another as it moves through a series of organisms (food chain) starting at the source and ending at the final disposal into the non-living environment. Use various types of habitats such as: a. a temperate prairie, b. a fresh water lake, c. a tundra, d. any other suitable habitat.	*Respect for Order in Nature*, Search for Data and their Meaning, Consideration of Consequences
Formulating models, Analyzing systems, Synthesizing	Energy Exchange, Interdependency of Nature, Energy Conservation, Generalized Perceptions, Force Fields, Science and Technology, Matter Conservation	35. describe the carbon-oxygen-hydrogen cycle as it occurs in the biosphere by relating the role of the the various components materials and processes such as: a. the series of events in photosynthesis which lead to capturing energy, b. green plants, c. animals, d. the series of events in respiration that release energy from food, e. conservation of energy in the cycle.	*Search for Data and their Meaning*, Demand for Verification, Consideration of Consequences
Analyzing systems, Formulating models	Interdependency of Nature, Matter Conservation, Force Fields, Science and Technology	36. relate the benefits each of the following groups of organisms give to their communities as they perform the functions by which they maintain themselves: a. producers, b. consumers — primary and secondary, c. decomposers	*Respect for Order in Nature*, Consideration of Consequences, Search for Data and their Meaning
Formulating Statistical Models, Interpreting data or Designing studies, Performing investigations, Affective and Social Evaluating	*Statistical Descriptions, Matter/Energy Conservation*, Interdependency of Nature	37. relate the bio-mass aspect of the food pyramid to conservation of energy as materials are passed from the lower trophic levels to the higher levels of the pyramid.	*Consideration of Premises, Consideration of Consequences*, Search for Data and their Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Defining operationally, Analyzing systems	*Interdependency of Nature, Constant Change*	38. working from a prepared diagram, describe the nitrogen cycle as it occurs in his own words using correctly the terms: nitrifying, denitrifying, fixing nitrogen, nitrate, ammonia, bacteria, animal wastes, and decomposers.	*Demonstrating Confidence and Satisfaction*
Analyzing systems, Synthesizing, Interpreting data	*Constant Change*, Interdependency of Nature, Science and Technology	39. describe, by words or diagrams, the process of succession as it occurs in in the following situations: a. a sandy lake shore, b. a fallen tree, c. an abandoned field, d. a small pond, e. a salt or fresh water marsh, f. a coral lagoon, g. artificial harbors and breakwaters, h. lakes behind dams, i. any suitable local area.	*Respect for Order in Nature, Search for Data and their Meaning*
Cognitively evaluating alternatives, Analyzing systems or Designing studies, Performing investigations, Synthesizing results, Affective and Social Evaluating	*Interdependency of Nature, Science and Technology, Science and Society*, Force Fields	40. describe the buildup of materials in habitats disturbed by man which may have detrimental effect upon the individuals of the ecosystem as a whole; in each case identify the manner in which the material may be harmful and contrast with economic and social values of continued usage. i.e. mercury, disposable containers, etc.	Consideration of Consequences, Consideration of Premises, Developing A Commitment to Aesthetics in Nature
Formulating models, Analyzing systems	Interdependency of Nature, and many others	41. discuss the implications of the hypothesis, "The biosphere, as it occurs on earth, is a single macro-organism".	Developing a Commitment to to Aesthetics in Nature, Consideration of Premises, Consideration of Consequences
Classifying, Equating	Differences and Similarities of Objects, Space/Time Reference Frames	42. by personal observation and investigation, identify a given number of organisms of a designated local ecosystem (some suggested ecosystems are: a. the back yard, b. the vacant lot in the neighborhood, c. the aquarium in the school room, d. the herbarium in the school room, e. any city park).	Demonstrating Confidence and Satisfaction
Synthesizing results, Designing studies, Performing Investigations	Interdependency of Nature, Matter/Energy Conservation, Energy Conservation, Science and Technology	43. construct a study to investigate the effects of competition for water, light, and nutrients on the characteristics and distribution of organisms in a biome and generalize these results to explain the distribution of organisms in various biomes.	*Search for Data and their Meaning*, Consideration of Consequences, Respect for Logic
Classifying, Interpreting data	Differences and Similarities of Objects, Differences and Similarities of Interactions, Interdependency of Nature	44. distinguish between heterotrophs and autotrophs by superficial examination of specimens of the organisms.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Classifying, Observing	Differences and Similarities of Objects	45. identify by microscopic examination of suitable specimens: a. bacterial colonies, b. mold, c. algae, d. protozoans, e. any suitable item.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Defining operationally, Interpreting data	Differences and Similarities of Objects, Differences and Similarities of Interactions	46. describe the general features of the classification system generally used by biologists such as: a. binomial nomenclature, b. major kingdoms of living organisms, c. subdivisions – phyla, genera, species.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying	*Differences and Similarities of Objects*	47. classify given organisms, both plant and animal, into their current phyla with the aid of appropriate keys.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Classifying	*Differences and Similarities of Objects*	48. classify, with a key, complete plant specimens into the following categories: a. monocotyledon, b. dicotyledon, c. gymnosperms, d. fungus, e. bryophytes, f. ferns	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Analyzing systems, Synthesizing or *Designing studies, Performing investigations,* Synthesizing results	*Fundamental Structures*, Constant Change, Force Fields	49. relate meiosis to: a. the prediction of variation of characteristics in offspring, b. Mendel's laws of segregation and independent assortment.	*Search for Data and their Meaning*, Consideration of Premises
Formulating statistical models	*Statistical Descriptions*, Differences and Similarities of Interactions, Force Fields	50. describe, by diagrams or mathematical procedures, the elements of inherited characters as they occur in: a. complete dominance, b. co-dominance, c. linkage of characters, d. sex linkage, e. multiple alleles, f. genes in gene pools (Hardy-Weinberg)	*Search for Data and their Meaning*, Questioning of All Things
Cognitively evaluating alternatives, Analyzing systems	*Generalized Perceptions*, Constant Change	51. state the major parts of Darwin's Theory of Natural Selection; cite evidence for and indicate the flaws in each part.	Developing a Commitment to Aesthetics in Nature, Search for Data and their Meaning, Consideration of Premises, Demand for Verification
Analyzing systems	*Differences and Similarities of Interactions, Interdependency of Nature, Constant Change*, Generalized Perceptions	52. cite examples of adaptation by organisms to their peculiar environment; distinguish between Creative, Darwinian, and Lamarckian adaptation.	*Developing a Commitment to Aesthetics in Nature, Search for Data and their Meaning*, Questioning of All Things, Demand for Verification
Designing studies, Performing Investigations, Synthesizing results	*Interdependency of Nature, Matter/Energy Conservation, Science and Technology*, Science and Society	53. predict the adaptations that may be initiated in various organisms that survive a changing environment.	*Consideration of Consequences, Developing A Commitment to Aesthetics in Nature*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Analyzing systems, Synthesizing or *Designing studies, Performing Investigations, Synthesizing results, Social Evaluating*	*Interdependency of Nature*, Energy Exchange, Energy Conservation, Matter Conservation	54. describe the relationships between the following items as they occur in various organisms: number of offspring, amount of parental care, survival rate, their position in the food web of their community. Cite examples to illustrate the relationships.	*Search for Data and their Meaning*, Consideration of Consequences, Developing A Commitment to Aesthetics in Nature
Interpreting data, Synthesizing	*Statistical Descriptions, Generalized Perceptions*	55. given data from suitable observations of plant growth at various temperatures, plot the data and generalize from its analysis the optimum temperature range for the growth of that organism.	Search for Data and their Meaning, Respect for Order in Nature

NOTE: In this set of objectives the word "reaction" is used to refer to student observed and/or manipulated chemical systems while "equation" refers to system that may be only discussed.

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Recognizing variables, Classifying or *Designing studies*	*Differences and Similarities of Objects*	1. group the substances in a collection of samples of materials and describe the basis for the grouping.	*Longing to Know and Understand, Search for Data and their Meaning, Demonstrating Confidence and Satisfaction*
Experimenting or Designing studies	*Differences and Similarities of Objects*	2. describe a procedure that could be used to classify a sample of a material as an element, a compound or a mixture.	*Search for Data and their Meaning,* Consideration of Premises
Manipulating variables, Classifying	*Differences and Similarities of Objects, Fundamental Structures*	3. describe at least one test that would help determine whether a sample that appears to be pure consists of one element or more than one element.	Search for Data and their Meaning
Formulating statistical models, Translating	*Energy Exchange, Energy Conservation,* Statistical Descriptions, Differences and Similarities of Interactions	4. calculate the value of the fourth item, from data provided or collected for any three of the following: (a) the thermal energy (heat transferred to or from) of a substance, (b) the mass of the substance, (c) the heat capacity of the substance and (d) the temperature change of the substance.	*Search for Data and their Meaning,* Respect for Logic, Respect for Order in Nature
Designing studies, Performing investigations	*Differences and Similarities of Objects, Statistical Descriptions*	5. identify a particular substance from a list of common chemicals by using a handbook to find characteristic properties of the chemicals.	*Search for Data and their Meaning, Questioning of All Things*
Psycho-motor skills, Assimilating, Measuring	*Differences and Similarities of Interactions,* Statistical Descriptions	6. quantitatively separate a solid from liquid by filtration.	*Demonstrating Confidence and Satisfaction*
Psycho-motor skills, Assimilating, Measuring	*Differences and Similarities of Interactions, Statistical Descriptions*	7. quantitatively separate a dissolved solid from a liquid by evaporation without decomposition of the solid.	Demonstrating Confidence and Satisfaction
Manipulating variables, Communicating	*Statistical Descriptions*	8. construct a heating curve and/or cooling curve for a given substance from data collected in the laboratory.	*Search for Data and their Meaning,* Demonstrating Confidence and Satisfaction
Abstracting, Formulating Hypotheses, or *Formulating models,* Interpreting data	*Generalized Perceptions, Fundamental Structures, Energy Exchange, Energy Forms,* Energy Conservation	9. infer the microscopic changes that occur at each inflection point and along the curve connecting the inflection points on a time-temperature plot for a pure substance.	*Longing to Know and Understand, Consideration of Premises,* Search for Data and their Meaning
Translating, Interpreting data	*Fundamental Structures, Statistical Descriptions,* Generalized Perceptions	10. name the elements represented, the number of the atoms of each element, and the mass of each element in one mole of the compound from the formula for any given compound.	*Valuing Scientific Heritage, Demonstrating Confidence and Satisfaction*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Performing investigations	*Matter Conservation*	11. collect evidence in support of the Law of Conservation of Mass in chemical reactions.	*Demand for Verification*, Respect for Order in Nature.
Translating	*Statistical Descriptions*, *Generalized Perceptions*	12. calculate the molecular (formula) weight of a compound for which the formula is given.	Demonstrating Confidence and Satisfaction
Performing investigations, Translating	*Statistical Descriptions*	13. collect experimental data and calculate the empirical formula of a compound.	*Search for Data and their Meaning*, Demonstrating Confidence and Satisfaction
Analyzing systems	*Generalized Perceptions*, *Statistical Descriptions*, Matter Conservation	14. write an equation to describe a chemical system that he has observed.	Respect for Logic
Translating	*Generalized Perceptions*	15. construct the chemical system described by an equation.	Demonstrating confidence and Satisfaction
Simulating, *Analyzing systems*	*Matter Conservation*, *Statistical Descriptions*	16. write a balanced chemical equation for a reaction involving no more than three reactants or products when given the formulas for the reactants and the product of the reaction.	*Respect for Logic*
Translating, Interpreting data	*Matter Conservation*, *Statistical Descriptions*	17. calculate the mass, moles, molecules or atoms for any reactant or product in a reaction from the chemical equation for the reaction and the corresponding mass, number of moles, number of molecules, or number of atoms for any other reactant or product.	*Respect for Logic*, Search for Data and their Meaning
Translating	*Matter Conservation*, *Statistical Description*	18. calculate mass, moles or volume of any of the gaseous products or reactants from the equation for the reaction and the corresponding mass, moles or volume of any of the other reactants or products.	*Respect for Logic*, *Consideration of Premises*, Search for Data and their Meaning
Psycho-motor skills, *Assimilating*, Measuring	*Statistical Descriptions*	19. do successive titration of three equal samples of standardized dilution which agree within the limits of the uncertainty of measurements of the aparatus used.	Demonstrating Confidence and Satisfaction
Translating	*Generalized Perceptions*, *Statistical Descriptions*, Fundamental Structures	20. for a given sample of a compound (or the mass of a sample) calculate any of the following from its correct formula: (a) the number of moles of the compound in the sample, (b) the number of moles of any one element in the sample, (c) the number of molecules (formula units) in the sample or (d) the number of atoms of any one element in the sample.	*Search for Data and their Meaning*, Respect for Logic, Consideration of Premises

