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ABSTRACT

This document presents a curriculum base for a particular school system comprised of eight high schools. Its purpose is to provide a conceptual base which encourages flexibility and diversity. The format is based on the conceptual schemes identified in the NSTA publication, Theory Into Action. Included in the publication is the philosophy of the science curriculum for this school district as well as a detailed description of the minimum required experiences in science to be fulfilled by students wishing to graduate from schools within the prescribed district. Conceptual schemes are presented in the content of biological sciences, physical science, earth and space science, chemistry, and physics. (Author/EB)

Science Curriculum Format

Jan. 1975

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INTRODUCTION TO THE 2ND EDITION OF THE SCIENCE CURRICULUM FORMAT

In September 1972, the science teachers in District 214 were given a copy of the "Science Curriculum Format." The purpose of that document was to provide each teacher with a set of conceptual, processes and meanings of science statements which would help him to identify the learning experiences a student should have while taking a science course in District 214. A second purpose was to provide some background to help students and teachers to understand the interdisciplinary nature of science and its role in describing reality. The third purpose of the effort was to provide a curriculum model which would be useful in coordinating the science program among the eight high schools in the District. Of primary interest in this regard was the ability of the model to generate and evaluate new courses and to communicate the changes to all of the buildings. The "Curriculum Format" was not intended to provide a description of a single district science curriculum. Its fourth purpose was therefore to provide a curriculum basis which would encourage flexibility between schools by identifying a common conceptual, activity and philosophical base rather than course titles and topics.

Since the first Format was distributed many revisions have been written which clarify original statements and describe changes made since its inception. If the Format is to remain valid and useful, it must be able to change with the new insights we have gained. This 2nd edition is written to identify those changes to respond to the weaknesses apparent in the 1st document.

The primary differences in the District 214 science curriculum since 1972 have been to develop more course alternatives for students and to place greater emphasis on "phenomenological" or "reality" science. These changes have resulted in new courses such as exploratory earth science, horticulture and the separation of botany and zoology into smaller courses. The increased emphasis on health education in biology is a further example of the change toward more realistic science. Another significant change in this edition of the Format has been the identification of the "Basic Minimum Experiences Required of All Students" (section IV). Rather than stating our requirements in terms of 2 years of courses in biological and physical science we have identified the basic experiences which should be required of all students. The effect has been to allow the students more alternatives such a earth science or space science as electives in fulfilling the 2 year science requirement. Finally, many of the statements in the 1st edition have been revised to specify the expected learning outcomes rather than the activity the student will do the achieve that outcome.

With the exception of the statements on required experiences the form of the Science Curriculum Format has hot changed from its original basic model. The separations into the areas of subject matter concepts, process skills and meanings or social relevance remain. The concepts are still heirarchically organized into the 4 levels of specificity. This revision includes examples of level 4 or student objectives for each of the areas.

An extensive evaluation of the Format is now being conducted. A copy of the evaluation instrument is included in the appendix. A primary interest of this evaluation will be to determine the relevance of the Format to teachers. Although this is not the only reason for writing the Format, the results should be very useful in developing new changes.

It is important to remind the reader that this document is not intended to be a description of the instructional techniques we use in the classroom. Although hopefully the Format will encourage individualized instruction, it does not describe the relationship which should be established between student and teacher. Neither are new teaching techniques such as audio-tutorial instruction, use of resource rooms or behavior modifications identified. Probably the most significant changes which are occuring in science classrooms in District 214 are instructional rather than curricular. The omission of these changes in this document does not mean that they are not important or exciting.

Many individuals have contributed to the preparation of the original version and this revision of the Science Format. Since most of the work was done at workshops, the names of contributors are generally listed with the section produced. The science chairmen have had primary input and review of the document. Mr. Sam Pacifico, Administrative Intern from the University of Wisconsin, made a large contribution in writing as well as coordinating the efforts of other contributors. We would also like to express appreciation to the various administrators in District 214 who provided funds for and otherwise encouraged this project.

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District Coordinator of
Mathematics and Science

December, 1974

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II. PHILOSOPHY OF SCIENCE CURRICULUM IN DISTRICT 214

Any curriculum has meaning only as it is related to students. If students are not able to relate what they learn in the classroom to their environment the essence of science teaching is lost. If students are not able to challenge themselves to broaden their thinking about reality, human existence and the prupose to life, science teaching has not been effective in relating the reasons for asking questions about our environment. If a science curriculum cannot encourage students to live with our environment with dignity it has failed to become more than a description and collection of courses.

Criteria for Developing a Format

In searching for a curriculum model it was of primary importance that it be meaningful to the classroom. This meant that it would have to be accurate and up to date. It would have to present reality in a form which would reduce the distinction between nature and classroom instruction in science. The model would have to be able to reduce the arbitary distinctions we have established between the branches of science. It would have to encourage the integration of science courses by following an interdisciplinary approach. Its content would have to be accurate and be able to communicate the reality it represented in the classroom.

A second set of criteria for a curriculum model is that it should reflect the processes which occur in investigating nature. The science curriculum must be able to increase the ability of students to ask questions, to anticipate changes and to manipulate their evnironment. It is necessary that a curriculum model demonstrates that science proceeds by experimental and laboratory investigation. A science curriculum must have purposeful activity to it.

The third concern that a science curriculum format must accommodate is that it must be able to communicate the meaning of science to students. The question of why one should study science must be given a valid and acceptable answer. The area of meaning is not clearly understood and should become more clear as science educators report their thinking to the profession. It is presently apparent that within the context of meaning exists elements of technology, application, values, and priorities. The most essential idea is that the purpose of instruction and investigation in science is to satisfy human needs. Without man there would be no science.

Finally, the science curriculum format must provide the largest possible payoff in its influence on learning. It must encourage the most efficient process of assimilating and retaining new material. It must facilitate the transfer of science concepts to other disciplines as well as to applications in one's confrontation with the environment. The format must encourage teachers to adopt efficient and meaningful methods of instruction. There must be flexibility in being able to provide the curriculum in 8 high schools while encouraging teachers to be able to utilize their indipendence in meeting the individual needs of their students.

The Conceptual Schemes Format

In attempting to satisfy the above criteria the science chairmen selected a model developed by the National Science Teachers Association (NSTA)* This model identifies

7 concepts which are basic to all of science[1]. They are concepts which are general but meaningful to learning about nature. The conservation of the sum of mass and energy in the universe is an example of a concept which is relevant to the natural as well as physical sciences. In addition to the 7 conceptual schemes NSTA has identified process schemes.[2] Additional sets have been developed by other groups in science education. The process set finally identified for the Format was a combination of these.

In reviewing the 7 NSTA conceptual schemes it was apparent that their level of generality precluded them from being meaningful to students in their original form. Their value was in providing a common base which when understood shows the simplicity and relationships of the main ideas of science. As a curriculum base they must be accepted as an initial step which only becomes meaningful to learning as they are more explicitly stated.

In order to provide meaning to the 7 schemes the initial workshop participants (1972) has the task of eleborating the concept statements. This elaboration was to follow a format of 4 levels of statements. The first level would be the NSTA 7 conceptual schemes. The 2nd would be their restatement in the context of the areas of biological physical, physics, chemical and earth sciences. The third level of elaboration would be the extension of the 2nd level statements to the point where they would be useful to a teacher in preparing his lessons for a unit. At this level the statments were to be meaningful to a teacher in determining the content of a given lesson and suggesting the teaching methods he might use. The fourth level of statements were to be meaningful to a teacher in determining the content of a given lesson and suggesting the teaching methods he might use. The fourth level of statements would be the extension of the 3rd level to a point where they would be meaningful to students. The 4th level statements could be the behaviorial objectives given to a student. If not behaviorally stated, they should be explicit enough so that a student could identify the 4th level statement that any test item or evaluation procedure would measure.

The intent of the format was that they 3rd level statements would be those common to any science course title in District 214. Building and teacher flexibility would be provided in the sequence the concepts are taught and in the writing of the 4th level statements. Hence the goal of the summer workshop participants was to write the 1st, 2nd and 3rd level statements. The 4th level were to be written by teachers as they use the format in instructing their students. It was anticipated that revision would occur as the 2nd and 3rd level statements were periodically reviewed by the entire science staff.

During the 1974 summer workshops samples of level 4 statements were developed. Objectives were to be written for courses in each of the areas identified in level 3. These statements were to be written in a form which was meaningful to students. Teachers of similar courses could adopt these or use them as examples as they wrote sets for their classes.

Exploratory, Preparatory and Advanced Investigative Course Designation

In the initial meetings of the science chairmen there was a common desire to remove the labels of slow, average, fast and honors from students placed in particular courses. It was preferred that the process of grouping be done by the interests and needs of the students rather than the existing placement procedures based on ability and achievement. In science there appears to be 3 natural distinctions in the needs

* For an elaboration of the background to this decision see Appendix 3, "Report of 1972 Conference of Science Chairmen"

of students which suggest a better way of grouping. There is need for all students to have experience in investigating our environment. Some students need science to prepare for further study in high school or college. Also, there are some students who by virtue of their interest and ability can investigate science at an independent and/or advanced level. As a result of the science chairmen determined to try to establish courses under the catagories of exploratory, preparatory and advanced investigative. (These distinctions are elaborated in the chairmen's report, c.f. appendix 3). Concepts at the 3rd level would be identified as to their appropriateness to each of the 3 types of courses. It was also proposed that a main characteristic of the exploratory courses would be their emphasis on process.

In implementing the Science Curriculum Format during 1972-74 it became apparent that the move toward course descriptions and away from ability groupings was valid. However, the need for elaborate titles for preparatory and advanced investigative courses was not necessary as the topic description was sufficient to identify the instruction level. The result was course groupings such as Exploratory Biology, Biology, and Botany-Zoology where preparatory and advanced investigative are understood as part of the latter titles.

Psychological Rational For Choosing a Conceptual Format

A model based on concepts is not the only way to teach science. It is probably more common to observe science being taught from a topical model than a conceptual one. A newer alternative that is frequently used is the heuristic approach of process based science or using the scientific method to learn how to think and investigate new ideas.

There is some emphasis among science educators to teach a totally activity oriented curriculum, i.e., "messing about". There is also some reason to choose a highly technology oriented curriculum with a large emphasis on vocational training.