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Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Translating	*Generalized Perceptions*, Statistical Descriptions	21. calculate for a gaseous sample the value of the fourth item from data for three of the following: (a) the number of moles (or mass) in the sample, (b) the pressure of gas in the sample, (c) the volume of the sample, (d) the temperature of the sample.	*Search for Data and their Meaning*, Respect for Logic
Translating, Abstracting	*Generalized Perceptions*, Differences and Similarities of Interactions	22. describe in qualitative terms how Kinetic Theory accounts for: (a) differences in gases and liquids, (b) pressure of a gas, (c) evaporation, (d) difference in diffusion rates for gases and liquids, (e) the ordinary observation that the boiling point increases with molecular weight, (f) the relationship between the rate of diffusion and molecular weight.	*Consideration of Premises*
Analyzing systems, Cognitively evaluating alternatives	*Generalized Perceptions*	23. identify those assumptions of the Kinetic Theory that are not true of real gases and describe at least one false prediction that could be made based on the theory because these assumptions are overgeneralizations.	*Questioning of All Things*
Formulating models, Abstracting	*Generalized Perceptions, Fundamental Structures, Energy Exchange, Energy Forms*, Energy Conservation	24. describe qualitatively what occurs during the phase change from a solid to a liquid in terms of (a) energy, (b) temperature, (c) distance between particles, (d) arrangement of particles and (e) motion of particles.	*Longing to Know and Understand, Consideration of Premises*, Search for Data and their Meaning
Translating	*Energy Exchange, Energy Forms*, Energy Conservation	25. calculate the change in energy when a given substance at a given temperature is changed to some new temperature in another phase when given the specific heat of the substance in each phase, the heat of vaporization, and the heat of fusion of the substance.	Search for Data and their Meaning
Interpreting data	*Fundamental Structures, Force Fields*	26. describe experimental evidence to support the concept that atoms contain subparticles that possess electrical charge.	Search for Data and their Meaning
Formulating statistical models, translating, Analyzing systems	*Generalized Perceptions*, Fundamental Structures, Differences and Similarities of Interactions, Statistical Descriptions	27. assign oxidation numbers to each element in a compound or radical.	*Longing to Know and Understand*, Respect for Order in Nature
Experimenting	*Fundamental Structures*, Statistical Descriptions	28. demonstrate a procedure for finding the approximate size of molecules and atoms.	Search for Data and their Meaning

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Interpreting data, Defining Operationally, Classifying	*Differences and Similarities of Interactions,* Matter Conservation, Generalized Perceptions	29. identify from a list of chemical equations those which represent oxidation-reduction (redox) reactions.	*Search for Data and their Meaning*
Analyzing systems, Defining operationally, Classifying	*Differences and Similarities of Interactions, Generalized Perceptions*	30. for any reaction involving oxidation and reduction, identify the reactant that is oxidized, the reactant that is reduced, the product of the oxidation and the product of the reduction.	*Search for Data and their Meaning*
Experimenting, Analyzing systems, Interpreting data	*Action Forces, Differences and Similarities of Interactions,* Generalized Perceptions	31. after conducting an investigation using lab equipment, strips of various metals and aqueous solutions of corresponding metal ions: (a) write equations for the half reactions which occur when any of the metal strips are placed in any solution containing one of these ions and (b) order the resulting half reactions in decreasing order of ease of oxidation.	*Longing to Know and Understand, Respect for Logic,* Valuing Scientific Heritage
Translating	*Differences and Similarities of Interactions, Action Forces, Energy Exchange, Force Fields, Energy Forms*	32. design and demonstrate a procedure for obtaining electricity from a chemical system using two metals and aqueous solutions of their salts.	*Respect for Logic, Consideration of Consequences*
Translating	*Energy forms*	33. construct a safe and adequate electric circuit for measuring the electrical variables of various combinations of half-cell reactions.	Demonstrating Confidence and Satisfaction
Performing investigations	Generalized Perceptions, Energy Forms, Energy Exchange, Differences and Similarities of Interactions	34. select any metal/metal ion half-cell as a standard; and measure the potential of at least two other metal/metal ion half-cells relative to the chosen standard	*Search for Data and their Meaning, Consideration of Premises, Respect for Logic,* Valuing Scientific Heritage
Analyzing systems, Measuring	*Differences and Similarities of Interactions, Force Fields, Action Forces, Energy Exchange, Energy Forms, Energy Conservation, Matter/Energy Conservation*	35. describe the process occurring in a given electrochemical cell by: (a) writing the equation(s) for the expected reaction(s), (b) indicating the direction of electron flow in the external circuit, (c) indicating the ion movement in the solution and (d) demonstrating the procedure for measuring the electrical potential of the cell.	*Search for Data and their Meaning,* Respect for Order in Nature
Formulating Hypotheses	*Matter/Energy Conservation, Generalized Perceptions*	36. describe the relationship between cell potential and/or Gibbs free energy and the possibility of a spontaneous reaction occurring in a given electrochemical cell.	*Search for Data and their Meaning, Consideration of Premises*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Translating, Social Evaluating	*Science and Society, Interdependency of Nature,* Science and Technology	37. list examples and reactions involving oxidation and reduction that are necessary for human existence and/or physical comfort.	*Consideration of Consequences,* Respect for Order in Nature
Translating, Social evaluating	*Science and Society. Interdependency of Nature,* Science and Technology	38. list examples of reactions involving oxidation and reduction that are detrimental for human existence and/ or physical comfort.	*Consideration of Consequences,* Respect for Order in Nature
Designing studies, Performing investigations	*Constant Change, Action Forces,* Science and Technology	39. conduct an investigation to determine those conditions that affect the rate of oxidation of some material (e.g. iron or paper).	*Search for Data and their Meaning*
Synthesizing results, Cognitively evaluating alternatives	*Interdependency of Nature, Science and Technology,* Science and Society	40. use the results of the investigation to propose a procedure for eliminating (or slowing) some oxidation such as the rusting of water pipes and/or for inducing (or speeding up) oxidation such as the rusting of metal cans.	*Consideration of Consequences, Respect for Order in Nature*
Defining operationally, Classifying	*Differences and Similarities of Interactions, Generalized Perceptions*	41. construct an operational definition of acids and bases, use it to classify common substances found in the home.	*Search for Data and their Meaning*
Abstracting	*Generalized Perceptions, Differences and Similarities of Interactions,* Fundamental Structures	42. identify, from a list of equations for simple chemical reaction, those substances (reactants or products) that would be considered acids as defined by: (a) Arrhenius, (b) Bronsted and Lowery.	*Search for Data and their Meaning,* Consideration of Premises
Experimenting, Analyzing systems	*Differences and Similarities of Objects, Differences and Similarities of Interactions, Fundamental Structures*	43. distinguish between *concentration* of an acid and *strength* of an acid.	*Consideration of Premises,* Search for Data and their Meaning
Analyzing systems, Formulating models, Interpreting data	*Differences and Similarities of Objects, Generalized Perceptions,* Fundamental Structures	44. identify properties that are a periodic function of the atomic number from a list of properties each as: melting point, atomic radius, atomic weight, density, ionization energy, heat of vaporization, etc.	*Search for Data and their Meaning,* Respect for Order in Nature
Translating	*Differences and Similarities of Objects, Generalized Perceptions,* Fundamental Structures, Energy Forms, Energy Exchange	45. for any of the properties listed, describe the trend observed as you move across a period or down a column in the periodic table, e.g. atomic radius, electronegativity, ionization energy, etc.	*Search for Data and their Meaning, Respect for Order in Nature*
Translating	*Fundamental Structures, Generalized Perceptions*	46. designate the number of electrons in each orbital of an atom or simple ion in its ground state.	*Consideration of Premises, Respect for Order in Nature*
Synthesizing, Formulating models	*Generalized Perceptions, Fundamental Structures, Force Fields, Energy Forms*	47. describe how the emission of hydrogen provides evidence for the theory that the energy of the electron of an atom is quantized.	*Valuing Scientific Heritage, Search for Data and their Meaning, Consideration of Premises*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Translating	*Differences and Similarities of Objects, Fundamental Structures,* Generalized Perceptions	48. identify the chemical family to which an atom belongs from data about the orbital occupancy of the outer or valence electrons.	*Respect for Order in Nature,* Demonstrating Confidence and Satisfaction
Translating	*Generalized Perceptions, Fundamental Structures*	49. write the electron configuration for an atom in its ground state from its atomic number.	*Respect for Order in Nature,* Demonstrating Confidence and Satisfaction
Simulating, Communicating	*Generalized Perceptions,* Differences and Similarities of Interactions	50. construct a Lewis (electron-dot) structure for any compound given its formula and, in complex cases, the structural arrangement.	*Respect for Logic*
Formulating statistical models, Translating	*Generalized Perceptions, Fundamental Structures,* Statistical Descriptions	51. calculate the number of protons, neutrons and electrons for an atom given the atomic number and the mass number of the atom.	*Consideration of Premises,* Respect for Order in Nature
Defining operationally	*Generalized Perceptions, Fundamental Structures,* Statistical Descriptions	52. identify those atoms which are isotopes of the same element given the atomic and mass numbers of various atoms.	*Consideration of Premises,* Respect for Order in Nature
Translating	*Statistical Descriptions, Differences and Similarities of Objects*	53. determine the number of moles and the molarity of each species present in an ionic solution formed by adding a known mass of solute to form a known volume of solution.	*Respect for Logic, Search for Data and their Meaning*
Translating	*Statistical Descriptions, Differences and Similarities of Objects,* Generalized Perceptions	54. determine the resulting concentration of each dissolved species when two solutions are mixed. Any precipitation and dissociation should be considered complete.	*Consideration of Premises, Search for Data and their Meaning*
Formulating models. Translating	*Generalized Perceptions, Differences and Similarities of Objects, Fundamental Structures*	55. predict whether two given atoms form an ionic, polar or non-polar covalent bond given values of electronegativity.	*Search for Data and their Meaning,* Consideration of Premises, Respect for Order in Nature
Translating	*Generalized Perceptions, Differences and Similarities of Objects,* Fundamental Structures, Energy Forms	56. order a list of bonds (e.g. HI, HBr, HCl) according to increasing polarity.	*Respect for Logic,* Respect for Order in Nature
Translating	*Differences and Similarities of Objects, Differences and Similarities of Interactions,* Interdependency of Nature, Energy Forms	57. predict the type of bonding for a substance from experimental data such as solubility, electrical conductivity (when fused or in solution) and melting point.	*Respect for Logic,* Respect for Order in Nature
Analyzing systems	*Action Forces, Energy Exchange, Matter/Energy Conservation,* Force Fields	58. describe the qualitative effect on the rate-of-reaction of a change in temperature or concentration.	*Search for Data and their Meaning*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Synthesizing, Analyzing systems	Matter/Energy Conservation, Force Fields, Interdependency of Nature	59. predict the change that will result in a system at equilibrium when any of the following occur: (a) the concentration of one of the components is changed, (b) the pressure of the system is changed, (c) the thermal energy is changed or (d) a catalyst is added to the system.	Respect for Logic, Respect for Order in Nature
Analyzing systems, Formulating models, Defining operationally	Matter/Energy Conservation, Generalized Perceptions	60. describe the mascroscopic and microscopic behavior of a system at equilibrium.	Search for Data and their Meaning, Consideration of Consequences
Formulating statistical models	Generalized Perceptions, Matter/Energy Conservation, Statistical Descriptions	61. write the equilibrium constant expression from the equation for a reaction.	Search for Data and their Meaning, Valuing Scientific Heritage
Translating	Statistical Descriptions, Generalized Perceptions, Matter/Energy Conservation	62. compute the equilibrium constant given the equation, the amount of each component at equilibrium and the volume of the system.	Search for Data and their Meaning, Valuing Scientific Heritage, Demonstrating Confidence and Satisfaction
Translating	Statistical Descriptions, Generalized Perceptions, Matter/Energy Conservation	63. compute the predicted concentration of each dissolved species and amount of precipitation when two solutions are mixed.	Respect for Logic, Consideration of Premises
Translating, Interpreting data	Matter/Energy Conservation, Matter Conservation, Statistical Descriptions, Action Forces, Generalized Perceptions	64. from a list of reactions and their equilibrium constants, rank the reactions in order of decreasing concentration of products at equilibrium.	Search for Data and their Meaning, Respect for Logic, Consideration of Premises
Analyzing systems	Force Fields, Action Forces, Matter/Energy Conservation	65. describe how the nature of the chemical bonds in a solute relates to its solubility in various solvents.	Search for Data and their Meaning, Consideration of Consequences, Developing A Commitment to Aesthetic in Nature
Formulating models	Science and Technology	66. construct an inference about the various bonds that must exist in a substance in order for it to act as an emulsifying, cleansing, and/or wetting agent.	Search for Data and their Meaning, Respect for Order in Nature
Cognitively evaluating alternatives, Social evaluating, Affective and Social Evaluating	Science and Technology, Science and Society, Interdependency of Nature	67. trace of history of various applications of chemicals in the everyday activities of home and industry and identify various environmental problems that have resulted from these applications, include in this discussion how attempts to correct one environmental problem have often led to the development of another.	Consideration of Consequences, Developing A Commitment to Aesthetics in Nature