The curriculum model we have selected does not exclude any of the above models, but has its emphasis on concepts. Inquiry and technology are included but do not provide the basic themes for the entire program. A conceptual format was chosen because of its apparent payoff in terms of transfer and retention. There is also evidence to support the view that new information is assimilated more efficiently when the learners possess a well organized cognitive structure built on relevant concepts. A primary advantage is the ability to include the large field of science under a relatively few simple ideas. The relationships within science are readily apparent in a conceptual model.

In addition to its learning effects the conceptual model has some teaching advantages. It is easily adapted to an individualized approach. Teachers are familiar with the basic content ideas. Most textbooks can be directly used or adapted easily to a concept format. Laboratory experiences can be readily adapted to a concept format. The issues which arise from a concept approach can be researched and changes made without reconstructing the entire program.

Status of the Science Curriculum Format

During the 1st 2 years of implementation of the Format much has been done to make it a complete document. However, it is reasonable to assume that there should be a basic review of its content every 2 years. The evaluation presently being conducted should help to direct future efforts. Some weaknesses in the Format are apparent.

1) The area on meaning has been fully developed.

2) The emphasis on career education is science should be more specifically defined.

3) A committee has begun to meet to broaden and coordinate our efforts in environmental education.

4) Satisfaction of the health education requirements needs to be evaluated.

5) Format descriptions for experimental courses need to be written e.g. Horticulture and Environmental-Organic Chemistry.

6) Implementation procedures and usefulness to the teacher will need to be continuously evaluated.

7) The present experimental status given by the Instructional Council in December 1972, should be evaluated for regular adoption.

MINIMUM REQUIRED EXPERIENCES IN SCIENCE FOR STUDENTS GRADUATING FROM DISTRICT 214

The following concepts are presented as being of sufficient importance to one's understanding of the universe that all students are required to complete courses in which they are taught. They form a conceptual basis for understanding nature in the context of its biological and physical characteristics. The statements are given in minimal form and should not be interpreted as constituting a complete course program of ideas or activities. The minimum required process statements are the same as those found in section VI. The health education topics are also listed here for purposes of reference since they are required by the Office of the Superintendent of Public Instruction, State of Illinois.

FUNDAMENTAL CONCEPTUAL SCHEMES OF THE BIOLOGICAL SCIENCES

A. Unity

1. The characteristics of life depend upon specific physical and chemical properties.

2. Generally, organisms are composed of a fundamental unit of structure and function known as the cell.

3. Metabolism involves the exchange, transformation, and perpetuation of matter and energy within the organism and between the organism and its environment.

4. An organism depends upon the availability and utilization of water, energy and minerals.

B. Diversity

1. Organisms generally fit into groups based on morphological and physiological similarities which distinguish them from other groups.

2. All organisms carry on the same vital processes, but the mechanisms in which these occur vary.

C. Continuity

1. Life is in a constant state of change.

2. The hereditary characters in most organisms are determined by the genes or factors that were transmitted to them in the chromosomes received from their parents.

3. The enormous variety of organisms, past and present, is thought to be the result of evolution.

D. Interaction

1. All living things are interdependent with one another and with their environment.

2. Life is organized from the molecular and intracellular level to the community and biosphere.

3. The balance of nature is maintained through the competition of organisms for the basis requirements of life.

4. Energy from the sun passes through a network of organisms beginning with green plants, the food producers, then to animals which eat plants, then to animals that eat those animals and so on.

5. The green plants are unique in that they are capable of photosynthetic activity and thus are directly or indirectly responsible for producing the food materials in the world.

6. Behavior is action which alters the relationship between the organism and its environment.

7. Disease is the organism's dysfunction at the physiological, morphological and/or behavioral level.

8. The natural environment is being altered through the effects of technology and the rapid expansion of population.

HEALTH EDUCATION INSTRUCTION IN BIOLOGY

A description of the topics to be taught in the health education component of biology follows. These topics will be integrated into the curriculum of the beginning biology program. Identification of the topics is not intended to prescribe sequence or their treatment as an isolated unit within the curriculum.

PHILOSOPHY AND HEALTH CONCEPTS

The purpose of these topics is to identify differences between good and bad health and general causes of each. The students will also be introduced to the concept of health as having physical, mental and social aspects.

CIRCULATION, RESPIRATION, AND SMOKING

Normal consideration of these topics includes the circulation of body fluids, the heart, blood, and respiratory system. The effects of smoking on the circulatory and respiratory systems will also be treated. Specific investigations will be made on the content of cigarette smoke and its know effects on the human system.

DISEASES - PREVENTION AND CONTROL

Consideration of diseases will include the theory which relates cause to environmental conditions, types of disease, progress of a communicable disease, transmission, veneral disease, heart disease, cancer, diabetes, epilepsy, anemia, ulcers and allergies. Effects and treatments of these diseases will be integrated into the appropriate biological concepts. The topics will thus become examples of human biological existence rather than considered as separate and non-relevant facts.

MOOD MODIFIERS

Students will be encouraged to deal with the problems of alcohol and drug consumption. They will review reasons people give for alcohol and drugs, psychological, social, and physical effects of consumption, available medical treatments, and some common misconceptions about alcohol and drugs. Laboratory activities will illustrate the action of depressants and stimulants.

GROWTH, DEVELOPMENT AND BIRTH

As part of the treatment of human reproduction, students will consider the following topics: the basic anatomy and physiology involved in reproduction including male and female reproductive organs and associated endocrinology; the birth process; and the psychological, social and physical sexual development of humans. Students will be encouraged to consider human maturation as a broad process incorporating biological as well as emotional mechanisms. The topics will be treated in a manner which encourages students to understand the process of reproduction and to form positive attitudes toward their feelings and knowledge.

PERSONAL HEALTH HABITS

In the process of investigating the production of energy from food sources, students will consider the digestive process, and system; basic human nutritional needs; weight and its control; the relationship of energy to exercise; and the control of bady activity through muscle and bone structure. Effects of sleep and personal hygiene on body function will also be treated.

The above topics do not describe the total biology curriculum. They are intended to identify those areas of the curriculum which safisfy the health education requirement of the State of Illinois. All biology teachers will have sufficient college preparation to qualify them to teach the prescribed material.

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District Coordinator of Mathematics and Science

Approved by the Board of Education
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FUNDAMENTAL CONCEPTUAL SCHEMES OF THE PHYSICAL SCIENCE

1. Matter is composed of fundamental particles - ie., the Proton, Neutron and Electron.

2. Matter can be classified into different levels of organization.

3. The properties of matter depend upon the kinds and arrangement of the fundamental particles.

4. The properties of matter can be measured.

5. The basis forces involved in the interaction of matter are nuclear, gravitational, electromagnetic.

6. The sum of matter and energy in the universe is a constant.

7. Energy distribution tend to progress from a higher to a lower value.

8. The Randomness (or Entropy) of matter and energy distribution tends to progress from a lower to a higher value.

9. The tendency to Minimum Energy and Maximum Randomness are opposing forces in interactions of matter.

10. The fundamental particles of matter are in constant motion.

11. Energy exists in different forms and is not a substance.

12. Energy can be transformed from one form to another and transferred from one place to another.

13. Changes in matter involve energy, are reversible, and depend on time. The rate of change is dependent on a variety of factors.

14. Matter may undergo changes in the areas of form, properties or position at varying rates.

III. CONCEPTUAL SCHEMES

LEVEL I

1) All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

2) Matter exists in the form of units which can be classified into hierarchies of organizational levels.

3) The behavior of matter in the universe can be described on a statistical basis.

4) Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.

5) All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations, or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

6) One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for states of matter: solid, liquid, and gaseous.

7) All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

LEVEL II - Biological Science

A. Unity exists among all forms of life in the recognition that organisms are similar chemically, have common fundamental units, have energy requirements, reproduce, evolve, respond to stimuli, and constitute parts of an interrelated whole.

B. Diversity is shown by adaptations that take any form which can be classified intc hierarchies of organizational levels.

C. Continuity among living organisms exists since today's organisms are only temporary manifestations of a lineage of life that extends backward in time. The biological events of the universe may be described on a statistical basis.

D. Interactions are the consequence of an organism's existence with other organisms and with the nonliving environments tending toward a balance of nature.

LEVEL II - Physical Science

A. Fundamental Particles of Matter

All matter is composed of fundamental particles which when coordinated as a unit produce atoms, which in turn serve as the building blocks of all matter. These elementary particles can be transformed into energy and vice-versa.

B. Bonding and Classification

Select atoms can unite to form molecules, and the complexity and properties of these molecules will depend upon the number and kind of atoms that comprise them. All existing matter and energy can be classified into different levels of organization.

C. Predictability

The behavior of matter can be described on a statistical basis, enabling us to make reliable predictions of what is likely to happen.

D. Basic Forces

The basic forces involved in the interactions of matter are electromagnetic, gravitational, and nuclear.

E. Matter and Energy and Driving Forces

Changes in matter may occur in varying degrees, at various rates, and in various patterns such that the interacting units of matter tend toward equilibrium states in which the energy content is a minimum, and the matter and energy distribution is most random. In the process of attaining equilibrium, energy transformations, or matter transformations, or energy-matter transformations occur. The sum of energy and matter in the universe remains constant matter can be converted into energy and vice versa.

F. Forms of Energy

One existing form of energy is that of the motion of units of matter. The motion of the basic units of matter is repponsible for heat, temperature. The physical forms of solid, liquid, and gas and various types of wave phenomena. Another existing form of energy is a consequence of the position of units of matter relative to space and time.

G. Matter and Time

All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time and space.

LEVEL II - Earth and Space Science

A. Fundamental Units of the Universe

All matter is composed of fundamental units. These units are basic to the structure of Earth Science in that they compose minerals and rocks which are the basic building blocks of matter in the universe. These materials behave in accordance with the laws of matter.

B. The Earth as a Planet
Earth Science has its place in the system of organizational levels. The complete scheme defines the universe in terms of its sub-levels. Building from fundamental particles upward, the physical universe may be summarized as follows: fundamental particles - atoms - molecules or ions - groups of molecules - earth materials - heavenly bodies - solar systems - galaxies - clusters of galaxies - universe. The earth and earth materials are part of this scheme.

C. Predictability - Uniformity of Process
Earthly events are statistical and may be used to predict local future events. "The Present is a Key to the Past." Specific patterned earth changes become predictable to the degree of variables effecting the system.

D. Basic Forces
Electromagnetic, gravitational, and nuclear forces are involved in the interactions of matter. These forces along with their effect on matter determines earth conditions.

E. Matter and Energy
The sum of matter and energy in the universe remains constant. Energy effects change, it may flow, or be stored, transferred or transformed. The changes in earth materials result in the continual redistribution of energy. Therefore the earth is considered a dynamic planet.

F. Earth Systems Exist in Space and Time
All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time and space. Time is an important element in the universe.

LEVEL II - Chemistry

A. Fundamental Particles of Matter
All matter is composed of fundamental particles which when coordinated as a unit produce atoms, which in turn serve as the building blocks of all matter. These elementary particles can be transformed into energy and vice-versa.

B. Bonding and Classification
Select atoms can unite to form molecules and the complexity and properties of these molecules will depend upon the number and kind of atoms that comprise them. All existing matter and energy can be classified into different levels of organization.

C. Statistical Nature of Matter
Since natural laws appear to be statistical rather than absolute and since the behavior of matter is dependent upon natural law it is evident that phenomena are predictable, and can be expressed mathematically.

D. Chemical Changes
Chemical changes result from the reactions between or the decomposition from within matter thus producing materials which are different and which may increase, decrease or have the same complexity. These changes are accompanied by changes in energy and are associated with electromagnetic or nuclear forces.

E. Driving Forces of Chemical Reactions
All reactions between units of matter involve energy. This energy is either liberated, stored, or converted to other forms. In all cases energy is conserved as molecules tend to obtain the best equilibrium state between minimum energy and maximum randomness. Interacting particles will reach an equilibrium position with respect to their products in a closed system.

F. Kinetic Theory of Matter
The motion of the basic units of matter is responsible for heat, temperature, and the physical phase of solid, liquid, and gas. The energy associated with this motion is directly proportional to the mass and velocity of the units.

G. Reaction Kinetics
Chemical reactions always include the phenomenon of time. Units of matter may undergo changes in form, properties, or positions with advent of time and these changes can occur at varying rates.

LEVEL II - Physics Education

PREAMBLE: The essence of physics is that it is a consequence of man attempting to arrive at as simple and general an understanding of all facets of the universe as is possible. There would be no physics without man.

We hold this truth to be self-evident. Man is the essence of all scientific endeavors. And, a proper and comprehensive exposure to total physics education demands academic experience designed toward the realization of a unifying general conceptual scheme.

Physics education does not necessarily have to take place in the usual courses traditional to District 214. Instead physics education may occur in any number of different manners, using many different vehicles to accomplish its goals and objectives.

To meet the challenges of decades to come, formats for physics education at all levels should prove flexible enough so as to allow new approaches to the development of learning experiences that enhance the "understanding" of basic concepts.

LEVEL II - Concepts in Physics

A. Nature of the Universe
Inherent in the design of the universe are the existence of certain phenomena which are observable in terms of space, time, mass, and charge interactions as serve as stimuli for man's attempt to understand his physical environment.

B. Nature of Matter
Matter is particulate in nature exists in space and time and is described in terms of its properties.

C. Nature of Energy

One existing form of energy is that of the motion of units of matter. The manifestation of this penomena is apparent to man in the forms of various thermal phenomena, different phases of matter and various types of wave phenomena which also have particle-like characteristics. Another existing form of energy is a consequence of the position of units of matter relative to space and time.

D. Interactions/Transformations of Matter and Energy

MATTER and ENERGY and BOTH RELATED and INTERRELATED. The bases of all ordinary matter interactions are electro-magnetic, gravitational, or nuclear forces. Changes may occur in varying degrees, at various rates, and in various patterns such that the interacting matter tends toward equilibrium states in which the energy content is a minimum and the matter and energy distribution is most random. In the process of attaining equilibrium, energy transformations, or matter transformations, or energy-matter transformations, occur. Nevertheless, the SUM of energy and matter in the universe remains constant.

E. Statistical Descriptions

The behavior of matter can be described on a statistical basis. The interaction of matter occurs in such a manner that the result may be described only in terms of what is likely to happen.

CONCEPTUAL SCHEMES LEVEL III

BIOLOGY, EXPLORATORY

A. Unity

1. The characteristics of life depend upon specific physical and chemical properties.

2. The survival and well-being of an organism depends in part upon the availability of water, energy or energy-yielding substances, minerals and in some cases, certain essential organic compounds that cannot be synthesized by the organism.

3. Generally, organisms are composed of a fundamental unit of structure and function known as the cell.

   a. The nucleus is that region of the cell that contains chromosomes and indirectly regulates the activities of the cell.

   b. Cytoplasm is a region and not a single substance, it is a fluid area that contains a variety of structures identifiable on the basis of their shape, staining properties and chemical activities.

   c. Cell membranes provide a selective barrier which maintains the intracellular environments suitable for the biological reactions occuring within the cells.

4. Similarities exist in the metabolic processes of organisms. Metabolism can be considered as the sum total of the life processes of an organism.

5. Order is a constant theme in biology. Life is organized from the Molecular and intracellular level to the community and biosphere.

B. Diversity

1. Biologists establish groups of organisms based on morphological and physiological differences.

   a. Organisms are usually considered to be either plants or animals.

   b. Organisms differ in structure, function and environmental requirements.

   c. The green plants are unique in that they are capable of photosynthetic activity, and thus are directly or indirectly responsible for producing all the food materials in the world.

2. All organisms carry on the same vital processes but the mechanisms in which these occur vary as they evolve from a simple to a complex plan of organization.

C. Continuity

1. The hereditary characters in most organisms are determined by factors that were transmitted to them in the chromosomes received from their parents.

    a. A gene pair is responsible for the expression of a trait.

    b. A trait may be considered dominant if it is expressed alone in the off-spring of parents with contrasting traits. The trait that is masked is considered recessive.

    c. The sex of an organsim is determined by the combination of X and Y chromosomes.

2. Man uses the principles of heredity in improving the varities of organisms which supply his needs.

3. New kinds of living things have arisen through mutations caused by changes in the games or organisms, such changes producing inheritable modifications.

4. The enormous variety of organisms, past and present, is thought to be the result of evolution.

    a. Species through many generations may evolve into new types, and the individuals and types best adapted to their life situations are the ones that survive.

D. Interaction

1. All living things are interdependent with one another and with their environment.

2. Energy from the sun passes through a network of organisms beginning with green plants, the food producers. At each transfer energy is dissipated and less life can be sustained.

3. A delicate balance exists in the biosphere which is dependent upon the continued existence and function of the organisms that are present.

4. The natural environment is being so altered through the effects of technology and the rapid expansion of wealth and population that man must make changes in his behavior or consider his extinction probable.

    a. The use of biological resources must be governed by the role these resources play in the ecosystem.

b. Conservation of our natural resources requires the management of our ecological systems so as to establish a balance of harvest and renewal, thus insuring a continuous yield of plants, animals, and other natural renewable materials.

c. Conservation of our human resources requires the wise control of environmental conditions to provide for man's physical, mental, emotional and social well-being.

5. Behavior is action which alters the relationship between the organism and its environment. It is externally directed activity and does not include the many internal changes which are constantly taking place in living things.

6. Disease is the organisms disfunction at the physiological morphological and/or behavioral level.

   a. Diseases are ideally controlled within populations, as well as individuals, by prevention rather than cure.

7. Human health is promoted by moderation and regulation in things such as cleanliness, exercise and food consumption.

8. The nutritional requirements of an organism are determined by the composition and physiological activities of its tissues and constituant cells. Genetic make-up, stress, developmental stage may cause the needs to differ from time to time and from individual to individual.

9. All drugs (medicine) and many other substances (such as table salt) should be considered potentially harmful to the people who use them. Judicious use tends to minimize the danger.

LEVEL III - Biology, General

A. Unity

1. The characteristics of life depend upon specific physical and chemical properties

   a. Some structures and associated processes are common to all living things while other are unique to particular types of organisms.

   b. Organisms exist within certain tolerable ranges or environmental conditions.

2. An organism depends upon the availability of water, energy or energy-yielding substances, minerals and in some cases, certain essential organic compounds that cannot be synthesized by the organism.

a. The complexity and diversity of living matter as we know it depends largely on the unique properties of the element carbon and the compound water.

b. The three essential energy nutrients usually lead to malfunctions in organisms.

3. Generally, living things are composed of a fundamental unit of structure and function known as the cell.

a. The nucleus is that region of the cell that contains chromosomes and indirectly regulates the activities of the cell.

b. Cytoplasm is a region and not a single substance, it is a fluid area that contains a variety of structures identifiable on the basis of their shape, staining properties and chemical activities.

c. Cell membranes provide a selective barrier which maintains the intracellular environments suitable for the biological reactions occuring within the cells.

d. The activities of living cells result essentially from chemically and physical processes in which reactants are supplied by nutrients that must be replenished.

4. Metabolism is the sum total of all the life processes of an organism

a. Metabolism is the exchange, transformation and perpetuation of matter and energy within the organism and between the organsim and its environment.

b. Ingestion is the process by which organisms take in raw materials.

c. Digestion, which is carried on in organisms by enzymes, makes food soluble in water, reducing complex nutrients to simpler materials which can pass through membranes.

d. Circulation is the intra or extra cellular transportation of substances.

e. Diffusion, the net movement of molecules or ions from a region of higher concentration to establish an equilibrium, is responsible for all transfer of matter and energy within organisms.

f. Respiration is the liberation of chemical energy from organic molecules within living cells.

g. Assimilation is the process by which digested foods are converted into the structural materials of protoplasm.

h. Secretion is the process by which useful products are produced in and given off by the cell.

i. Excretion is the process of eliminating the waste products formed by the biochemical reactions occuring within the organism.

j. Reproduction in all organisms is a process in which there is development of a new individual either sexually or asexually.

k. Growth in living things is developmental; there is a progression in most cases from the one-cell stage through maturity to old age (and, in most cases, death).

5. Order is a constant theme in biology. Life is organized from the molecular and intracellular level to the community and biosphere.

a. Associations of specialized cells performing the same function form a tissue; groups of different tissues combined in characteristic patterns form organs; and collections of functionally related organs constitute systems within the organism.