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Cognitively evaluating alternatives, Social evaluating, Affective evaluating	*Science and Technology, Science and Society,* Energy Exchange	68. use the detergent, pesticide, packaging and/or fertilizer industry to illustrate how man's use of chemical knowledge to improve his well-being has led to other problems for him and identify types of data that should be analyzed and projected in the future before any new product should be marketed for mass consumption.	*Consideration of Consequences, Developing A Commitment to Aesthetics in Nature*
Synthesizing	*Generalized Perceptions*	69. demonstrate an understanding of the long term development of scientific thoughts by tracing the historical development of concepts such as: (a) atomic theory, (b) kinetic theory, (c) law of definite composition (proportion), (d) periodicity, (e) the mole concept and (f) the concept of acid and base.	*Valuing Scientific Heritage*
Analyzing systems	*Generalized Perceptions*	70. construct a microscopic model consistent with some hypothetical information provided about matter on a distant planet.	*Questioning of All Things*
Analyzing systems	*Generalized Perceptions*	71. determine if some hypothetical information provided about matter on a distant planet is consistent with our model of matter (atomic theory).	*Questioning of All Things*
Formulating Hypotheses	*Generalized Perceptions*	72. construct a test of a hypothesis about a chemical system or phenomenon.	*Longing to Know and Understand, Respect for Logic*
Refining problems	*Generalized Perceptions*	73. describe observations that would support a hypothesis and those that refute a hypothesis about a chemical system or phenomenon.	*Demand for Verification, Consideration of Premises*
Synthesizing results	*Generalized Perceptions*	74. construct a report of a test of a hypothesis about a chemical system of phenomenon which: (a) is written so that it can be understood by a competent reader, (b) provides all data which are relevant to the hypothesis, (c) presents the data in an orderly manner and (d) provides reasonable conclusions based on the data reported.	*Consideration of Premises, Consideration of Consequences, Respect for Logic, Demand for Verification, Search for Data and their Meaning*
Formulating models	*Fundamental Structures, Generalized Perceptions*	75. construct ball and stick models for a number of organic compounds; some compounds in the list should contain double or triple bonds.	*Search for Data and their Meaning*
Formulating models	*Fundamental Structures, Generalized Perceptions*	76. construct ball and stick models of at least two compounds which are stereoisomers and explain (in terms of a model) why these compounds have different properties even though they have the same formula.	*Search for Data and their Meaning*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Performing investigations	*Differences and Similarities of Interactions, Generalized Perceptions, Science and Technology*	77. demonstrate that the chemistry of many organic compounds can be understood (in large part) by studying the functional groups in the compound through performing a number of syntheses such as: (a) esterification, (b) saponification, (c) limited oxidation of alcohols, (d) peptidization and (e) synthetic polymerization.	*Longing to Know and Understand*
Formulating models or *Performing investigations*	*Interdependency of Nature, Science and Technology,* Science and Society	78. identify and describe various ways natural chemical processes in the living organism may be affected by the presence of foreign chemical substances within the organism.	*Respect for Order in Nature,* Search for Data and their Meaning
Formulating models, Analyzing systems	*Fundamental Structures, Matter/Energy Conservation*	79. write equations to represent nuclear transformation resulting in natural decay of radioactive materials.	*Search for Data and their Meaning*
Translating, Synthesizing	*Fundamental Structures, Matter/Energy Conservation, Generalized Perceptions, Action Forces, Force Fields*	80. predict from a list of various atoms (with atomic number and mass indicated) those which should have nuclear stability and those which should not.	*Consideration of Premises*
Synthesizing	*Energy Forms, Energy Exchange, Matter/Energy Conservation, Science and Technology*	81. write equations to represent nuclear transformations that are capable of sustaining a chain reaction.	*Consideration of Premises, Consideration of Consequences*
Social evaluating	*Science and Technology, Science and Society*	82. discuss possible applications of nuclear transformations including factors that must be considered in order to judge whether the application is "useful or useless" and "safe or dangerous".	*Consideration of Consequences*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Defining operationally, Using space/time relationships	*Space/Time Reference Frames*, Statistical Descriptions, Differences and Similarities of Interactions	1. distinguish between distance and displacement.	Search for Data and their Meaning
Translating, Interpreting data	*Statistical Descriptions*, Space/Time Reference Frames, Differences and Similarities of Interactions	2. solve selected problems involving distance and displacement concepts using estimation for the magnitude and accepted units for the answers.	*Consideration of Premises*, Search for Data and their Meaning, Demonstrating Confidence and Satisfaction
Analyzing systems, *Defining operationally*, *Measuring*, *or Synthesizing results*, *Formulating statistical models*	*Statistical Descriptions*, *Space/Time Reference Frames*, Differences and Similarities of Interactions	3. suggest or construct devices to measure time intervals.	*Search for Data and their Meaning*, Consideration of Premises
Synthesizing, *Analyzing systems*	*Statistical Descriptions*, *Constant Change*, Space/Time Reference Frames, Differences and Similarities of Interactions, Generalized Perceptions	4. recognize the probabilistic nature of time units.	*Consideration of Premises*, Demand for Verification
Abstracting, *Defining operationally*, Interpreting data	*Space/Time Reference Frames*, Statistical Descriptions, Generalized Perceptions	5. combine distance (and displacement) intervals with time intervals to derive new physical concepts which better explain observed phenomena: speed, velocity and acceleration.	*Search for Data and their Meaning*
Analyzing systems, *Interpreting data*	*Space/Time Reference Frames*, *Statistical Descriptions*, Generalized Perceptions	6. distinguish between instantaneous and average speed; instantaneous and average velocity; and instantaneous and average acceleration.	*Consideration of Premises*, Respect for Logic, Search for Data and their Meaning, Longing to Know and Understand
Interpreting data, Communicating	*Statistical Descriptions*, Space/Time Reference Frames	7. construct graphs of speed vs. time; distance vs. time; and acceleration vs. time.	Search for Data and their Meaning
Formulating statistical models, Synthesizing, Interpreting data	*Statistical Descriptions*, Space/Time Reference Frames, Generalized Perceptions	8. interpret the above graphs using areas and slopes as the representation of physical quantities.	Search for Data and their Meaning
Experimenting, *Analyzing systems*	*Force Fields*, *Differences and Similarities of Interactions*, Generalized Perceptions	9. compare and contrast gravitational and inertial mass.	*Longing to Know and Understand*, *Search for Data and their Meaning*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Defining operationally, Synthesizing, Experimenting, Manipulating variables	*Action Forces,* Differences and Similarities of Interactions	10. define force in terms of mass and acceleration.	*Search for Data and their Meaning, Longing to Know and Understand,* Respect for Order in Nature
Experimenting, Analyzing systems, Defining operationally	*Action Forces,* Differences and Similarities of Interactions, Generalized Perceptions	11. identify friction as a force.	*Search for Data and their Meaning,* Longing to Know and Understand, Consideration of Consequences
Defining operationally, Experimenting, Synthesizing, Manipulating variables	*Space/Time Reference Frames, Statistical Descriptions, Differences and Similarities of Interactions,* Generalized Perceptions	12. define momentum in terms of mass and velocity from empirical data.	*Longing to Know and Understand, Search for Data and their Meaning*
Synthesizing, or *Formulating statistical models*	*Generalized Perceptions, Force Fields, Space/Time Reference Frames, Differences and Similarities of Interactions*	13. combine the physical quantities of force, mass, distance, etc. and relate them to the Newtonian synthesis (Newton's three laws of motion and universal graviation).	*Respect for Logic, Respect for Order in Nature*
Analyzing systems, Defining operationally, Manipulating variables	*Space/Time Reference Frames, Generalized Perceptions*	14. define and use inertial frames of reference in discussing kinematics of motion.	*Search for Data and their Meaning, Questioning of All Things*
Defining operationally	*Differences and Similerities of Interactions*	15. list various physical properties as scalar or vector quantities.	*Longing to Know and Understand,* Respect for Logic
Analyzing systems, Manipulating variables	*Differences and Similarities of Interactions, Statistical Descriptions,* Generalized Perceptions	16. use defined parameters of heat concepts in a like manner as in kinematics to solve selected problems.	*Search for Data and their Meaning, Respect for Order in Nature*
Experimenting, Defining operationally, Manipulating variables	*Statistical Descriptions, Energy Exchange,* Energy Conservation, Differences and Similarities of Interactions, Generalized Perceptions	17. do quantitative experiments to determine: specific heats of solids and liquids, heat of fusion, heat of vaporization and mechanical equivalent of heat.	*Search for Data and their Meaning,* Developing A Commitment to Aesthetics in Nature
Measuring, Defining operationally, Recognizing variables, Manipulating variables	*Statistical Descriptions*	18. construct and calibrate a thermometer (use Celsius temperature scale).	Search for Data and their Meaning
Simulating, Measuring	Statistical Descriptions	19. construct and use a graph of Fahrenheit vs. Celsius temperatures.	Demonstrating Confidence and Satisfaction

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Formulating models, Abstracting, Analyzing systems, Interpreting data, Manipulating variables	*Generalized Perceptions, Differences and Similarities of Interactions, Action Forces*	20. formulate microscopic models to explain heat transport in fluids and solids.	*Search for Data and their Meaning, Respect for Logic*
Analyzing systems, Simulating	*Science and Technology, Energy Exchange, Energy Forms,* Energy Conservation	21. design and construct heat exchange engines or make models of them such as steam engines or refrigerators.	*Longing to Know and Understand,* Demonstrating Confidence and Satisfaction
Analyzing systems, Formulating models	*Energy Conservation, Differences and Similarities of Interactions, Generalized Perceptions*	22. interpret a graph of the Carnot cycle.	*Respect for Logic,* Valuing Scientific Heritage
Synthesizing, Experimenting, Manipulating variables	*Energy Conservation, Generalized Perceptions*	23. calculate the mechanical equivalent of heat from empirical data he has collected.	*Search for Data and their Meaning, Demand for Verification,* Valuing Scientific Heritage, Respect for Order in Nature
Formulating models, Analyzing systems, Manipulating variables	*Generalized Perceptions,* Differences and Similarities of Interactions	24. formulate a model of electricity to explain selected electrical phenomena.	*Search for Data and their Meaning*
Translating, Manipulating variables	Generalized Perceptions, Differences and Similarities of Interactions	25. use this model to describe other electrical phenomena.	*Respect for Logic*
Analyzing systems, Cognitively evaluating alternatives	*Science and Technology, Science and Society, Energy Forms,* Energy Exchange, Interdependency of Nature	26. discuss the monetary value of electrical energy used in some selected segment of society (e.g. the home, the community, a given industry) and compare the cost of that energy with the cost of providing the same amount of energy by some other means.	*Questioning of All Things, Consideration of Consequences,* Search for Data and their Meaning
Analyzing systems, Manipulating variables	*Differences and Similarities of Interactions,* Energy Conservation, Science and Technology	27. trace the path of an elementary charge through various circuits, i.e.: series, parallel and combinations of a simple nature.	*Search for Data and their Meaning, Respect for Logic*
Formulating statistical models, Defining operationally, Manipulating variables	*Statistical Descriptions, Generalized Perceptions*	28. determine the resistance of a number of conductors using meters and algebra.	*Search for Data and their Meaning, Respect for Logic, Demand for Verification*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Performing Investigations, Formulating statistical models	*Action Forces, Differences and Similarities of Interactions*, Interdependency of Nature, Generalized Perceptions	29. construct current balances to demonstrate relationships between: current conductors, separation of conductors, and number of conductors when checked against a constant force.	*Search for Data and their Meaning*, Respect for Order in Nature
Performing Investigations, Translating	*Force Fields, Statistical Descriptions*, Generalized Perceptions	30. perform an investigation to determine the nature of the force field around a charged object and solve problems using the discovered descriptions of this field.	*Search for Data and their Meaning*, Respect for Logic
Formulating models	*Space/Time Reference Frames, Action Forces*, Generalized Perceptions	31. construct both macroscopic and microscopic models for magnetic fields to explain various observed magnetic phenomena.	*Questioning of All Things, Search for Data and their Meaning*
Experimenting, Synthesizing, Translating	*Force Fields, Differences and Similarities of Interactions*, Generalized Perceptions	32. discover, state, and apply a rule for determining the direction of a magnetic field around an electric current.	*Search for Data and their Meaning*
Experimenting	*Differences and Similarities of Interactions, Force Fields, Interdependency of Nature*, Generalized Perceptions	33. demonstrate Lenz' Law.	*Search for Data and their Meaning, Respect for Logic*, Respect for Order in Nature
Formulating models, Cognitively evaluating alternatives	*Generalized Perceptions, Force Fields*	34. construct various hypotheses to explain the earth's magnetic field and other celestial magnetism citing both supportive and contrary evidence for each.	*Consideration of Premises*, Search for Data and their Meaning
Translating	*Science and Technology, Force Fields, Action Forces*	35. demonstrate how the forces on electric currents in magnetic fields are employed in meters and motors.	*Longing to Know and Understand, Demonstrating Confidence and Satisfaction*
Experimenting, Synthesizing, Translating, Defining operationally	*Energy Conservation, Science and Technology*, Energy Exchange, Generalized Perceptions	36. develop from observed phenomena an operational definition of EMF which can be used to solve various electron transport problems.	*Search for Data and their Meaning, Respect for Logic*, Consideration of Premises
Formulating models, Simulating, Analyzing systems	*Energy Exchange, Energy Conservation*, Science and Technology	37. construct a transformer and explain its operation in terms of induced current and EMF.	*Search for Data and their Meaning*, Respect for Order in Nature
Analyzing systems, Synthesizing	*Fundamental Structures, Statistical Descriptions, Differences and Similarities of Objects*	38. cite evidence for the theory that electric charge exists in discrete units and calculate the size of this unit from empirical data.	*Search for Data and their Meaning, Consideration of Premises*, Respect for Logic
Experimenting, Synthesizing, Analyzing systems	*Force Fields, Action Forces, Space/Time Reference Frames*	39. demonstrate or cite evidence for the relationship between the *force* on a charged object, its *velocity* through a magnetic field and the *strength* of the field.	*Search for Data and their Meaning, Questioning of All Things*, Consideration of Premises

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Analyzing systems, Synthesizing	*Fundamental Structures, Force Fields,* Statistical Descriptions	40. describe or demonstrate how the mass of a charged particle may be determined from data collected about its transit of an electric or magnetic field.	*Search for Data and their Meaning, Consideration of Premises*
Analyzing systems	*Force Fields, Matter/ Energy Conservation*	41. apply the concepts of electric field and potential difference to explain various phenomena involving open and closed circuits.	*Search for Data and their Meaning, Respect for Logic*
Analyzing systems	*Energy Forms,* Science and Technology	42. identify the kinds of energy: mechanical, electrical, thermal, chemical, and electromagnetic exhibited in complex systems.	Demonstrating Confidence and Satisfaction, Longing to Know and Understand
Analyzing systems	*Energy Exchange*	43. trace a transfer of energy through a cycle involving two or more changes in kind from diagrams, pictures, or demonstration.	Demonstrating Confidence and Satisfaction
Formulating statistical models, Synthesizing, *Defining operationally*	*Generalized Perceptions, Statistical Descriptions, Energy Exchange*	44. derive an expression for translational kinetic energy using mass and velocity.	*Search for Data and their Meaning, Respect for Logic*
Analyzing systems	*Energy Conservation,* Statistical Descriptions	45. identify the conservation of mechanical energy principle in systems where it is subtly hidden.	*Search for Data and their Meaning*
Analyzing systems	*Energy Conservation,* Statistical Descriptions	46. demonstrate energy conservation using interactions which involve a change in energy forms.	*Search for Data and their Meaning*
Translating	*Energy Conservation, Statistical Descriptions, Generalized Perceptions*	47. apply the principle of conservation of energy and momentum to predict the behavior of objects involved in an elastic collision.	*Demand for Verification, Respect for Logic*
Experimenting, Synthesizing	Action Forces, Generalized Perceptions	48. relate flow rate of fluids and pressure (Bernoulli's principle).	*Search for Data and their Meaning, Valuing Scientific Heritage*
Synthesizing, or Formulating statistical models	*Force Fields, Action Forces,* Statistical Descriptions, Generalized Perceptions, Science and Society	49. relate field ideas to inverse square proportionalities and equal area-equal times events. (Kepler's laws)	*Search for Data and their Meaning, Respect for Logic, Valuing Scientific Heritage*
Analyzing systems	*Differences and Similarities of Interactions, Generalized Perceptions*	50. identify selected periodic motions such as: pendulum, uniform circular motion and spring oscillator.	*Longing to Know and Understand*
Formulating models	*Differences and Similarities of Interactions, Generalized Perceptions*	51. relate periodic motions to wave motions such as: sound, light, radio, microwave, ultra-sonics and heat.	*Search for Data and their Meaning*
Analyzing systems	*Energy Exchange, Matter/ Energy Conservation*	52. compare and contrast the wave model and the particle model in describing energy transfer and other phenomena.	*Search for Data and their Meaning,* Respect for Logic

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Synethesizing	*Fundamental Structures, Statistical Descriptions*	53. trace the history of the discovery of particles, i.e. nuclear.	*Search for Data and their Meaning*, Valuing Scientific Heritage
Formulating models	*Fundamental Structures, Differences and Similarities of Objects*, Statistical Descriptions	54. identify properties of elementary particles such as: electron, proton, neutron and positron in terms of mass, size, charge and energy level.	*Search for Data and their Meaning*, Consideration of Premises
Formulating models, Analyzing systems	*Differences and Similarities of Interactions, Generalized Perceptions, Statistical Descriptions*, Action Forces, Energy Exchange, Matter/Energy Conservation	55. apply the laws learned in mechanics and in dynamics to account for the kinetic-molecular-theory for gases.	*Consideration of Premises, Respect for Logic*, Demand for Verification
Analyzing systems	*Energy Conservation*, Fundamental Structures, Statistical Descriptions	56. cite evidence to support the law of conservation of energy for the microscopic as well as macroscopic state.	*Search for Data and their Meaning, Consideration of Premises*
Manipulating variables	*Differences and Similarities of Interactions*, Statistical Descriptions	57. test the laws of relfection, refraction, diffraction and interference for light in the laboratory.	*Search for Data and their Meaning*
Synthesizing	*Differences and Similarities of Interactions*	58. extend these findings to enough other members of the electromagnetic family to show the close relationships between the members of that family.	*Search for Data and their Meaning, Demand for Verification*
Defining operationally	*Differences and Similarities of Interactions*, Statistical Descriptions	59. order the commonly recognized segments of the electromagnetic spectrum according to wavelength or frequency.	*Search for Data and their Meaning*
Experimenting	*Space/Time Reference Frames*, Differences and Similarities of Interactions	60. demonstrate total internal reflection.	Longing to Know and Understand
Formulating models, Analyzing systems	*Differences and Similarities of Interactions*, Generalized Perceptions	61. demonstrate the primciple of superposition of waves, construct a model to explain its effects and use it to explain various phenomena in sound, water and light waves.	Search for Data and their Meaning
Formulating models, Analyzing systems	*Differences and Similarities of Interactions*, Generalized Perceptions	62. demonstrate how dispersion, diffraction and interference differ and construct models to illustrate these differences.	*Search for Data and their Meaning*, Consideration of Premises
Formulating models, Interpreting data	Fundamental Structures, Action Forces, Energy Exchange, Energy Conservation	63. construct a model for electric current and defend this model in terms of both energy loss and charge movement.	*Search for Data and their Meaning*, Consideration of Premises
Analyzing systems, Formulating models	*Force Fields, Interdependency of Nature*, Generalized Perceptions	64. construct a model to explain the inter-relationship of electric and magnetic fields and use this model to describe simple electromagnetic radiation.	*Search for Data and their Meaning*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Experimenting, Formulating models	*Space/Time Reference Frames, Force Fields,* Interdependency of Nature	65. demonstrate the polarization of light and modify the model of light to explain it.	*Search for Data and their Meaning, Consideration of Premises*
Analyzing systems	Science and Technology	66. list several practical applications of electromagnetic energy to daily existence.	Consideration of Consequences, Valuing Scientific Heritage
Performing investigations	*Energy Conservation,* Generalized Perceptions	67. perform an experiment to demonstrate the photoelectric effect and construct a model to explain it.	*Consideration of Premises*
Formulating statistical models	*Energy Conservation,* Statistical Descriptions	68. relate the energy content of the various segments of the photoelectric spectrum to frequency or wavelength.	*Search for Data and their Meaning*
Performing investigations	*Differences and Similarities of Interactions, Generalized Perceptions,* Interdependency of Nature, Science and Technology, Science and Socity	69. discuss the transparency of various materials to various segments of the electromagnetic spectrum including a discussion of such phenomena as the greenhouse effect, snow blindness, Becquerel effect, radio reception, etc.	*Search for Data and their Meaning, Consideration of Premises, Consideration of Consequences*
Analyzing systems, Synthesizing	*Differences and Similarities of Interactions, Science and Technology,* Statistical Descriptions	70. describe the condition necessary for electromagnetic wave amplification by stimulated emission of radiation (maser and laser) and discuss some present and potential beneficial uses of this phenomena.	*Search for Data and their Meaning, Consideration of Consequences,* Valuing Scientific Heritage
Formulating statistical models, Analyzing systems, Cognitively evaluating alternatives	*Matter/Energy Conservation,* Generalized Perceptions	71. write nuclear equations for simple reactions and show where conservation principles apply and also where they seem to fail.	*Search for Data and their Meaning, Consideration of Premises*
Analyzing systems, Defining operationally	*Fundamental Structures, Differences and Similarities of Objects, Differences and Similarities of Interactions*	72. discuss the properties of the elementary types of radiation (alpha, beta and gamma).	*Search for Data and their Meaning*
Performing investigations, Synthesizing results	*Differences and Similarities of Interactions, Differences and Similarities of Objects,* Generalized Perceptions	73. use both the wave and particle models to describe various phenomena involving electromagnetic radiation.	*Questioning of All Things, Search for Data and their Meaning, Consideration of Premises*
Performing investigations, Synthesizing results	*Differences and Similarities of Interactions, Differences and Similarities of Objects,* Generalized Perceptions	74. use both the wave and particle models to describe various behaviors of matter.	*Questioning of All Things, Search for Data and their Meaning,* Consideration of Premises
Synthesizing results	*Generalized Perceptions*	75. construct a model of the hydrogen atom utilizing the theory of particle waves to explain nonradiating energy states.	*Search for Data and their Meaning, Consideration of Premises*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Analyzing systems or Performing investigations	*Matter/Energy Conservation*, Statistical Descriptions, Generalized Perceptions	76. solve a simple example of $E=mc^2$	*Questioning of All Things, Search for Data and their Meaning*, Consideration of Premises
Translating	*Matter/Energy Conservation*, Statistical Descriptions, Generalized Perceptions, Science and Technology	77. use the concepts of conservation of mass/energy, momentum and charge to solve a variety of real problems.	*Developing A Commitment to Aesthetics in Nature*
Analyzing systems, Synthesizing	*Differences and Similarities of Interactions*, Science and Technology	78. describe in simplified general terms the operation of an atomic particle accelerator.	*Search for Data and their Meaning*
Analyzing systems	Science and Society	79. write a paper on the advisability of peaceful uses of atomic energy.	Consideration of Consequences

3.33-E High School Objectives – Earth Science

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Interpreting data	*Energy Exchange, Energy forms,* Generalized Perceptions	1. describe the general conversion of one form of energy to another.	Search for Data and their Meaning
Analyzing systems	*Energy Exchange, Energy Forms, Energy Conservation,* Generalized Perceptions	2. trace solar energy through its various changes in driving the water cycle on earth.	*Respect for Logic, Respect for Order in Nature,* Search for Data and their Meaning
Analyzing systems or *Synthesizing results*	*Energy Exchange, Energy Forms, Energy Conservation,* Generalized Perceptions	3. illustrate by using *natural* examples: a. how energy may flow or be stored b. how energy may be transferred or transformed	*Respect for Order in Nature,* Search for Data and their Meaning
Analyzing systems, Abstracting, Interpreting data	*Force Fields, Differences and Similarities of Interactions, Space/Time Reference Frames*	4. explain why a frame of reference is important in describing the motion (or the rest state) of an object.	*Consideration of Premises,* Search for Data and their Meaning
Translating, Interpreting data	*Force Fields,* Space/Time Reference Frames	5. describe experiments that support the concepts that: a. the earth rotates on an axis b. the earth revolves around the sun	*Consideration of Premises,* Search for Data and their Meaning
Analyzing systems	*Space/Time Reference Frames*	6. cite examples of the relationship among time of day, seasons, and the motion of the earth.	*Search for Data and their Meaning,* Respect for Logic
Cognitively evaluating alternatives, Formulating models	*Generalized Perceptions, Space/Time Reference Frames,* Constant Change	7. outline several different theories for the origin of the solar system and identify at least one major flaw in each.	*Questioning of All Things, Search for Data and their Meaning, Consideration of Premises,* Valuing Scientific Heritage
Interpreting data, Measuring or *Synthesizing results*	*Statistical Descriptions,* Differences and Similarities of Objects, Differences and Similarities of Interactions	8. describe methods that can be used to find the shape, size, density, etc. of the earth.	*Valuing Scientific Heritage,* Search for Data and their Meaing
Defining operationally, Interpreting data	*Differences and Similarities of Objects, Space/Time Reference Frames,* Generalized Perceptions	9. describe some general physical characteristics of the atmosphere, hydrosphere, and lithosphere.	*Search for Data and their Meaning*
Experimenting, Analyzing systems or *Synthesizing results*	*Interdependency of Nature, Fundamental Structures*	10. discuss the relative importance of several common elements of each sphere in terms of abundance and chemical activity.	*Respect for Order in Nature, Search for Data and their Meaning*
Analyzing systems	*Differences and Similarities of Objects*	11. list the elements that occur in abundance in all three spheres.	*Respect for Order in Nature, Search for Data and their Meaning*
Synthesizing, Analyzing systems	*Differences and Similarities of Objects, Interdependency of Nature*	12. discuss the relative importance of elements common to each list in terms of their chemical role in each sphere.	*Respect for Order in Nature, Search for Data and their Meaning*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Analyzing systems, Formulating hypotheses	*Interdependency of Nature*	13. discuss the relationship between *mineral* resources and *natural* resources.	*Respect for Order in Nature*, Search for Data and their Meaning
Translating or Synthesizing results	*Energy Forms, Energy Exchange*	14. explain the theory for origin of the sun's energy.	*Search for Data and their Meaning*, Consideration of Premises
Synthesizing, Formulating models	*Differences and Similarities of Interactions, Force Fields*, Generalized Perceptions	15. correlate unequal heating, gravitation, and rotation with unequal pressure distribution and convective circulation in the atmosphere.	*Respect for Logic*, Longing to Know and Understand
Synthesizing, Formulating models	*Force Fields, Energy Exchange*, Matter/Energy Conservation	16. describe the effect of in-coming solar energy on the development of the general structure of the atmosphere.	*Search for Data and their Meaning, Respect for Order in Nature*, Consideration of Premises
Experimenting, Formulating statistical models	*Interdependency of Nature*, Space/Time Reference Frames, Generalized Perceptions	17. relate the properties of a gas in terms of temperature, pressure, and volume.	*Search for Data and their Meaning*
Formulating models, Interpreting data	*Fundamental Structures*	18. describe and give examples of moisture (water) in the atmosphere.	*Search for Data and their Meaning*
Analyzing systems, Translating, or *Synthesizing results*	*Interdependency of Nature, Force Fields*	19. describe, in his own words, how the lower part of the atmosphere produces the "greenhouse effect".	*Search for Data and their Meaning, Consideration of Consequences*
Analyzing systems, Formulating models	*Force Fields, Constant Change*, Interdependency of Nature	20. relate changes in temperature, pressure, and volume to the production of pressure cells.	*Search for Data and their Meaning*
Defining operationally, Interpreting data	*Space/Time Reference Frames*	21. define operationally warm and cold fronts in terms of air-mass movement.	*Valuing Scientific Heritage*
Synthesizing, Analyzing systems, Formulating models	*Interdependency of Nature, Force Fields*, Science and Technology	22. discuss how geographic location, topography, nearby water, population centers, etc. will influence local weather.	*Respect for Order in Nature* Search for Data and their Meaning, Consideration of Consequences
Predicting, Testing	*Differences and Similarities of Interaction Generalized Perceptions, Science and Technology*, Constant Change	23. make a 12, 24 and 36 hour weather prediction for his school's locality from weather maps for successive days.	*Consideration of Premises, Respect for Order in Nature*
Analyzing systems, Formulating models, Interpreting data	*Force Fields, Constant Change*, Action Forces, Energy Exchange, Energy Forms, Matter/Energy Conservation	24. explain several ways by which waves and currents are generated at or near the hydrosphere-atmosphere interface.	*Search for Data and their Meaning*, Consideration of Premises