6. Life is in a constant state of change.

B. Diversity

1. Organisms generally fit into groups based on morphological and physiological similarities which distinguish from other groups.

a. There has been a consistant, orderly and gradual pattern of development of life from simple to more complex organisms.

b. While no single characteristic differentiates all organisms differences between them do not exist. These differences become more pronounced in the higher forms.

c. Organisms are usually considered to be either protisten, plants, or animals.

d. Organisms differ in structure, function and environmental requirements.

e. The green plants are unique in that they are capable of photosynthetic activity and thus are directly or indirectly responsible for producing all the food materials in the world.

2. All organsims carry on the same vital processes but the mechanisms in which these occur vary as they evolve from a simple to a complex plan of organization.

a. Higher organisms are a collection of organ systems.

b. Organ systems may vary among organisms depending on their complexity.

C. Continuity

1. The hereditary characteristics in most organisms are determined by the genes or factors that were transmitted to them in the chromosomes received from their parents.

   a. The phenomenon of heredity in all living things thus far investigated is attributable to the replication and transmission of the genetic materials DNA or RNA.

   b. The flow of hereditary characteristics through time is made possible through the processes of mitosis and metosis.

   c. The fundamental unit of heredity, the gene, consists of numerous separable components found on paired chromosomes of cells.

   d. Genes are arranged in a single file on chromosomes which are usually inherited together.

   e. A gene pair is responsible for the expression of a trait.

   f. A trait may be considered dominant if it is expressed along in the offspring of parents with contrasting traits. The trait that is masked is considered recessive.

   g. The sex of an organism is determined by the combination of X and Y chromosomes. Some traits are linked to or influenced by the sex of an organism.

   h. Since sex cells meet at random in fertilization the traits of individuals for any generation occur in certain predictable ratios.

   i. An organism is pure for a trait if the gene pair for the trait is the same.

   j. An organism is hybrid for a trait if the gene for that trait is different.

   k. Most organisms carry undesirable genes which, if brought together by inbreeding or chance, may express themselves as abnormalities in the offspring of such a union. This may have social implications for man.

2. Man uses the principles of heredity in improving the varieties of organisms which supply his needs.

3. New kinds of living things have arisen through mutations caused by changes in the genes or organisms, such changes producing inheritable modifications.

4. The gene pool consists of all the genes of a given population.

5. The enormous variety of organisms, past and present, is thought to be the result of evolution.

   a. Present living cells are seen to arise from preexisting living cells.

   b. Species through many generations may evolve into new types, and the individuals and types best adapted to their life situations are the ones that survive.

      1. Every species of organism is subject to certain environmental influences and only those members that are capable of surviving these reproduce new offsprings and transmit many of their characteristics to their offspring.

      2. In the reproductive cycle of living organisms there are always more offspring produced than are expected to survive.

   c. While many biological events appear to be random, these events can often be described or predicted statistically.

   d. Fossils, usually formed from the preserved hard parts of organisms, dated by the rocks in which they are found, reveal portions of the actual story of life's past changes.

      1. Evolution of life, is not toward a hypothetically perfect form of organism, but towards the most effective adaption in a particular environment and niche.

D. <u>Interaction</u>

1. All living things are interdependent with one another and with their environment.

   a. No one major ecological factor but a combination of them determines the environment; soil, water, air, energy, living organisms (including man) all contribute.

   b. All living systems-from cells to biomes are in a dynamic steady-state which may be altered when a component in the system is changed.

2. Energy from the sun passes through a network of organisms beginning with green plants - the food producers - then to animals which eat plants, then to animals that eat those animals and so on. At each transfer energy is dissipated and less life can be sustained.

   a. The earth's carrying capacity of finite for one and all species. Its space, materials, and available energy are limited.

   b. Those chemical elements, which are basic building blocks of all life, are constantly cycled on our planet by chemical, biological, and geological processes.

c. All living organisms have other living things which compete with them for the available energy.

3. A delicate balance exists in the biosphere which is dependent upon the continued existence and function of the organisms that are present.

a. The variability of environmental factors influences the growth and distribution of life at all levels; ffom the small scale (microcosm) to the large (biome).

b. Most species of microorganisms in their natural habitat are not dangerous to man and are essential components of the ecosystem.

c. Environmental factors which influence and in turn are influenced by population, tend to stabilize the population's size. Those factors which incluence populations but are independent of them may cause instability.

4. The natural environment is being altered through the effects of technology and the rapid expansion of population.

a. To meet future needs, the use of biological resources must be governed by the role these resources play in the ecosystem.

b. Conservation of our natural resources requires the management of our ecological systems as to establish a balance of harvest and renewal, thus insuring a continuous yield of plants, animals, and other natural renewable materials.

c. Conservation of our human resources requires the wise control of environmental conditions to provide for man's physical, mental emotional and social well-being.

5. Behavior is action which alters the relationship between the organism and its environment. It is externally directed activity and does not include the many internal changes which are constantly taking place in living things.

6. Diseases are a byproduct of the metabolism and reproduction of pathogenic microorganisms, reflecting the interaction of the pathogen with a susceptible host.

a. The dispersal of most pathogenic organisms is primarily passive. However, vectors such as insects and other organisms do account for the transmission of some pathogens.

b. Disease are ideally controlled within populations, as well as individuals, by prevention rather than cure.

7. Human health is promoted by moderation and regulation in things such as cleanliness, exercise, and food consumption.

8. The nutritional requirements of an organism are determined by the composition and physiological activities of its tissues and constituant cells. Genetic make-up, stress development stage may cause the needs to differ from time to time and from individual to individual.

9. All drugs (medicine) and many other substances (such as table salt) should be considered potentially harmful to the people who use them. Judicious use tends to minimize the danger.

LEVEL III - Advanced Biology

1. Living organisms reproduce either sexually or asexually.

2. Asexual reproduction is the most efficient method for providing exact copies of parent stock.

3. Sexual reproduction, although somewhat less efficient than asexual, provides for genetic recombination and therefore greater possible change.

4. The herditary characters in most organisms are determined by the genes or facts that were transmitted to them in the chromosomes received from their parents.

   a. The phenomenon of heredity in all living things thus far investigated is attributed to the replication and transmission of the genetic materials DNA or RNA.

      1. The DNA in a cell determines the type of RNA made and the RNA in turn specifies the types of proteins which will be formed. Some of these proteins become enzymes. In this way genetic material determines characteristics of living organisms.

      2. The universal genetic code is based on various combinations of four different nucleotides. A single coding unit consisting of three such nucleotides usually specifies a particular amino acid. Another may initiate or terminate synthesis of a polypetide.

   b. The flow of hereditary characteristics through time is made possible through the processes of mitosis and miosis.

   c. The fundamental unit of heredity, the gene, consists of numerous separable components found on paired chromosomes of cells.

   d. Genes are arranged in a single file on chromosomes which are usually inherited together.

      1. At times the genetic materials of two homologous chromosomes may be exchanged. This lends together to greater variation in offspring and allows one to map the chromosomes.

e. A gene pair is responsible for the expression of a trait.

f. A trait may be considered dominant if it is expressed alone in the offspring of parents with contrasting traits. The trait that is masked is considered recessive.

g. The sex of an organism is determined by the combination of X and Y chromosomes. (XX - female, XY - male) Some traits are linked to or influenced by the sex of an organism.

h. Since sex cells meet at random in fertilization the traits of individuals for any generation occur in certain predictable ratios.

i. Most organisms carry undersirable genes which, if brought together by inbreeding or chance, may express themselves as abnormalities in the offspring of such a union. This may have social implications for man.

5. New kinds of living things have arisen through mutations caused by change in the genes of organisms, such changes producing inheritable modifications.

6. The gene pool consists of all the genes of a given population.

   a. The genes within a given pool may be altered by:

      1. mutation
      2. random genetic drift
      3. gene migration
      4. differential reproduction

7. The enormous variety of organisms, past and present, is thought to be the result of evolution.

   a. Present living cells are seen to arise from preexisting living cells.

      1. Evolutionary specialization of long duration has resulted in morphological and physiological difference among the cells of an organism.

      2. In sexually reproducing organisms, many new species arise when a segment of a population is isolated under conditions where it is free to evolve along different lines until it can no longer interbreed with decendents of the original population, where as asexually, evolutionary potential is very limited.

   b. Species through many generations may evolve into new types, and the individuals and types best adapted to their life situations are the ones that survive.

      1. Every species of organism is subject to certain environmental influences and only those members that are capable of surviving these reproduce new offspring.

      2. In the reproductive cycle of living organisms there are always more offspring produced than are expected to survive.

c. While many biological events appear to be random, these events can often be described or predicted statistically.

1. There is scientific evidence that the origin, evolution, and continuation of life on this planet are dependent on natural phenomena.

2. Organisms relatively similar in structure and development are grouped together because they are believed to be related through common decent.

3. One theory concerning the origin of life on earth proposes that it arose spontaneously in an aquatic environment by the action of energy on nonliving material that became self-reproducing.

4. One theory states that life began in an oxygen-free atmosphere. The atmosphere changed when primitive cells developed a photosynthetic capacity and released oxygen. Present atmospheric oxygen is predominantly of photosynthetic origin.

d. Fossils, usually formed from the preserved hard parts of organisms, dated by the rocks in which they are found, reveal portions of the actual story of life's past changes.

1. Evolution of all life, including that of man, is not toward a hypthetically perfect form of organism, but towards the most effective adaption in a particular environment and niche.

8. All living things are interdependent with one another and with their environment.

a. No one major ecological factor but a combination of them determine the the environment; soil, water, air, energy, living organisms (including man) all contribute.

b. All living systems from cell to biomes are in a dynamic steady-state which may be altered when a component in the system is changed.

9. Energy from the sun passes through a network of organisms beginning with green plants-the food producers- then to animals which eat plants, then to animals that eat those animals and so on. At each transfer energy is disipated and less life can be sustained.

a. The earth's carrying capacity is finite for one and all species. Its space, materials, and available energy are limited.

1. Those chemical elements, which are basic building blocks of all life, are constantly cycled on our planet by chemical, biological and geological processes.

b. All living organisms have other living things which compete with them for the available energy.

10. The Biosphere embodies the balance of nature, it includes an energy relationship that binds all living beings into one inseparable world.

a. After a slow phase, population growth from relatively low to relatively high levels usually tends to occur exponentially, then to decline as numbers approach environmental capacity.

b. Living things tend to increase in numbers to the level the environment will permit. Man's ability to modify his environment does not make him an exception. His success in bypassing some environmental barriers is now challenged by new barriers.

c. When organisms alter the environment by their presence, they may adversely affect conditions for their own survival while improving conditions for the survival of other organisms thus allowing a succession of changes to occur.

d. The more constant the internal environment of an organism the freer it can be of external environmental restrictions.

11. The natural environment is being so altered through the effects of technology and the rapid expansion of wealth and population that man must make drastic changes in his behavior or consider his extinction probable.

a. Conservation of our natural resources requires the management of our ecological systems so as to establish a balance of harvest and renewal, thus insuring a continuous yield of plants, animals, and other natural renewable materials.

12. Behavior is action which alters the relationship between the organism and its environment. It is externally directed activity and does not include the many internal changes which are constantly taking place in living things.

LEVEL III - Organismic Biology

A. Development in Higher Animals

1. Fertilization
The onset of an organisms life begins with the union of sex cells (gametes) during the process of fertilization.

2. Gastrulation
The first noticeable activity in development is the repeated divisions (cleavage) and growth of the zygote to eventually form a specialized structure known as the gastrula.

3. Differentiation
The unique characteristics of an embryo begins with the formation of three germ cell layers (ectoderm, mesoderm, endoderm) followed by the differentiation and subsequent specialization of these cells to form tissues and eventually organs.

4. Embryology
Animals show diversity in methods of sustaining life in the embryo until the new individual can fair for itself.

5. Reproductive Engineering
Science with the advent of modern tools and techniques have made it possible to alter the normal embryonic and reproductive patterns of all animals including humans.

B. Structure and Function of Higher Animals

Multicellular animals always show some degree of cell specialization (a division of labor) and this specialization exhibits a complementary relationship between structure and function.

1. Digestion

a. Animals show diversity in patterns of securing food (ingestion) in processes of dissimilating these materials to a usable form for the body (digestion).

b. The dissimilation of food materials is controlled by a series of enzymes - substrate reactions.

2. Respiration

All higher animals have some mechanism for exchanging carbon dioxide for oxygen through a semi-permable moist membrane (gills, air sacs, skin or lungs).

3. Circulation

Higher animals show both diversity and unity in maintaining a steady-state control (homeostasis) for internal cells by the constant delivery and removal of cellular materials through a transporting system.

4. Excretion

Metabolic waste products, particularly nitrogenous products must be removed from the body to maintain homeostasis. The basic functioning unit is the nephron. Kidneys, sweat glands and the liver all have excretory functions.

5. Skeletal and Muscular Systems

The animal way of life is most characterized by body movement and distinct supporting system.

a. Movement either body or organ directed is controlled by muscular contractions, voluntarily or involuntarily.

b. Structural design of the animal is determined by the skeletal framework, either internally (endoskeleton) or externally (exoskeleton).

6. Endocrine and Nervous System

All higher animals have homestalic mechanisms for maintaining an almost constant internal environment.

a. This homeostactic coordination is brought about by nerves and hormones carrying orders from one part of the body to another part.

7. Reproduction

The success of any species is highly dependent upon the reproductive processes possessed by individuals of that species. Diversity and unity in reproductive patterns and systems exists in higher animals according to the structure of reproductive organs, hormonal orgensis and spermatogensis and means of fertilization.

8. Behavior
Behavior is the voluntary and involuntary response of the organism to external and internal stimuli for the preservation of life.

LEVEL III - Botany - Zoology

A. Unity

1. The distinctive properties of living things depend upon the physical and chemical properties of protoplasm, upon the complexity of its molecular organization and upon the complexity of cells which protoplasm may compose.

   a. Some structures and associated processes are common to all living things while other are unique to particular types of organisms.

   b. Food, oxygen, certain tolerable ranges of termperature, moisture, and light, are essential to the life of all living things.

   c. Four basic attributes of living systems are: (1) the capacity to make copies of themselves; (2) the capability for change; (3) the capacity to store information and; (4) the ability to translate this information for use in complex activities.

2. The survival and well-being of an organism depends in part upon the availability of water, energy or energy-yielding substances, minerals, and in some cases certain essential organic compounds that cannot be synthesized by the organism.

   a. The complexity and diversity of living matter as we know it depends largely on the unique properties of the element carbon and the compound water.

   b. The three essential energy nutrients are protiens, carbohydrates, and fats.

   c. The three essential non-energy foods are water, minerals and vitamins.

   d. Dificiencies of essential nutrients usually lead to malfunctions in organisms.

3. By and large living things are composed of a fundamental unit of structure and function known as the cell.

   a. The nucleus is that region of the cell that contains chromosomes and indirectly regulates all the activities of the cell.

   b. Cytoplasm is a region and not a single substance, it is a fluid area that contains a variety of structures identifiable on the basis of their shape, staining properties and chemical activities.

   c. Cell membranes provide a selective barrier which maintains the intracellular environments suitable for the biological reactions occuring within the cells.

   d. The activities of living cells result essentially from chemically and physical processes in which the reactants are supplied by nutrients that must be replenished.

4. Metabolism can be defined as the sum total of all the life processes of an organism.

a. Metabolism is the exchange, transformation, and perpetuation of matter and energy within the organism, between the organism and its environment.

1. In a biochemical reaction there is no loss or gain of energy, only a transformation of energy from one form to another.

2. Although individual reactions in biological systems tend to be reversible, the sum total of such reaction usually leads to stable, predictable and generally irreversible changes.

3. All chemical reactions occuring within cells are controlled by regulating the amount, type and specifically of the enzymes present. Complex living systems would not be possible without this control.

4. The general mechanisms for the utilization, storage and transfer of energy appears to be basically similar in all organisms. All organisms employ ATP as the universal energy carrier.

5. When internal disturbances occur in organisms as a result of various stresses, adjustments occur through regulatory mechanisms or adaptations that tend to move the system toward a normal state or one compatible with survival.

b. Movement of protoplasm is either by itself or within itself.

c. Ingestion is the process by which organisms take in raw materials.

d. Digestion, which is carried on in organisms by enzymes, makes food soluble in water, reducing complex nutrients to simpler materials which can pass through membranes.

e. Circulation is the intra or extra cellular transportation of substances.

f. Diffusion, the net movement of molecules or ions from a region of higher concentration to establish an equilibrium, is responsible for all transfer of matter and energy within organisms.

g. Respiration is the liberation of chemical energy from organic molecules within living cells.

h. Assimilation is the process by which digested foods are converted into the structural materials of protoplasm.

i. Secretion is the process by which useful products are produced in and given off by the cell.

j. Excretion is the process of eliminating the waste products formed by the biochemical reactions occuring within the organism.

k. Reproduction in all organisms is a process in which there is development of a new individual either sexually or asexually.

1. The process of nuclear division in which chromosomes separate after replication, insures the presence of identical genetic material in each of the two daughter nuclei and in each cell resulting from cell division.

1. Growth in living things is developmental; there is a progression in most cases from the one-cell stage through maturity to old age (and, in most cases, death).

5. Order is a constant theme in biology. Life is organized from the molecular and intracellular level to the community and biosphere.

a. Associations of specialized cells performing the same function form a tissue groups of different tissues combined in characteristic patterns form organs and collections of functionally related organs constitute systems within the organism.

B. Diversity

1. Biologists establish groups of organisms based on morphological and physiological differences.

a. There has been a consistant, orderly and gradual pattern of development from simple to more complex organisms.

b. While no single characteristic differentiates all organisms, differences between them do exist. These differences become more pronounced in the higher forms.

1. A species is the basic classifying unit into which biologists divide organisms. By one definition species may be thought of as an assemblage of individuals capable of mating and producing fertile offspring.

2. The early embryonic stages of different animals may show gross morphological similarities. These similarities become less evident with further development.

3. Different species show the utmost diversity in number, size and form of chromosomes, but each species has its characteristic chromosome complement which is preserved at each cell division.

c. The higher plants are unique in that they are capable of photosynthetic activity and thus are directly or indirectly responsible for producing all the food materials in the world.

2. All organisms carry on the same vital processes* but the mechanisms in which these occur vary as they evolve from a simple to a complex plan of organization.

*Respiration	Reproduction
Assimilation	Absorption
Movement	Circulation
Ingestion	Excretion
Digestion	Secretion

a. Higher organisms are a collection of organ systems.*

*Digestive	Respiratory
Integumentary	Excretory
Muscular	Endocrine
Skeletal	Nervous
Circulatory	Reproductive

1. Human health is promoted by moderation and regulation in things such as cleanliness, exercise and food consumption.

2. The nutritional requirements of an organism are determined by the composition and physiological activities of its tissues and constituant cells. Genetic make-up, stress, and developmental stage may cause the needs to differ from time to time and from individual to individual.

3. All drugs (medicine) and many other substances (such as table salt) should be considered potentially harmful to the people who use them. Judicious use tends to minimize the danger.

C. Continuity

1. The hereditary characters in most organisms are determined by the genes or factors that were transmitted to them in the chromosomes received from their parents.

a. The phenomenon of heredity in all living things thus far investigated is attributable to the replication and transmission of the genetic materials DNA or RNA.

1. The DNA in a cell determines the type of RNA made, and the RNA in turn specifies the types of proteins which will be formed. Some of these proteins become structural components while others become enzymes. In this way genetic material determines characteristics of living organisms.

2. The universal genetic code is based on various combinations of four different nucleotides. A single coding unit consisting of three such nucleotides usually specifies a particular amino acid. Another may initiate or terminate synthesis of a polypetide.

3. The specificity of an antibody or enzyme is based on its unique capacity to unite preferentially with a definite chemical substance or configuration. Such a capacity reflects the genetic endowment of the cells producing the antibody or enzyme.

b. The flow of hereditary characteristics through time is made possible through the processes of mitosis and meiosis.

c. The fundamental unit of heredity, the gene, consists of numerous separable components found on paired chromosomes of cells.

d. Genes are arranged in a single file on chromosomes which are usually inherited together.