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Analyzing systems, Formulating models, Interpreting data	*Force Fields, Constant Change,* Action Forces, Energy Exchange, Energy Forms, Matter/Energy Conservation	25. explain how deep water ocean currents are generated.	*Search for Data and their Meaning,* Consideration of Premises
Analyzing systems, Formulating models	Force Fields, Interdependency of Nature, Action Forces	26. discuss, in his own words, the formation of tides.	*Search for Data and their Premises, Respect for Order in Nature*
Synthesizing, Interpreting data	*Differences and Similarities of Interactions, Space/Time Reference Frames, Constant Change, Matter/Energy Conservation*	27. grossly trace the major oceanic circulation patterns on a map of the world.	*Search for Data and their Meaning, Respect for Order in Nature*
Formulating models, Defining operationally, Formulating Hypotheses or *Synthesizing results*	*Constant Change, Generalized Perceptions,* Matter/Energy Conservation, Action Forces	28. describe the major topographic features of continental shelves and ocean basins, and suggest hypotheses concerning their origin.	*Search for Data and their Meaning*
Formulaing models, Analyzing systems, Interpreting data, or *Synthesizing results*	*Constant Change, Force Fields,* Action Forces	29. list shoreline features and correlate the production of these features with wave and current activity in shallow water.	*Search for Data and their Meaning,* Respect for Order in Nature
Interpreting data, Defining operationally	*Differences and Similarities of Objects, Science and Technology*	30. identify common rock forming minerals and ores using their physical properties.	*Search for Data and their Meaning*
Classifying	*Differences and Similarities of Objects*	31. identify several unfamiliar minerals with an appropriate mineral key.	*Respect for Logic, Demonstrating Confidence and Satisfaction*
Experimenting, Interpreting data	*Differences and Similarities of Objects*	32. identify textural, structural, and compositional features in hand specimens of common rocks.	*Search for Data and their Meaning*
Formulating models, Classifying, or *Synthesizing results*	*Differences and Similarities of Objects, Constant Change,* Force Fields, Generalized Perceptions	33. classify specimens of common rocks and describe their origin in general terms.	*Search for Data and their Meaning,* Valuing Scientific Heritage
Formulating models, Analyzing systems or *Synthesizing results*	*Force Fields, Constant Change, Matter/Energy Conservation,* Generalized Perceptions	34. enumerate the sources of heat to produce a magma and trace the cooling history of a magma from its birth to the formation of a batholith and/or to the formation of volcanic mountains and plateaus.	*Respect for Logic, Search for Data and their Meaning, Consideration of Premises*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Formulating statistical models, *Analyzing systems*, or *Synthesizing results*	*Force Fields*, *Constant Change*, *Matter/Energy Conservation*, Generalized Perceptions	35. explain the origin of metamorphic rocks by discussing the temperature and pressure conditions that may be inferred at increasing depths within the earth's crust.	*Respect for Logic*, *Search for Data and their Meaning*, *Consideration of Premises*
Formulating models, Analyzing systems, or Synthesizing results	*Constant Change*, *Force Fields*, *Matter/Energy Conservation*, Generalized Perceptions	36. describe the environments where sediments may accumulate and how sedimentary rocks are formed.	*Respect for Logic*, *Search for Data and their Meaning*, Respect for Order in Nature
Synthesizing, *Formulating models*	*Constant Change*, *Matter/Energy Conservation*	37. trace a particle of matter through the rock cycle along various paths it may take.	*Respect for Logic*, *Respect for Order in Nature*
Analyzing systems, *Formulating models*, *Interpreting data*, Classifying, or *Synthesizing results*	*Differences and Similarities of Interactions*, *Constant Change*, *Force Fields*, Matter/Energy Conservation	38. explain and illustrate with examples the effects produced by major gradational processes as the shape of the earth's surface is changed.	*Search for Data and their Meaning*, *Consideration of Premises*
Synthesizing, Analyzing systems, Formulating models	*Matter/Energy Conservation*, Generalized Preceptions, Constant Change	39. illustrate with example how geologic processes tend toward an equilibrium state as the earth's surface is modified.	*Consideration of Premises*, Search for Data and their Meaning
Analyzing systems, Simulating	*Constant Change*, Force Fields	40. relate the origin of sedimentary rocks to weathering, mass movement and erosion.	*Search for Data and their Meaning*, *Consideration of Premises*
Formulating models, *Analyzing systems* or *Synthesizing results*	*Action Forces*, Statistical Descriptions	41. describe why an earthquake occurs.	*Search for Data and their Meaning*, *Consideration of Premises*
Defining operationally, *Recognizing variables*	*Differences and Similarities of Objects*, *Differences and Similarities of Interactions*	42. describe in gross terms the nature of P, S, and surface waves.	*Search for Data and their Meaning*
Formulating models, *Interpreting data* or *Synthesizing results*	*Generalized Perceptions*, Differences and Similarities of Interactions, Space/Time Reference Frames	43. explain how earthquake (seismic) wave data are used to postulate the general interior structure of the earth.	*Consideration of Premises*, *Search for Data and their Meaning*
Formulating models or *Synthesizing results*	*Interdependency of Nature*, *Generalized Perceptions*	44. formulate a model to explain the earth magnetic field.	*Consideration of Premises*, *Search for Data and their Meaning*, *Respect for Logic*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Formulating models, Interpreting data	*Force Fields, Action Forces,* Matter/Energy Conservation	45. discuss the possible relationship between vulcanism and earthquake activity.	*Search for Data and their Meaning,* Consideration of Premises
Formulating models, Analyzing systems, Interpreting data, or *Synthesizing results*	*Matter/Energy Conservation, Constant Change*	46. discuss the development of geosynclinal mountains.	*Search for Data and their Meaning, Consideration of Premises*
Analyzing systems, Interpreting data or *Synthesizing results*	*Matter/Energy Conservation,* Constant Change	47. cite evidence and explain uplift (emergence) and subsidence (submergence) of crustal blocks not necessarily associated with geosyncline mountains.	*Search for Data and their Meaning, Consideration of Premises*
Interpreting data or *Synthesizing results*	*Differences and Similarities of Interactions,* Constant Change, Matter/ Energy Conservation	48. locate the major earthquake and volcanic areas on a map of the world (past and present) and identify areas where future activity might be predictable.	*Respect for Logic, Consideration of Premises*
Interpreting data	*Constant Change, Statistical Descriptions,* Generalized Perceptions	49. explain radioactive decay and how it may be used to measure geologic time intervals.	*Search for Data and their Meaning, Consideration of Premises*
Analyzing systems	*Generalized Perceptions, Statistical Descriptions,* Constant Change	50. list several examples of how relative geologic time is measured and how relative time differs from absolute (radiometric) time.	*Search for Data and their Meaning,* Consideration of Premises
Assimilating	*Constant Change, Statistical Descriptions,* Generalized Perceptions	51. demonstrate a familiarity with the Geologic Time Scale.	Demonstrating Confidence and Satisfaction, Search for Data and their Meaning
Interpreting data	*Differences and Similarities of Objects*	52. identify common fossils and determine their mode of preservation.	Search for Data and their Meaning
Interpreting data	*Constant Change*	53. cite fossil evidence to support the theory that organisms have evolved from simple to more complex forms.	*Search for Data and their Meaning, Consideration of Premises*
Analyzing Systems, Interpreting data	*Constant Change, Differences and Similarities of Interactions*	54. illustrate by example the use of fossils as tools in interpreting earth history.	*Search for Data and their Meaning, Consideration of Premises*
Analyzing systems or *Synthesizing results,* Designing studies, Performing investigations	*Differences and Similarities of Interactions, Action Forces, Space/Time Reference Frames,* Constant Change	55. measure and describe a simple stratigraphic section, correlate this section with nearby sections, and explain any variations in sequence, rock-type, fossil content, structure, etc.	*Search for Data and their Meaning, Consideration of Premises*

Processes	Conceptual Schemes	OBJECTIVES: Dependent upon ability and past experience, the student will:	Values and Attitudes
Synthesizing	*Constant Change, Differences and Similarities of Interactions,* Generalized Perceptions	56. describe a logical sequence of events from information given in a cross-sectional diagram containing sedimentary, igenous, and metamorphic rocks by using the principles of (a) original horizontality, (b) super-position, (c) unconformity, (d) cross-cutting relationships, and (e) faunal succession.	*Consideration of Premises, Search for Data and their Meaning*
Proposing answers, Cognitively evaluating alternatives, Interpreting data	*Science and Technology, Interdependency of Nature,* Differences and Similarities of Interactions, Force Fields	57. report orally or in writing observations he has made of accelerated natural pollution of surface water (streams and lakes) in his locality and discuss ways to reduce this accelerated natural pollution in the future.	*Consideration of Consequences,* Developing A Commitment to Aesthetics in Nature
Synthesizing results	*Science and Technology, Interdependency of Nature,* Differences and Similarities of Interactions, Force Fields	58. predict problems that may develop in the future conerning the quality of water in his locality after obtaining information about the laws in his area concerning human waste disposal and interviewing public health and sanitation officials concerning the quality of surface and subsurface water in his area.	*Consideration of Consequences,* Developing A Commitment to Aesthetics in Nature
Synthesizing results, an. *Cognitively evaluating alternatives*	*Science and Technology, Interdependency of Nature, Differences and Similarities of Interactions,* Force Fields	59. predict what changes in the earth mean annual temperature may occur (remember the greenhouse effect) and how these changes may affect the natural environment if man's activity constantly increases the abundance of carbon dioxide and dust in the atmosphere.	*Consideration of Consequences,* Developing A Commitment to Aesthetics in Nature
Synthesizing results, Proposing answers, Cognitively evaluating alternatives	*Matter Conservation, Energy Conservation, Interdependency of Nature, Science and Technology*	60. distinguish between renewable and non-renewable mineral resources (giving examples of each) and suggest things that may be done to increase man's use of some non-renewable mineral resources after these resources have been used in manufacturing.	*Consideration of Consequences,* Developing A Commitment to Aesthetics in Nature
Synthesizing results	*Interdependency of Nature, Force Fields, Science and Technology*	61. construct hypotheses concerning the possible effects on future changes in the earth's surface of such technological application as damming waterways (both small and large) and underground nuclear explosions, etc.	*Consideration of Consequences,* Respect for Order in Nature

4.0 Suggested Sequences for Science Learning Experiences

4.10 General Comments about Sequence

4.11 *Need for a Coherent K–12 Program*

These Guidelines have emphasized the need to organize school science programs around a few clearly stated themes for the achievement of specific goals and the development of stated terminal student behavior patterns. To accomplish this, the total K–12 school science program must be a coherent whole. The program cannot be a series of several unrelated learning experiences but must be a sequence of many well planned and coordinated activities. All irrelevant activities and objectives must be eliminated.

4.12 Need to Personalize Instruction

The preceding does not imply that science learning experiences cannot be varied to meet the individual needs of the students. If the program is not personalized to the individual interests and real life problems of each student, it is unlikely the goals of the program will be realized. The sequence of science learning experiences must be correlated with backgrounds, stages of development, and immediate individual interests of the students if they are to discover, understand and execute their roles in a dynamic society.

4.13 *Length of the School Science Sequence*

If high school graduates are to develop responsible adult behaviors, they must have many experiences in sciencing throughout their childhood. Competency in using the processes of sciencing, comprehension of the conceptual schemes of science, and development of the values and attitudes of and toward science do not arise spontaneously. A short exposure to science in secondary school is not sufficient. Since sciencing is an inductive process, it demands the previous development of ideas in order for this synthesis to occur. Elementary students should have science learning experiences each year beginning with kindergarten, or preschool training where it exists. Such experiences should be an integral part of both the 7th and 8th grade programs. If students are to be effective members of today's and tomorrow's society, at least two years experience with science (one life and one physical or earth) in grades 9 through 12 are encouraged, although not required by State rules.

4.20 *Secondary School Science—* Action of the Commission on General Education

On May 19, 1970, the Commission on General Education of the Indiana State Board of Education acted on recommendations of the Indiana State Science Advisory Committee concerning Secondary School Science. This section (all 4.2 prefixed subsections) is a statement of that action.

4.21 *Courses Acceptable for Grades 9–12*

Course	Grade	Periods Per Week	Semester	Unit Value
Integrated (General) Science	9 to 12	5 to 7	1 or 2	.5 or 1
Biology	9 to 12	5 to 7	1 or 2	.5 or 1
Chemistry	9 to 12	5 to 7	1 or 2	.5 or 1
Earth Science	9 to 12	5 to 7	1 or 2	.5 or 1
Physics	9 to 12	5 to 7	1 or 2	.5 or 1
Physical Science	9 to 12	5 to 7	1 or 2	.5 or 1
Applied Physical Science	9 to 12	5 to 7	1 or 2	.5 or 1
Applied Life Science	9 to 12	5 to 7	1 or 2	.5 or 1
Advanced Science				
Advanced Integrated Science	11 or 12	5 to 7	1 or 2	.5 or 1
Advanced Biology	11 or 12	5 to 7	1 or 2	.5 to 1
Advanced Chemistry	11 or 12	5 to 7	1 or 2	.5 or 1
Advanced Earth Science	11 or 12	5 to 7	1 or 2	.5 or 1
Advanced Physics	11 or 12	5 to 7	1 or 2	.5 or 1
Integrated Science Sequence				
Integrated Science I	9 to 12	5 to 7	1 or 2	.5 or 1
Integrated Science II	10 to 12	5 to 7	1 or 2	.5 or 1
Integrated Science III	11 or 12	5 to 7	1 or 2	.5 or 1
Integrated Science IV	12	5 to 7	1 or 2	.5 or 1

4.22 *Course Descriptions for Above Course Titles*

Integrated (General) Science This course may serve as a terminal science course or as an initial high school course intended to develop a solid foundation for the study of Biology, Chemistry, Physics and/or Earth Science. The course should involve a study of basic concepts drawn from the biological, physical and earth sciences. It should stress the processes that man uses to understand, control and adapt to his environment.

Biology An investigative study of the structures and functions of living organisms, their interactions with the environment and the interdependence of populations and individuals.

Chemistry An investigative study of matter and its chemical interactions. This study should normally be organized around the concepts of atomic structure, bonding, stoichiometry (the quantitative study of chemical reactions) and other changes that accompany chemical reactions. Whenever practical, examples should be chosen which illustrate everyday chemical change.

Earth Science A broad study of the lithosphere (the solid earth), atmosphere and hydrosphere of the earth including a study of celestial phenomena as they affect the earth with emphasis on the energy at work to form and modify earth materials, landforms and continents through geologic time. Laboratory study, field trips and local geological features should be used in the study whenever feasible.

Physics An investigative study and synthesis of the fundamental concepts of mechanics, wave motion, heat, light, electricity, magnetism, electromagnetism and modern physics. Not only should examples be drawn from everyday experiences whenever possible, but also from celestial phenomena.

Physical Science An investigative study of the basic concepts of chemistry, physics and related sciences which may serve as a terminal course in the physical science or a foundation course for a more sophisticated study of Biology, Chemistry, Physics and/or Earth Science.

Applied Physical Science—A terminal course in physical science dealing with the principles of physical science as they apply to technology and everyday life. This course is recommended only for those students who can better profit from it than from the above courses in physical science.

Applied Life Science—A terminal course in biological science dealing with biological principles as they apply to personal hygiene and the physical well-being of the student and his community. This course is recommended only for those students who can better profit from it than from the standard biology course.

Advanced Science.—All advanced science courses should place emphasis on scientific literacy, the unifying themes of scientific knowledge (i.e. the conservation of matter and energy, the particulate nature of matter, the interdependency of nature, etc.) and the methods of scientific inquiry. This should be true even for those courses which employ an advanced concentrated study in a single discipline as a vehicle. Except for students who enter an advanced science course from an integrated science sequence, it is strongly recommended that previous work in both biological and physical science be made prerequisite to enrollment in any advanced science course.

Advanced Integrated Science A course for use in schools without an integrated science sequence. It should extend the basic concepts underlying all of the sciences to develop comprehensive theoretical models useful in testing the hypotheses of the conservation principles.

Advanced Biology An extended investigation into the activities and interactions of living organisms by the development and refinements of the methods of scientific inquiry.

Advanced Chemistry An extended investigation of chemical interactions of matter in living and nonliving materials stressing the unifying themes of chemistry and the methods of scientific inquiry.

Advanced Earth Science An extended study of earth science topics utilizing and synthesizing concepts from other scientific disciplines. The course may be broad in the subject matter coverage or may be an in-depth study of specific areas of earth science.

Advanced Physics An extended investigation of fundamental concepts and the methods by which they are synthesized into theoretical models for the study of interacting systems of the macro and micro cosmos.

The Integrated Science Sequence To eliminate the unnecessary duplication and to stress the interrelationships of the various sciences, local schools are encouraged to develop a sequence of integrated science courses for grades 9 through 12. This sequence shall involve an investigative study of common basic science concepts drawn from the biological, physical and earth sciences. The length of the sequence may vary from two to eight semesters, but the entire sequence must be coordinated to provide a balanced treatment of the various science disciplines. It should also be designed so the student can terminate his science study after completing any year of the Integrated Science Sequence with a properly balanced science program. Since this sequence will be experimental, prior approval of the proposed course of study must be obtained from the Department of Public Instruction.

4.23 *General Rules Concerning Senior High Science*

The above courses are approved for all high schools for the grade and credit indicated with the following additional limitations:

1. Each course should be taught as a laboratory science as required by Rules G-1 and G-3. A laboratory science is any course devoted to the study of the natural sciences in which a minimum of 20% of the total instructional time is devoted to laboratory activities. Laboratory activities are defined as activities in which students use appropriate equipment and materials to perform investigations germane to the subject.
2. The minimum graduation requirement of one unit of laboratory science (Rule G-1) may be satisfied by

any of the courses other than Integrated Science II, III or IV or those listed under Advanced Science, but two semesters of satisfactory work in a particular course must be completed to meet this minimum requirement.

Where there is a good reason to offer other specialized and applied science courses as advanced 11th or 12th grade subjects, permission to offer such courses must be requested from the Department of Public Instruction. This requirement is waived for Aeronautics, Botany, Electricity, Physiography, Radio and Zoology through the 1970-71 school year.

4.24 *Suggested Programs of Studies for Seventh, Eighth and Ninth Grades*

-Science-

7th grade	. . . . 3-5 periods per week
8th grade	. . . . 3-5 periods per week
9th grade	. . . . 5-7 periods per week

Science in Grades 7 through 9 should be designed as a sequential program including, but not limited to, study in the life and physical sciences and should include laboratory work at all grade levels. Ninth grade science courses should be so designed that they meet the requirements for a laboratory science course as outlined in Rule G-1. (See General Rule 1 in 4.23)

4.30 **Performance Objectives List and Course Design**

Perhaps a few words are needed concerning the four or five strands of performance objectives in 3.31 through 3.33 and their use in course designs. This is particularly true regarding the senior high school courses since the committee did not develop a separate list of objectives for each course listed in 4.21. Since related questions may arise at the elementary and junior high levels, some comments concerning the use of these objectives at all levels are appropriate.

4.31 *The Elementary School Science Program*

The committee believes that the format of the objective list is such that it can provide guidance to teachers using various elementary science curriculum organizational patterns–from the more traditional unit approach to the various recently developed systems approaches. In all cases, however, elementary programs should focus on sciencing rather than learning about science through verbal instruction only. This sciencing should involve all aspects of the students' interest in nature. This interest, particularly with children in the elementary years, cannot be campartmentalized into single areas of science for long periods of time; therefore, elementary science programs should interweave all four strands as student interest and ability demand. The only limitation should be student background and maturation, i.e., readiness and ability to perform the processes of sciencing.

4.32 *The Junior High School Science Program*

There are two, perhaps three, distinct organizational patterns employed in designing junior high school science programs. Until a little over a decade ago, the most common practice involved General Science in the 7th and 8th grades followed by either a third year of General Science or Biology in the 9th grade.

Over the last decade, due to three major factors the improved elementary programs, the introduction of molecular biology into high school courses, and the influx of discipline trained secondary teachers into 7th and 8th grade science classes–there has been a gradual drift away from this organizational pattern. The trend has been toward what is often referred to as either a *sequence* or *block* program, i.e., a year of life science, a year of earth and space science and a year of physical science (chemistry and physics). The usual pattern has been to place the life science at the 7th grade with the grade placement of the other two blocks depending on local rationale and staff assignments.

During the last five years, many educators have begun to re-examine the junior high science program. Their conclusion has been that this arrangement does not necessarily produce a coherent, comprehensive science program for the junior high school. They have not advocated returning to the general science approach which was seldom little more than a series of minicourses. Instead, they are recommending a reorganization of the junior high science program around unifying themes utilizing subject matter from each science discipline as it supports these themes. This approach is generally referred to as a *unified* or *integrated* approach.

Although, as a body, the committee felt this latter approach is probably best, it realized that teacher preparation and availability of materials presently hinders its usage in many schools; consequently, it has taken the middle ground of *not stating a preference between the block or the integrated approaches.*

If the block approach is used, the strand structure in 3.32 is easily employable in course design. The appropriate subject matter strand would be utilized with the addition of appropriate objectives from the general strand.

If the integrated approach is chosen, the problem is a bit more complex since it will necessitate interweaving all four strands into each course. Additional coordinated planning will be required to assure that the total junior high program is comprehensive without being redundant. Planning is necessary if science is to be developed as a coherent intelligent enterprise with a logical student orderliness. Of course, similar planning would be necessary with regard to the general strand in the block approach.

4.33 *The Use of the Strands in Senior High School Science Course Design*

From the course titles listed in 4.21 and the course descriptions in 4.22, it is apparent that there are several alternative routes available to senior high schools in providing an adequate program. These routes are discussed in 4.34. The selection of performance objectives from the five strands in planning senior high science courses is discussed in this section.

How these strands may be employed in planning the courses of Biology, Chemistry, Earth Science, Physics, Advanced Biology. Advanced Chemistry, Advanced Earth Science and Advanced Physics is the most obvious. The appropriate content strand would be employed with relevant objectives from the general strand interwoven. As mentioned in 3.22, selection of those objectives appropriate to introductory courses and advanced courses will depend somewhat on the local situation and student ability. Each of the four strands was constructed with enough depth to go beyond the scope of any introductory course. Two possibilities are open to schools offering an introductory course and an advanced course. (1) They can be selective, if adequately comprehensive, in planning the introductory course and reserve certain specific but more advanced objectives for the advanced course. (2) They can cover most of the objectives in the introductory course and return to those with a potential for greater in-depth investigation in advanced courses. The latter is perhaps the better approach with the instructional objectives being considerably different for the advanced course in terms of conditions and criteria of acceptable performance. In fact, this approach was considered when two sets of processes were listed in column 1. The first set is appropriate for an introductory course and the second for an advanced course. Of course, these alternatives can also provide for differences in student ability in indtroductory courses.

An Integrated (General) Science course will involve the selection and interweaving of objectives appropriate for the student population from all five strands. If this course is used as base for specific discipline courses, coordinated departmental planning is required.

An Advanced Integrated Science course requires coordinating the planning with that for the prerequisite courses. It also involves selecting and interweaving those objectives from all five strands which contribute to the goals of the course and which have a potential for greater in-depth investigation than undertaken in the introductory courses.

From the course description, it should be apparent that a Physical Science course should draw appropriate objectives from the general, chemistry and physics strands with perhaps a few selected ones from the earth science strand. Again, if it is used as base for a more sophisticated study of biology, chemistry, earth science and/or physics, coordinated departmental planning is a must.

The Applied Life and Applied Physical Science course will involve objectives from the general strand plus the appropriate subject matter strand(s). Those selected would be limited by the purposes of the courses. Some of the objectives included in the Junior High-Middle School list may need to be included. Although the performance objectives of those two courses may be similar to those for biology and physical science, the instructional objectives and strategies will be considerably different.

Development of an Integrated Sequence will demand coordinated departmental planning to properly mix and sequence objectives from all five strands into a coherent 9-12 science program.

4.34 *Suggested Course Sequences for Secondary School Science*

To meet their varied needs, several possible science course sequences should be provided for secondary students. These needs range from merely living in today's dynamic society through making decisions about social and political issues to pursuing careers in science and technology. Some possible sequences are suggested by Chart 4.1

Two ideas have been incorporated into this chart as well as in the grade level designation for the various courses in 4.21 that differ somewhat from the conventional approach to sequencing senior high school science courses.

First, and perhaps most important, is the removal of any restrictions on the ordering of biology, chemistry, earth science, and physics. Although the conventional sequence has been earth science (if offered), biology, chemistry and physics, in terms of one course supporting another, this order is a complete reverse of logic. Additionally, when students are allowed freedom in ordering these courses, there is some evidence that problems of decreasing enrollments are reduced. Teaching physics or chemistry to freshmen or sophomores will demand considerable change in instructional objectives and strategies, but such change may actually provide more relevant chemistry and physics programs.