1. At times the genetic materials of two homologous chromosomes may be ex-

changed. This leads to greater variation in offspring and allows one to map the chromosome.

e. A gene pair is responsible for the expression of a trait.

f. A trait may be considered dominant if it is expressed alone in the offspring of parents with contrasting traits. The trait that is masked is considered recessive.

g. The sex of an organism is determined by the combination of X and Y chromosomes. (XX - female; XY - male) Some traits are linked to or influenced by the sex of an organism.

h. Since six cells meet at random in fertilization the traits of individuals for any generation occur in certain predictable ratios.

i. An organism is pure for a trait if the gene pair for that trait is the same.

j. An organism is hybrid for a trait if the gene pair for that trait is different.

k. Most organisms carry undersirable genes which, if brought together by inbreeding or chance, may express themselves as abnormalities in the offspring of such a union. This may have social implications for man.

2. Man uses the principles of heredity in improving the varities of organisms which supply his needs.

3. New kinds of living things have arisen through mutations caused by changes in the genes or organisms, such changes producing inheritable modifications.

a. Genetic mutation on the molecular level occurs as the alteration, addition rearrangement, or ommision of nucleotides in the nucleotide sequence of a gene.

b. Mutation in a population is essentially random; selection converts this randomness into a pattern.

c. The agents of mutation (radiation and some chemicals) affect biological systems by causing damage to cells and genes.

4. The gene pool consists of all the genes of a given population.

a. The genes within a given pool may be altered by:

1. Mutation
2. Random genetic drift
3. Gene migration
4. Differential reproduction

5. The enormous variety of organisms, past and present, is thought to be the result of evolution.

a. Present living cells are seen to arise from preexisting living cells.

1. Evolutionary specialization of long duration has resulted in morphological and physiological difference among the cells of an organism.

2. In sexually reproducing organisms, many new species arise when a segment of a population is isolated under conditions where it is free to evolve along different lines until it can no longer interbreed with decendents of the original population, where as asexually, evolutionary potential is very limited.

b. Species through many generations may evolve into new types, and the individuals and types best adapted to their life situations are the ones that survive.

1. Every species of organism is subject to certain environmental influence and only those members that are capable of surviving these reproduce new offspring and transmit many of their characteristics to their offspring.

2. In the reproductive cycle of living organisms there are always more offspring produced than are expected to survive.

c. While many biological events appear to be random, these events can often described or predicted statistically.

1. There is scientific evidence that the origin, evolution and continuation of life on this planet are dependent on natural phenomena.

2. Organisms relatively similar in structure and development are grouped together because they are believed to be related through common decent.

3. One theory concerning the origin of life on earth proposes that it arose spontaneously in an aquatic environment by the action of energy on nonliving material that became self-reproducing.

4. One theory states that life began in an oxygen-free atmosphere. The atmosphere changed when primitive cells developed a photosynthetic capacity and released oxygen. Present atmospheric oxygen is predominantly of photosynthetic origin.

d. Fossils, usually formed from the preserved hard parts of organisms, dated by the rocks in which they are found, reveal portions of the actual story of life's past changes.

1. Fossils represent ancient once-living organisms and populations. Much of our information about them is derived in part from principles based on the study of modern organisms and populations

2. Fossils of algae-like organisms and bacteria provide evidence of the earliest life on earth. These organisms are found in sedimentary formations believed to have been deposited more than three billion years ago.

3. Evolution of all life, including that of man, is not toward a hypetically perfect form of organism, but towards the most effective adaptation in a particular environment and niche.

D. Interaction

1. All living things are interdependent with one another and with their environment.

   a. No one major ecological factor but a combination of them determines the environment; soil, water, air, energy, living organisms (including man) all contribute.

   b. All living systems-from cells to biomes-are in a dynamic steady-state which may be altered when a component in the system is changed.

2. Energy from the sun passes through a network of organisms beginning with green plants-the food producers-then to animals which eat plants, then to animals that eat those animals and so on. At each transfer energy is dissipated and less life can be sustained.

   a. The sun, be virtue of the energy of its radiation and its position with relation to the earth, constantly works changes in the earth's surface and atmosphere, affecting all life directly or indirectly.

   b. The earth's carrying capacity is finite for one and all species. Its space, materials and available energy are limited.

      1. Those chemical elements, which are basic building blocks of all life, are constantly cycled on our planet by chemical, biological and geological processes.

         a. The conservative nature of living systems in exemplified by cyclic processes that have evolved, from the metabolic activities within a single cell to cycles occuring on a world-wide scale.

   c. All living organisms have other living things which compete with them for the available energy.

3. The Biosphere embodies the balance of nature, it includes an energy relationship that binds all living beings into one inseparable world.

   a. The variability of environmental factors influences the growth and distribution of life at all levels; from the small scale (micrososm) to the large (biome).

   b. Most species of microorganisms in their natural habitat are not dangerous to man and are essential components of the ocosystem.

   c. Environmental factors which influence and in turn are influenced by a population, tend to stabilize the population's size. Those factors which influence populations but are independent of them may cause instability.

1. Population growth in animals is solely a function of the relationship between birth rates, death rates and migration. When egress is not possible, continued increase can only be stopped by reduced birth rates and/or increased death rates.

2. After a slow phase, population growth from relatively low to relatively high levels usually tends to occur exponentially, then to decline as numbers approach environmental capacity.

d. Living things tend to increase in numbers to the level the environment will permit. Man's ability to modify his environment does not make an exception. His success in bypassing some environmental barriers is now challenged by new barriers.

e. When organisms alter the environment by their presence, they may adversely affect conditions for their own survival while improving conditions for the survival of other organisms thus allowing a succession of changes to occur.

f. The more constant the internal environment of an organism, the freer it can be of external environmental restrictions.

g. Diversification and specialization in species both lead to communities of living things characterized by interdependence, sharing and mutual tolerance, relative density, complexity and the efficient use of space matter and energy.

h. Ecosystems, such as inland bodies of water, with measurable energy inputs, outputs, and determinable transfer functions, can be partially modeled.

4. The natural environment is being so altered through the effects of technology and the rapid expansion of wealth and population that man must make drastic changes in his behavior of consider his extinction probable.

a. To meet future needs, the use of biological resources must be governed by the role these resources play in the ecosystem.

b. Conservation of our natural resources requires the management of our ecological systems so as to establish a balance of harvest and renewal, thus insuring a continuous yield of plants, animals and other natural renewable materials.

c. Conservation of our human resources requires the wise control of environmental conditions to provide for man's physical, mental, emotional and social well-being.

1. The control of plant and animal pests by factors such as disease, natural enemies and competitors is less harmful to the environment (in some cases) than many of the chemical synthesized for that purpose by man.

2. Man as an ecological force has been able to change some populations of organisms to suit his needs through selection and differential reproduction rates.

3. The indefinite extension of human life may not be a desirable goal because of the personal and social problems it could create.

4. Organisms become troublesome to man when his own activities alter or upset the existing steady-state. In this respect many organisms have become better adjusted to man than he has to them.

5. Behavior is action which alters the relationship between the organism and its environment. It is externally directed activity and does not include the many interanl changes which are constantly taking place in living things.

   a. Animal behavior has evolved just as structure and biochemical processes have.

   b. Behavioral patterns can be described in terms of one of more of the following: their functional significance, evolutionary history, developmental roots in the individual's experience, and physiological mechanisms.

   c. In many animal species the opportunities for mating depend upon socially determined interactions such as position in a dominance hierarchy or possession of territory. Individuals who are able to survive physically may not contribute their genetic material to the next generation due to lack of territory or social dominance.

   d. The behaviors of men and many other animals have much in common.

6. Diseases are a byproduct of the metabolism and reproduction of pathogenic microorganisms, reflecting the interaction of the pathogen with a susceptible host.

   a. Diseases are due to natural causes. All physical and possibly all mental diseases are based on molecular interactions.

   b. Varieties of organisms are well as individuals differ in their susceptibility of diseases, as pathogenic organisms also differ in their ability to induce diseases. This variation is hereditary but its expression is dependent on the environments

   c. The dispersal of most pathogenic organisms is primarily passive. However, vectors such as insects and other organisms do account for the transmission of some pathogens.

   d. Diseases in organisms may result from such factors as genetic constitution and physiological dysfuntion, and/or may be caused by living agents such as viruses, bacteria, fungi, parasitic higher organisms, and insects.

   e. Diseases are ideally controlled within populations, as well as individuals, by prevention rather than cure.

   f. Infectious diseases are controlled by excluding the pathogen from the host's environment, eradicating it from this environment, and by preventing or limiting its growth within the host.

LEVEL III - Human Physiology

1. Many, if not most, of the processes carried out by the human body are dependent on the proper functioning of osmosis, diffusion and enzymes.

   a. Diffusion is the movement of molecules and/or ions as a result of their own motion or of being hit by other molecules and/or ions.

   b. Osmosis is the movement of a liquid, usually water, from a region of higher to lower concentration of water across a membrane.

   c. Enzymes are proteins present in the body which function to speed up chemical reactions and remain unchanged as a result.

      1. No known chemical reaction in the human body occurs without the presence and assistance of enzymes.

      2. The operation of enzymes is affected by such factors as pH, temperature changes, amount of substrate present and the amount of enzyme present.

2. Digestion, which is carried on in organisms by enzymes, makes food soluble in the decomposition of the food into smaller particles and simpler compounds which can pass through the small intestinal wall and ultimately in cells.

   a. The adult human has 32 teeth of 4 basic types, incisors, canines, premolars and molars, which aide in the mechanical breakdown of entering food.

   b. Food is broken down further and digested as it passes through the esophagus and stomach into the small intestine.

   c. The small intestive absorbs digested food through the villi into the blood stream.

   d. The large intestine concentrates wastes, absorbs water and passes the feces to the rectum.

   e. Associated with the digestive system are the pancreas and liver which perform improtant functions in the process of digestion.

   f. Biochemical digestion consists of the breakdown through hydration of carbohydrates into sugars, fats, into fatty acids and glycerol and proteins into amino acids.

2. Ciculation involves the extra cellular transportation of substances to and from cells.

   a. Blood, which is a buffer solution, consists of the liquid, plasma, and various materials in solution, of major importance being the blood cells: leucocytes, erythrocytes and platelets.

1. The various blood types are inherited.

2. The clotting of blood is due to the platelets initiating a sequence of chemical events which ultimately leads to the formation of a clot.

b. The heart functions to pump the blood through the various blood vessels to all parts of the body including the lungs, which oxygenate the blood and remove CO_2.

1. The heart is ultimately the source of blood pressure which is measured with an instrument know as the sphigmomanometer.

2. Nervous control of the heart is affected and carried out through the SA and AV nodes, the Bundle Branches, and the sympathetic and parasynphatic nervous systems.

3. Physicians use an electrocardiogram to determine if the heart is functioning properly.

c. The lumpathatic system, which has vessels directly attached to blood vessels near the neck, collects large cellular wastes, proteins, debri and dead cells from the tissues and transports them to the blood in the lymph.

d. The circulatory system is prone to many disorders which can impair the health of man.

4. The respiratory system is responsible for the oxygenation and removal of CO_2 from the blood.

a. Air entering the respiratory system as it travels to the blood passes through many respiratory organs, such as the trachea, larynx, bronchi and alveoli.

b. Respiratory movements are controlled by various muscles and along with alternating pressures govern the amount of air which enters the system.

c. Oxygen is primarily carried in the blood as oxyhemoglobin and CO_2 primarily as HCO_3.

d. The respiratory system is prone to many disorders which can impair the health of man.

5. The excretory system is responsible for the removal of nitrogenous cellular wastes and excessive materials in solution in the blood.

a. Blood entering the kidneys through the renal artery is filtered in the glomerulus of Bowman's capsule and exists through the renal vein

b. Filtered wastes and other materials pass through the parts of the nephron where they are concentrated into urine and out of the kidney via the renal pelvis and ureter to the urinary bladder to ultimately be eliminated from the body.

c. Pressures caused by the varying amount of fluids and substances in the kidney determine the amount of wastes filtered and rate of blood being filtered.

d. The excretory system is prone to many disorders which can impair the health of man.

6. The central nervous system by means of the peripheral nervous system controls, under most circumstances, the functioning of all bodily organs and systems.

a. A nervous impulse which is chemical in origin, travels over neuronal and muscular membranes causing the organs to perform their various activities and motions.

b. The central nervous system consists of the brain and spinal cord and all of their associated parts and subdivisions.

c. Memory, thought, sleep, learning and associated processes stem from proper brain functioning.

d. The nervous system, as with all other systems, is prone to many disorders which can impair the health of man.

7. The endocrine system, functioning as an accessory nervous system, through hormones secreted by specific glands into the blood stream, controls the correct functioning of most bodily systems and processes, including growth, secretion of digestive enzymes and the reproductive systems of men and women.

8. Muscles, under the control of the nervous system, give shape and form to the body, are responsible for all body movement and produce necessary body heat.

a. There are 3 types of muscles: 1) skeletal, associated with most voluntary movement and attached to the skeleton. 2) smooth, associated with muscular organs such as those of the digestive and excretory systems, and cardiac, found only in the heart.

b. Muscles require constant nervous stimulation to maintain muscle tone or they soon atrophy.

c. At the end of all skeletal muscles are tendons which attach muscles to bones.

d. The muscles are prone to disease and frequently to injury interfering with the proper functioning of this system.

9. The skeleton provides a framework, protection and is used by the muscles in their functioning.

a. Ligaments attach bone to bone.

b. Cartilage is embryonic bone and often acts as a padding at points where 2 bones would rub together during movements.

c. Skeletal tissue consists primarily of a calcium phosphate matrix in which are imbedded the bone cells, osteocytes, connected through a complex network called the Haversian System.

d. Bones can be broken and otherwise damaged leading to an impairment of movement.

10. Sexual reproduction is the process which results in the production of a new individual.

a. The development of primary (sex organs) and secondary (deep voice, body hair, etc.) sex characteristics in the male is controlled by hormones.

b. The development of primary and secondary sex characteristics in the female is also controlled by hormones.

1. Before birth the ovaries of a female have developed the ova which later are expelled monthly through the uterus and vagina.

2. The monthly menstrual cycle of the female is the result of the alternation of follicle stimulating hormone and estrogen and results in the maturation and expulsion of an ovum from one of the ovaries, and if fertilization does not occur, is expelled along with the uterine lining.

c. The fertilization of an egg by a sperm results in the production of a zygote which can develop into a fetus.

1. Before, during and after fertilization many abnormal occurences can result in the mother naturally aborting the child or fertilization being impossible.

2. Fertilization can be prevented by various birth control devices.

d. Embryology is the study of the development of the zygote into an embryo. The embryo and fetus undergo many changes in anatomy before the birth of the baby.

LEVEL III - Exploratory Physical Science

Reference:

A. Matter is composed of various combinations of neutrons, protons, and electrons. These particles have mass and in the case of protons and electrons, electric charge. (I)

B. Matter is organized and classified in increasing levels of complexity. Fundamental particles → atoms → molecules → crystals (chuncks of matter.) The properties of any one substance are unique but it may have some of the properties of its ingredients. The properties of any one substance vary depending upon the arrangements of its ingredients. (II)

C. The behavior of matter can be described on a statistical basis. Therefore, we only predict what is likely to happen - not what will happen. (III)

D. Gravitational, electromagnetic and nuclear forces are responsible for changes in matter eg. bonding motion of planets and satellites, behavior of light. (IV)

E. Matter and energy in the universe are conserved or the sum of matter and energy are related. Energy may be transformed from one form to another. Chemical reactions, may involve changes in composition of matter and in chemical potential energy, or may absorb or release energy in the form of light, heat, or electricity. In any event the net gain or loss of energy for the whole system is zero. Changes in a system always result in a maximum degree of randomness. (equilibrium). (V)

F. At temperatures above absolute zero all molecules are in constant motion. The kinetic energy possessed by an object is proportional to the object in motion. The molecular motion of a gas exerts a pressure by transferring momentum to the walls of the container. Changes of phase occur when added energy is sufficient to overcome the attractive forces between particles. This added energy increases the potential energy of the molecules. The diffusion of gases and liquids, and the movement of electricity, are examples of the motion of particles. (VI)

G. - Certain forms of matter may change with time. These changes may be slow as in geological changes or rapid as in some radio-active substances. (VII)

LEVEL III - Exploratory Physical Science

The Nature of Science

1. To introduce students to some of the methods of scientific investigation such as the use of direct and indirect evidence, and the use of classification. (C)

2. To develop students' ability to make careful observations, take careful measurements, and to keep useful and complete records. (C)

3. To familiarize students with the metric system as a total of the scientist. Unit used are the Km, m, cm, mm, Kg, g, L, ml, cc. (C)

Investigating the Structure of Matter

1. To establish a brief historical background for our investigations into the structure of matter. (A,B)

2. To help students begin a critical examination of evidence on which to base their theories for the structure of matter. (A,B,G)

3. To introduce students to the concepts of mass, density, and specific gravity as sources of information concerning the structure of matter. (B)

Learning More About Matter From Solutions

1. To continue investigation of the structure of matter by studying characteristics of solutions. (B)

2. To study the differences and similarities that exist among such mixtures as solutions, suspensions, and dispersions. (B)

3. To introduce the concept the dynamic equilibrium. (B,E)

4. To measure the mass, volume and density of solutions in order to determine their concentration and to increase understanding of those concepts. (B)

The Patterns of Crystals

1. To refine the theory for the structure of matter through an intensive study of crystal growth and the characteristics of different crystal patterns. (B)

2. To provide additional opportunities to classify materials. (B)

3. To emphasize the concept of equilibrium as it applies to physical changes. (E)

4. To stimulate interest in energy by raising questions about the effect of heat upon matter. (F)

Temperature and Heat

1. To begin a study of heat and a critical examination of theories for heat. (F)

2. To relate the heat theories to theories for matter. (B,F)

3. To introduce students to the techniques of data collection on heat and temperature and to the use of graphs as a form for ordering data. (C)

The Gaseous State

1. To refine the concepts of matter and of heat by a study of the gaseous state of matter. (B,F)

2. To replace the caloric fluid theory with the kinetic molecular theory as a better explanation for the phenomena observed. (F)

Reviewing the Evidence and the Theories

1. To organize the collection of observations made thus far in developing theories about the structure of matter and the nature of heat, and to assess our tentative conclusions, by testing their capacity to explain many of the changes that occur in matter. (B,F)

2. To conduct further experiments to refine these theories before investigating other forms of energy. (B,F)

Radiation

1. To test the validity of the particle motion (kinetic-molecular) theory in additional areas. (F)

2. To introduce a new type of heat transfer (radiation). (D)

3. To begin to clarify the differences among the forms of heat and light. (D,F)

The Energy of Motion

1. To continue the study of energy by investigating motion. (E,F)

2. To determine the effect of energy of motion on matter. (E,F)

3. To further consider the implication of new investigations on the developing theories of matter and energy. (E,F)

4. To study the potential and kinetic energy of a pendulum. (E,F)

Force Fields

1. To introduce the concept of force fields including magnetic and electrostatic fields. (D)

2. To study the nature of these forces and how they act at a distance. (D)

Chemical Energy

1. To study chemical energy as one of the important forms of energy which affects matter. (E)

2. To relate previous experiments to the concept of chemical energy. (E)

3. To stress the concepts of equilibrium and randomness. (E)

4. To consider the theories of matter and energy in relation to chemical phenomena. (B,E)

LEVEL III - Physical Science, General

Reference:

A. The scientific method appears to offer mankind the most efficient means for manipulating and understanding natural phenomena that can be observed and measured. (Preamble)

B. Non-living matter is composed of protons, neutrons, electrons, and other fundamental particles that combine and interact in specific ways. These particles have mass and, in the case of protons and electrons, have electric charge. When the nature or degree of the interactions and combinations change, nuclear, chemical and electromagnetic energy can be released. (I)

C. Non-living matter is organized and can be classified into the units made up of protons, electrons and neutrons. These units exhibit increasing levels of complexity ranging from the fundamental particles to atoms, from atoms to molecules, and from molecules to mixtures of molecules. Even the smallest, readily observable bit of matter consists of enormous numbers of such units. In these larger aggregates matter can be classified and identified by means of observable properties. (II)

D. The behavior of these large aggregates of units can be partly described by statistical mechanics. One result of such a descreption is that predictions about any state of matter have a certain degree of uncertainty inherent in them. Another result is an accurate understanding of such observables as temperature, and pressure, and the derivation of equations of state for gases, liquids and solids. (III)

E. Units of Matter are acted upon by forces; the most fundamental of which are gravitational, electromagnetic, and nuclear forces. Such forces can give rise to motion of these units according to well-established laws such as Newton's Laws. These forces are also responsible for chemical bonding, the motion of planets, stars and satellites, the structure of solids, liquids and gases, and many other characteristics of matter. Units of matter moving under the influence of forces experience changes in their energy. (IV)

F. The sum of energy and matter in the universe is constant, being in dynamic equilibrium. In chemical changes, and in slow moving and massive dynamic systems, energy is conserved. In nuclear reactions energy is converted to mass, or mass into energy. Energy may be transformed from one form to another. Electromagnetic energy can be transported through empty space. Changes of any type in any system at constant pressure and temperature tend towards an equilibrium state in which the energy content is a minimum and the degree of randomness is a maximum. (V)

G. One of the forms of energy is kinetic energy of motion of molecules and groups of molecules. Such motion can be effected by the influence of forces in accordance with Newton's Law. Other manifestations of this motion on a moledular level are heat, temperature, electric current, diffusion, and gas pressure. Energy of motion is also important in understanding the nature of the gas, liquid, and solid states. The kinetic energy possessed by an object is proportional to the mass and to the square of the velocity of the object. (VI)

H. The motion of microscopic units of matter can be described in terms of velocity and acceleration; such motion being effected by forces as noted in statement E. The concept of velocity can be applied to changes of any kind observable with time such as chemical reactions, nuclear transformations, and geological changes.