Second, it should be noted that by providing an applied course in both life and physical science, the possibility of a minor in science exists for the slow learner.

Another explanation is needed. The Integrated Sequence should not be considered as a fourth sequence but rather an alternate for any or all of the other three sequences. In fact, if assignments, i.e. instructional objectives and strategies, are sufficiently personalized, a single integrated sequence could embody all three of the other sequences.

Chart 4.1 SECONDARY SCIENCE SEQUENCE CHART

Grade	7	8	9	10	11	12
Basic Sequence	Basic 7	Science 8	Applied	Life Science Applied	and Physical	Science
Standard Sequences	Science 7	8	Integrated (General) Science or Physical Science	1 to 4 units of Biology, Chemistry, Earth Science or Physics		
Science or Technical Career Sequence	Science 7	8	2 or 3 units of the 5 courses in the Normal Sequence			1 or 2 units of Advanced Science
Integrated Sequence	INTEGRATED SCIENCE 7	8	I	I or II	I, II or III	II, III, or IV

Heavy solid lines indicate more rigid separations in the chart, the light solid line indicates flexibility in a sequence while the vertical dashed lines indicate flexibility in terms of the grade placement of courses. The arrows indicate that students may shift from one sequence to another if interests and ability assessments change.

5.0 Practical Tools and Suggestions

As the committee considered what should be included in these Guidelines, it recognized a need for certain types of material that did not neatly fit into the central themes developed to this point. These materials were grouped under the heading "Practical Tools and Suggestions" and placed in their own distinct section. As the publication developed, it became apparent that these items must be limited in number to keep the Guidelines to manageable size. The three that remain follow.

5.10 Guidelines for the Selection of Science Textbooks

The increased emphasis on active student involvement in science learning has not eliminated the need for the science textbook. It has, however, increased the need for definite selection criteria.

The evaluation instrument should be so constructed that irrelevant criteria can be ignored without affecting its validity. It should also permit the reviewer to express himself beyond marking words or numbers on a scale. However, any compilation necessitates the use of some type of scale. This scale needs to be simple, flexible and easily interpreted.

The following suggested instrument requires the rating of only eight categories (nine when a series of texts is being reviewed). It provides the reviewer some direction by outlining points for consideration under each category.

The space for statements concerning special strengths or weaknesses permits the reviewer to record his special feelings. This information is often valuable in the final selection decision.

All persons concerned with the use of the text should be involved in the selection process. Every teacher who will use the textbook should have the opportunity to help in the evaluation. Principals should be provided information which will keep them apprised of the available materials in the subject area. Students and parents can often focus attention on other items for review since they may be free of some of the biases of professional educators.

Since educators are being held more accountable for their actions, the results of local textbook evaluation should be reported and kept accessible for review. Completed evaluation forms and tabulations should remain on file throughout the adoption period.

5.11 SUGGESTED SCIENCE TEXTBOOK EVALUATION INSTRUMENT

Name of course (grade level) ______________________________

Title of book ______________________________

Author(s) ______________________________

Publisher ______________________________ Copyright Date ______________.

Reviewer ______________________________ Date ______________

DIRECTIONS:

First familiarize yourself generally with the make-up and contents of the textbook. Then, after becoming familiar with "points to consider" under each of the categories, i.e. philosophy, subject matter content, presentation, etc., evaluate the text more closely and rate it as superior, very good, average, poor or unsatisfactory in each category.

Any outstanding strength or weakness of the text in any particular category should be indicated in the alloted space following that category. Also, if you rate the text as superior or unsatisfactory in any category, justify this rating in this same space. These comments are as valuable, if not more valuable in decision making, as the ratings.

There may be situations where certain points to consider are not applicable. If this is the case, simply ignore these points.

Finally, respond to the summary items at the end of this instrument.

THE INSTRUMENT

I. Philosophy

Points to consider in evaluating the philosophy of this text are that it:

A. Harmonizes with your school's philosophy and course of study as well as those of the state,

B. Presents topics in a manner which displays the underlying organizational structure of the subject matter,

C. Encourages students to think out solutions rather than merely memorize details,

D. Includes unique contributions of minority groups and presents material in a manner that is acceptable to various ethnic groups.

E. Treats controversial subjects impartially.

After thorough review, my appraisal of the philosophy of this text is:

Superior __________ Very Good __________ Average __________ Poor __________ Unsatisfactory ____

The outstanding strengths or weaknesses in the philosophy of this text are:

____

____

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____

II. Subject Matter-Content

Points to consider in evaluating the content of this text are that it:

A. Has sufficient scope to adequately cover all desired topics,

B. Provides a proper balance of various types of subject matter,

C. Uses fundamental principles correctly and consistently,

D. Relates to the real world of the student, i.e. his environment, general interests and activities,

E. Gives attention to the historical development of science either in the narrative or notes and reading references,

F. Contains topics dealing with recent advances in science and technology,

G. Provides for consideration of the social significance of science,

H. Gives adequate treatment to career aspects of science,

I. Contains an adequate number of problems, experiments and other activities varied enough in difficulty to provide for a wide range of student abilities,

J. Correlates with State objectives for the course or grade,

After thorough review, my appraisal of this text's content is:

Superior ____________ Very Good ____________ Average ____________ Poor ____________ Unsatisfactory ______

The outstanding strengths and weaknesses in this text's content are:

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III. Organization

Points to consider in evaluating the organization of this text are that it:

A. Utilizes a single theme or a few well chosen ones to correlate the material presented.

B. Presents topics in a satisfactory sequence, i.e. one which facilitates learning.

C. Clearly defines lessons of appropriate length and difficulty,

D. Is organized into chapters, sections and/or units of appropriate length, difficulty and content,

E. Is organized so it is adaptable for use with students of varied abilities and backgrounds.

F. Is arranged so certain sections can be omitted,

G. Is adaptable to various types in teaching (group study, team teaching, self study, project method, etc.

H. Easily correlates with other materials to permit a coherent K-12 science program.

After thorough review, my appraisal of this text's organization is:

Superior ____________ Very Good ____________ Average ____________ Poor ____________ Unsatisfactory ______

The outstanding strengths and weaknesses of this text's organization are:

IV. Presentation of Material

Points to consider in evaluating this text's presentation of material are that it:

A. Uses a language level appropriate for its intended readers,

B. Presents material in a clear, concise and interesting manner which will encourage a continued interest in the subject.

C. Develops principles as intuitive concepts rather than stating them as facts,

D. Is consistent in its use of terminology,

E. Presents explanatory material clearly and precisely,

F. Uses well-chosen examples and illustrations which are properly applied,

G. Avoids overuse of personal attributes in discussing inanimate objects,

H. Uses realistic, current problems, etc. in a manner in which the student can understand and follow,

I. Uses realistic, current problems and reference situations,

J. Presents questions, problems, etc. in a manner in which the student can understand and follow,

K. Provides opportunities for independent and creative thinking,

L. Provides opportunities for inductive and deductive reasoning,

M. Provides opportunities for the use of science as a problem solving tool,

N. Does not contain errors of fact or statement. Cite page and line for any such errors uncovered.

After thorough review, my appraisal of this text's presentation of material is:

Superior ________ Very good ________ Average ________ Poor ________ Unsatisfactory ________

The outstanding strengths or weaknesses in this text's presentation of material are:

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V. **Authorship and Copyright Date**

Points to consider about the author(s) of this text are that he (they):

A. Has professional experience at the particular academic level,

B. Has tested his material in classroom situations,

C. Has received assistance from specialists in preparing the material,

D. Represents a general philosophy of education that is compatible with that of your school and school corporation. If not, briefly explain the difference.

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Points to consider in evaluating the copyright date of this text are that it:

E. Contains current material as indicated by a copyright not more than two years old (if over 2 years, evaluate very carefully),

F. Has undergone significant change or a major revision with latest copyright, i.e. includes provisions for utilizing latest teaching procedures, technology, experimental data and discoveries,

G. Is up-to-date, not obsolete with modern information merely added.

After thorough review, my appraisal of the authorship and copyright date of this text is:

Superior ________ Very good ________ Average ________ Poor ________ Unsatisfactory ________

The outstanding strengths or weaknesses concerning the authorship and copyright date of this text are:

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VI. **Physical Characteristics**

Points to consider in evaluating the physical make-up of this text are that it:

A. Is pri ed in type (size) suitable for grade level,

B. Employs open, attractive and uncluttered page layouts,

C. Makes attractive and functional use of color,

D. Is illustrated with adequate charts, graphs, diagrams, drawings and photographs which are clear, attractive, meaningful, up-to-date, adequately labeled and properly placed,

E. Is printed on quality, serviceable paper,

F. Is substantially and adequately bound for the handling and use the book will receive.

After thorough review, my appraisal of this text's physical characteristics is:

Superior ________ Very good ________ Average ________ Poor ________ Unsatisfactory ________

The outstanding strengths or weaknesses of the physical characteristics of this text are:

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VII. **Aids for Locating Information**

Points to consi er in evaluating the ease of finding material in the text are that it:

A. Contains a comprehensive and accurate index. If inaccurate citations are found, identify the specific citations. ____

____

B. Contains an adequate glossary of terms,

C. Contains adequate tables, etc. in appendix,

D. Has materials arranged in a manner so that scope and the objectives of lessons, units and sections are clear,

E. Contains a useful table of content,

F. Is adequately cross-referenced,

G. Includes adequate bibliography in terms of both scope and content.

After thorough review, my appraisal of the aids for locating information in this text is:

Superior ________ Very good ________ Average ________ Poor ________ Unsatisfactory ________

The outstanding strengths or weaknesses of the aids for locating information in this text are:

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VIII. Services and Supplemental Materials

Points to consider in evaluating the supplementary material available with this text are that:

A. There is a Teacher's Edition available which:

1. Is arranged conveniently for effective use,
2. Identifies and defines objectives for lessons, chapters, units and course,
3. Suggests a variety of classroom strategies,
4. Lists suggestions and materials for diagnostic and remedial work,
5. Lists activities, games and projects for enrichment for all ability levels,
6. Identifies sources of supplementary materials (various media),
7. Identifies equipment and material needed for student activities.

B. The text is supplemented by:

1. Coordinated test booklets,
2. Accompanying audio-visual aids such as records, filmstrips, transparancies, tapes, charts, etc.,
3. Challenging workbooks that reinforce major concepts.

C. If not incorporated into the text, supplementary materials are available for:

1. Remedial and enrichment work,
2. Self instruction in manipulative and computational skills,
3. Coordinated laboratory experiences.

After thorough review, my appraisal of the services and supplemental materials for this text is:

Superior ________ Very good ________ Average ________ Poor ________ Unsatisfactory ________

The outstanding strengths or weaknesses in the services and supplemental materials for this text are:

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IX. Series Content and Coordination (To be used when evaluating a coordinated textbook series such as an Elementary or Junior High series.)

Points to consider in evaluating the series of texts are that the series:

A. Was either written by a common author (or team) or coordinated by a lead author (or editor) to assure an orderly development of the subject,

B. Comprehensively covers the subject with no unrealistic gaps,

C. Provides for the continual synthesis of basic data and concepts into a more generalized conceptual framework,

D. Encourages the continual development of the students' mental processes,

E. Provides for the development of healthy attitudes and values,

F. Creates an interest in the subject which will continue into adult life,

G. Introduces concepts at appropriate grade levels for student comprehension in terms of our best knowledge of child growth and development,

H. Has no unduly weak member in terms of the previous sections of this instrument,

I. Has no units which do not contribute to the central theme(s) used in developing a coherent, sequential science program.

After thorough review, my appraisal of this series of texts is:

Superior ________ Very good ________ Average ________ Poor ________ Unsatisfactory ________

The outstanding strengths or weaknesses of this series are:

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Summary

Areas of greatest usefulness: (If acceptable for general use in these four categories, so indicate.)

1. Type of school ______
2. Type of student ______
3. Grade level for most effective use (for High School texts only) ______
4. Any special teacher training needed for effectively using these materials ______

The outstanding strengths of text (or series) are:

______

The outstanding weaknesses of text (or series) are:

______

Comments about this text (or series) omitted elsewhere are:

______

Adoption Recommendation

After thorough review of all aspects of this text (or series), for adoption, my rating of it is:

Highly Recommend ______ Recommend ______ Not Recommend ______

Considering all of the books I have reviewed in this category, my ranking of this text (or series) is:

1st ______ 2nd ______ 3rd ______ 4th ______ 5th ______ 6th ______ 7th ______

Other (give rank) ______

5.20 Safety in Science

Since science requires the learner to play an active role in the learning process, the student needs a workroom where he can control the conditions of his observations and investigate a variety of problems. In this workroom the student will use a wide variety of manipulative equipment, living organisms, glassware, chemicals, and many types of scientific apparatus. All of these may be potentially dangerous if handled improperly; thus it is essential that safety practices must be a part of science learning.

All students must develop sensible attitudes about safety precautions in sciencing. Attitudes determine behavior and cannot be taught as abstraction but must be built from actual learning experiences. Simple explanations of what not to do must be reinforced with understandable reasons. Safety attitudes cannot be left to chance. The school must guide students toward those meanings and behaviors which produce safety for the individual and society. The school must accept the responsibility for a safety program beyond the traditional campaign aimed at pedestrian, hallway and driver safety.

The school should develop and implement a comprehensive safety program as an integral part of the science program. This program should be implemented and supported by an administrative policy statement. The program should include:

1. A continuous preventive educational program for each level and area of science, K–12.
2. Procedures and instructions concerning potential hazards common to science classes. These hazards include caustic and explosive material, liquids and solids at extreme temperatures, toxic fumes, poisons, sharp objects, electrical circuits, radiation sources, etc.
3. Signs identifying hazards and reminding students of safe practices.
4. First aid kits with written procedures for first aid treatment for every teacher.
5. Programs for supervision and monitoring students for compliance with safety regulations.
6. Well kept records of school accidents to identify specific hazard areas and improve precautionary practices.
7. Rooms, furniture, and equipment designed to include provisions for safety in science rooms.

Science teachers must be safety minded at all times. Teachers must set the example for students by following the safety rules themselves such as wearing eye protective devices. In addition, each school should have a policy for appropriate, impartial disciplinary action for willful violation of safety rules.

The following are a few questions that science teachers could consider in devising safety procedures for their course:

1. Do I have rules for good housekeeping?
2. Are materials arranged in an orderly fashion?
3. Are materials labeled correctly and safely stored?
4. Do the students practice safe methods of manipulation—lighting a burner; cutting and bending glass; heating, cooling and pouring, inserting tubing into stoppers and diluting acids?
5. Do the students know the functions of the tools they use and how to safely use them?
6. Is the activity a reasonable, safe one and have the students been instructed as to any special hazards?
7. Do the students use the protective gear when applicable—eye safety devices, aprons, shields, fume hoods, etc.?
8. Are there proper disposal arrangements for broken glass, spilled liquids, dissected animal materials, cultures, etc?
9. Are the plants and animals used in the classroom safe and do they receive humane and considerate care?
10. Do animals have a proper habitat and food and are they secured in a clean environment, free from contamination?
11. Before field trips are taken, are hazardous plants and animals identified?
12. Do any of the activities promote undesirable physiological or psychological effects upon students?

5.30 Facilities for Science Instruction

Science learning facilities should be congruous with existing or anticipated programs yet have flexibility for meeting uncertain future needs. Providing such facilities requires comprehensive knowledge and understanding of the variety of components comprising the total facilities system. These facilities must not be viewed simply in terms of their supporting role in the science program, but as a part of the total learning environment of the student. Thus the purpose here is to present guidelines that will be useful both in the development of new science teaching facilities and in the modification of existing ones.

General Considerations

Since sciencing should be student-centered and student-directed with the teacher cast in the role of a resource person or coordinator of activities, facilities must be designed to provide space and equipment for a variety of student investigations and experiments.

If science programs are to meet the needs of students at all levels of ability and interest, facilities and equipment should have the flexibility to permit each student to participate in activities appropriate to his own capabilities and interests. These diverse needs may be met more effectively by the merging of certain subjects or the addition of new ones. The science facilities must be adaptable to change. Adequate space and facilities must be available to accomodate and to encourage the development of extended individual or group projects without the normal instructional programs being hindered. Facilities for science instructions should be planned so the demands of increased enrollment or the addition of new and special equipment will not require extensive modification.

It is imperative that careful attention be given to those features which will result in a minimum of confusion and a maximum of safety. Both students and teachers should be able to move about without undue restriction. Safety demands a design which reflects consideration of not only the common kinds of accidents, but all possible dangers. It should not be assumed that students will always handle equipment in the proper way. Thought should be given to the ways in which the equipment *might* be abused and the equipment designed accordingly. The design of storage facilities is important in this regard, especially when dealing with chemicals that are potentially hazardous. Electrical equipment that constitutes possible shock hazards *must* have a provision for proper grounding. Electrical outlets should be located with both convenience and safety in mind.

Selection of construction materials should reflect the variable durability requirements of various elements of the facilities system. Careful planning in advance will increase the probability of attaining a desirable balance between durability and economy.

Regardless of grade level, all science requires equipment which students can manipulate. Whether the equipment is manufactured commercially or in the local school facilities, it must allow for ease of manipulation and have long-range durability.

Every science facility should contain or have access to areas for the construction, maintenance and modofication of apparatus and equipment. Often school shop facilities may meet this demand; nevertheless, a basic set of tools should be available in the immediate area, especially at the secondary level.

Personalizing instruction has placed an increased emphasis on the multi-media approach to instruction. This type of instruction demands provisions for the use of audio-visual materials, the mass media, programmed instruction materials and other appropriate aids. These should be available for use by individuals or small groups as well as by the whole class. Lighting arrangements should be such that individuals can view film loops or slides, etc. without interfering with the activities of other students.

To encourage students to work independently and to develop their own ideas and projects, access to resource materials such as journals, magazines, scientific reports, etc. should be relatively easy. Unnecessary duplication of school library facilities is not recommended, but the student will find more incentive to explore new areas and ideas when appropriate supporting material is available in his working environment. Space should be provided for the study of these materials with a minimum of distraction.

All school facilities should be designed so the teacher, as well as the student, can function. Space *must* be provided for the teacher to plan activities, grade papers, prepare reports, etc. with minimum interruption. Equally important is the necessity for private conferences with individuals or small groups of students and with parents or other visitors. Facilities should be designed so normal classroom activities can proceed with a minimum distraction while the teacher conducts these conferences.

Science facilities should reflect the contribution of a broad range of expertise and experience. The planning of facilities should involve school administrators, school board members and laymen in the community in addition to science teachers, supervisors, science educators, specialists and architects. This kind of joint effort will likely prevent developing the unworkable, inflexible facilities which often result when a few individuals representing a restricted point of view plan facilities.

Special Considerations

The above guidelines are, for the most part, general enough to be appropriate for all grade levels, K-12. There are, however, certain unique requirements for each grade level or range of grade levels. For present purposes, it seems appropriate to separate these requirements into two broad categories—elementary and secondary. Detailed consideration of the topics touched upon here can be found in various publications (1, 2, 3) and in planning manuals from the various laboratory furniture suppliers.

Science Facilities for the Elementary School

Perhaps the most notable distinction between the requirements for elementary school science facilties and those of the secondary school is that elementary school instruction is, for the most part, carried on in a self-contained classroom or area. A few schools have developed elementary science centers or, in departmentalized arrangements, elementary science laboratories. The latter are more prevalent in grades four, five and six. The most serious restriction on the self-contained classroom is the limited area available for activities and for storage of materials. Therefore, the primary emphasis in the planning for such facilities should be flexibility.

Minimum requirements for the science program in a self-contained classroom include: a work counter with one or more sinks provided with hot and cold water, convenient electrical outlets to supply 110–120 volts AC, sources of heat (such as liquid fuel burners), low-voltage sources and/or dry cells and sufficient space for such things as terrariums and growing plants. It is essential that the furniture be movable to accomodate a variety of activities and be of a quality to resist almost certain abuse. While safety is of paramount importance at this level, it is also *essential* that the students be allowed to manipulate a variety of materials and equipment. It is strongly recommended that a child development specialist be involved in planning facilities for the beginning grades. Students at these early levels need sensory and manipulative experiences and the facilities should provide for these needs.

Secondary School Science Facilities

Secondary school science facilities should be brought together in a single area in the school plant. A science wing or science suite is preferable to single-room laboratories which isolate various sciences from one another.

Well planned centralized science facilities eliminate the duplication of expensive equipment. Only one set of basic equipment is required. Such expensive items as centrifuges, milligram balances and oscilloscopes become readily available to all disciplines. Reduced equipment requirements make possible better equipped laboratories. Central supply areas, specialized equipment such as fume hoods and other safety equipment and continuously ventilated bulk chemical storage cabinets can be placed near the point of use. However, delicate and electronic equipment which might be affected by chemical fumes should be stored in a storage area separated from the one used for chemicals.

Adequate space should be allocated for extended student investigations and projects within the suite. Portable fume hoods, a stove, a refrigerator, a plant-growing case with climate control, an animal growing case aerated to the outside, a darkroom area, reference book shelves, a preparation area and portable demonstration tables with service leads should be among the facilities.

Space should be provided for the instructors to experiment, prepare and perform other managerial duties. Mobile demonstration tables should be available for advance preparation of materials for use during lectures and small-group discussions. The assembled demonstration equipment can then be transported to the instructional areas eliminating the need for hasty set-ups between classes.

Large and small group instruction areas with service islands or connections, media facilities and a science instructional materials center should also be in close proximity to the laboratories.

1. *Science Facilities for Our Schools K-12*. National Science Teachers Association, Washington, D.C., 1963.

2. *School Facilities for Science Instruction*. National Science Teachers Association, Washington, D. C., 2nd edition, 1961, 266 pages.

3. "New Shapes For The New Sciences," *School Management*, Vol. 12, No. 4, April 1968, pp. 14-21.

6.0 Annotated Bibliography

Introduction

Any attempt to provide a complete listing and description of all pertinent and valuable material would be fruitless as well as infinite in both time and frustration.

This section therefore contains several categories of possible interest, and an attempt has been made to classify publications in discreet categories. Although this is impossible at times due to the nature of the material, the classification approach should be useful in efficiently locating desired material.

The listings presented here represent only those materials useful in constructing programs and developing a basic framework from which to operate. Regular perusal of current and future magazine and journal articles will be necessary if one is to keep up with research and developments which will be of value to the individual.

Finally, those publications which are mostly or entirely pertinent to recent and current science curricula are not included.

Performance Objectives in Science Programs

Bloom Benjamin S. (Ed.), *Taxonomy of Educational Objectives, Handbook I: Cognotive Domain,* David McKay Company, Inc., New York, 1956.

A most useful description of six classifications of cognitive behavior. Valuable for specification of educational goals as well as evaluation.

Eiss, Albert F. and Harbeck, Mary B., *Behavioral Objectives in the Affective Domain,* National Science Supervisors Association, Washington, D.C. 1969.

A concise presentation of affect in science instruction. It is particularly concerned with those science-related values held by pupils, and provides examples of affective objectives and evaluation techniques to determine the success of the science program in producing the desired affective outcomes.

Esbensen, Thorwald, *Working With Individualized Instruction,* Fearon Publishers, Palo Alto, California, 1968.

Describes how the Duluth, Minnesota school system developed and incorporated individualized instructional programs into three elementary schools. A must for anyone, elementary or secondary, who is interested in moving toward more individualized of instruction.

Mager, Robert F., *Developing Attitude Toward Learning,* Fearon Publishers, Palo Alto, California, 1968.

Presents three principles teachers can use to identify pupil behaviors which most likely indicate a favorable disposition to learn and to like to learn.

Mager, Robert F., *Preparing Instructional Objectives,* Fearon Publishers, Palo Alto, California, 1962.

A programmed instruction book which will enable one to identify, define and construct educational objectives. A highly practical book for all educators.

Mager, Robert F. and Beach, Kenneth M., Jr., *Developing Vocational Instruction,* Fearon Publishers, Palo Alto, California, 1967.

Although specifically directed at vocational education, the teacher can use this approach for the systematic development of instructional programs for any subject.

Philosophy and Goals for School Science Programs

Bell, Daniel (Ed.), *Toward the Year 2000: Work In Progress,* Beacon Press, Boston, Mass., 1969.

A series of articles attempting to predict our future, including aspects of science, technology and society.

Bresler, Jack B. (Ed.) *Environments of Man,* Addison-Wesley Publishing Company, Reading, Mass., 1968.

Contains 24 articles of topics concerned with man, his environment, and society.

Broudy, Harry S., "Science and Human Values," *The Science Teacher,* March, 1969.

Discusses the need to leave pupils with a sense of the unity of science with life as a "whole" rather than having a value system distinct from life.

Burns, Richard W. and Brooks, Gary D., "What are Education Processes", *The Science Teacher,* February, 1970.

Discusses the relation of thought processes to the educational process.

Commoner, Barry, *Science and Survival,* Viking Press Compass Edition, New York, 1966.

Discussion of problems and issues resulting from the unconsidered impact of scientific and technological achievements of society.

Crosson, Frederick J. (Ed.), *Science and Contemporary Society,* University of Notre Dame Press, Notre Dame, 1967.

Consists of ten essays dealing with science, literature, philosophy, religion, human welfare, education, and man's future.

Hurd, Paul DeHart, "Scientific Enlightenment For an Age of Science," *The Science Teacher,* January, 1970.

Presents a list of broad objectives which offer a description of the "Scientifically Literate" person.

Raths, Lewis E., et. al., *Values and Teaching,* Charles E. Merrill, Columbus, Ohio, 1966.

Discusses how to set teaching situations which allow a child to develop his own values.

General References

Andersen, Hans O., (Ed.), *Readings in Science Education for the Secondary School,* The Macmillan Company, New York, 1969.

Contains highly valuable information specific to secondary school science teachers and supervisors.

DeCecco, John P., *The Psychology of Learning and Instruction: Educational Psychology,* Prentice-Hall, Inc., Englewood Cliffs, N.J., 1968.

This textbook utilizes behaviorally stated objectives throughout, and may be a foreruuner of textbooks of the future. This book is a "must" for teachers.

Gega, Peter C., *Science in Elementary Education,* John Wiley and Sons, Inc., New York, 1970.

Victor, Edward and Lerner, Marjorie S., *Readings in Science Education for the Elementary School,* The Macmillan Company, New York, 1967.

A comprehensive textbook on elementary science teaching. Includes teaching strategies, evaluation, material, and model-lesson plans.

Contains a series of articles by leading educators and organizations which provide highly specific and valuable information for elementary science teachers and supervisors.