LEVEL III - Physical Science, General

The Nature of Physical Science

1. To introduce students to some of the methods of scientific investigation, such as the use of direct and indirect evidence, and the use of classification (A,C)

2. To introduce students to the way scientists make careful observations, take careful measurements, and keep useful and complete records. (A)

3. To familiarize students with the logics of a measuring system, including the metric system, and the conversion from one system of measurement to another. Units used in the metric system are Km, m, cm, Kg, g, l, ml, etc. (A)

4. To be able to identify and distinguish between science and technology and to understand their development and relationship to each other. (A)

Investigating the Structure of Matter

1. To establish a brief historical background for our investigations into the structure of matter. (B,A)

2. To help students begin a critical examination of evidence upon which to base the theories of the structure of matter. (B,A,C)

3. To introduce students to the concepts of mass, mixture, compounds, elements, physical and chemical properties, as sources of information concerning the structure of matter. (B,C,E)

4. To continue the investigation of the structure of matter by studying characteristics of chemical reactions, atomic structure, solutions, ions. (E,C,F)

5. To introduce students to elementary concepts of kinetic theory by studying the behavior of gases and the relation between temperature and the motion of molecules. The relationship between the three phases of matter and kinetic theory should also be understood. (E)

6. To study the elementary principles of nuclear fission and radiation (B,E,F,H)

7. To gain an understanding of the importance of dynamic equilibrium in nature. (H,F)

8. To illustrate the humanistic value of the above concepts by appropriate reference to technological advances, (both pro and con) in the fields of health, anti-pollution, energy production, merchandizing, nuclear reactors. (A)

Forces and Energy

1. Understand the nature of speed, velocity and acceleration. (H).

2. To develop an understanding of the nature of forces, some skill in combining forces, and an understanding of static equilibrium. (E)

3. To develop an understanding of the relationships among force, energy, work and power, and Newton's Laws. (E,G,H)

4. To apply basic concepts of energy transfer from one form to another. (F)

5. To gain an understanding of kinetic and potential energy. (F,E)

6. To develop an understanding of the law of conservation of energy. (F)

7. To gain an understanding of the kinetic nature of heat and temperature and its transfer from one place to another. (F,G,H)

8. To illustrate the humanistic value of the above concepts by proper examples of forces, flows, energy and power taken from such fields as mechanics and machinery, electricity and magnetism, calorimetry. (A)

Wave Motion and Energy

1. To understand that waves are a means of transferring energy of various types. (F,E,H)

2. To study the production and nature of transverse and longitudinal waves and gain an understanding of the interaction between two waves, as well as their interaction with matter. (F,E,H)

3. To illustrate the humanistic value of the above concepts by appropriate examples taken from the field of music, sound, light, art, radio and television. (A)

LEVEL III - Physical Science, Chemistry and Physics

A. Fundamental Particles of Matter

1. Matter is composed of fundamental particles, i.e., protons, neutrons, electrons.

   a) Each type of particle has specific physical and electrical properties.

   b) Each type of particle has a defined location within an atom.

2. The presence and characteristics of the fundamental particles have been determined experimentally.

3. The number, type and arrangement of the fundamental particles will be specific for each element.

   a) Elements are arranged in tables according to physical and/or chemical properties.

   b) Variations in the number of neutrons within atoms of an element can occur.

   c) The arrangement of the electrons in an atom contributes to specific physical and chemical characteristics.

B. Bonding and Classification

1. The properties of matter depend upon the kinds and arrangement of atoms in the substance.

2. Matter can be classified into different levels of organization.

   a) Elements contain only one type of atom.

   b) Compounds are made of specific elements in fixed proportions.

   c) Mixture may contain any number of substances in any proportions.

3. Interactions can occur between atoms of one element and atoms of another element.

   a) Interactions between elements are related to the arrangement of electroms within the atoms.

   b) Electrons can be lost, gained or shared during chemical interactions.

   c) The number of electrons remains constant during chemical interactions.

   d) Energy changes occur during chemical interactions.

C. Predictability

1. Some properties of matter can be measured.

   a) Several systems of measurement exist based on different standards.

   b) The metric system is used by all scientists.

   c) Distance, mass, temperature and time are basic to measurement systems.

   d) Area, volume and heat are derived quantitative measurements.

2. The occurence of an event is expressed in terms of its probability.

   a) All events have a probability for failure.

   b) There is always error in measurement.

   c) Numbers used in calculations can be expressed as significant figures.

D. Basic Forces

1. The basic forces involved in the interaction of matter are nuclear, gravitational and elecgromagnetic.

   a) Satisfactory explanations for the nature of these forces are not available.

   b) These forces are detected and measured by the effect they cause on samples of matter.

2. The intensity of the effect of these basic forces is dependent upon the magnitude of the force and the distances involved.

E. Matter and Energy and Driving Forces

1. The sum of all matter and energy in the universe is constant.

   a) Matter and energy are interconvertible.

   b) Changes in matter are accompanied by energy changes.

   c) Energy can be "stored" in matter

2. Energy distributions tend to progress from a higher to a lower value.

   a) Heat energy flows from hot areas to colder areas.

   b) Heat energy can be transferred by conduction, convection or radiation.

3. The randomness (or entropy) of matter and energy distribution tends to progress from a lower to a higher value.

4. The tendency of minimum energy and maximum randomness are opposing forces in interactions of matter.

F. Forms of Energy

1. The fundamental particles of matter are in constant motion

   a) The application of energy in the form of heat or radiation causes an increase in molecular motion.

   b) Temperature is an indicator of the average motion of the particles in an object.

2. Energy exists in many forms

   a) Energy can be transferred from one object to another object,

   b) Energy can be converted from one form to another form.

   c) The total amount of energy in the universe remains constant.

   d) Energy exists in discrete amounts but is not particulate.

3. Energy in the form of electromagnetic waves is responsible for many phenomena.

   a) Light is the visible portion of the electro-magnetic spectrum.

   b) Color is the result of various frequencies of electromagnetic radiation.

   c) Infra-red, ultra-violet, radio waves and others are electromagnetic radiation at other frequencies.

   d) Light waves can be reflected, or refracted by optical devices

G. Matter and Time

1. Matter exists in a condition of constant change.

   a) Changes in matter require a continuous supply of energy.

   b) Many changes in matter are reversible.

2. The rate of change in matter is dependent upon a variety of factors.

   a) Most changes in matter accelerate with increased energy levels.

   b) Many changes in matter vary with the size of the particles involved.

   c) Changes in matter can be expressed quantitatively.

LEVEL III - Physical Science, Earth *

A. Fundamental Units

1. Atoms, isotopes, molecules, elements, and compounds are responsible for the formation of minerals, ores and rocks.

2. The physical and chemical properties, including crystal structure of earth materials are determined by kind, arrangement, and interaction of the atoms that comprise them.

3. The physical and chemical properties of a mineral can be used to identify it.

4. The mineral is a naturally occurring crystalline substance having a characteristic chemical composition and physical properties by which it may be identified.

5. Igeous, sedimentary, and metamorphic rocks are derived from minerals and organic substances in varying form.

6. Relative depth under the surface and conditions under which the rock is formed, provide a basis for determining both the class and specific identify of the rock.

7. Rocks may be classified on the basis of genesis, on the basis of minerals present and size and arrangement of grains.

8. The rate of weathering both chemical and physical, depends upon the composition of earth materials and their response to varying surface environments.

9. Earthquake waves provide evidence about the general structure of the interior of the earth suggesting where and how the density may change and giving some indication of the earth's composition.

10. Soil particle size relates to porosity, water retention and permeability.

11. The development of mature soils from unweathered rock relates to the passing of time, climate, vegetation, parent material, topography and man.

12. The composition and physical form of a land area depends on the climatic factors, soil types, vegetative cover, management practices and slope.

* The reader is referred to appendix for a set of conceptual schemes integrating geology, oceanography, meterology, aeronautics, astronomy and space science.

B. The Earth as a Planet

1. The earth is located in a system of celestial bodies.

2. The structure, processes and evolutionary history of the earth were and are partially influenced by the earth's position in the solar system.

3. The paths of the planets and other bodies in the universe may be described as determined largely be gravitational attraction and the body's inertia.

4. The seasons on earth are a result of the revolution of the earth about the sun and the earth's equatorial plane with respect to the plane of the earth's orbit.

5. The earth is not a homogeneous sphere but a comparison may be made between the earth and such a sphere to show that conditions in the earth's interior change upon such conditions a mass, radius and rate of rotation.

6. Day and night on earth result from the position of the earth in the solar system and from the rotation of the earth's orbit about its axis.

7. Tides in the sea and on the earth are results of the changing of relative positions of the sun, moon and earth.

C. Predictability

1. The study of present geologic processes and products is a basis for the interpretation of earth history.

2. The earth was formed billions of years ago and has been undergoing change since its formation.

3. The geologic time scale is used to relate geologic events and to arrange them in relative time sequence.

4. The study of fossils and their enclosing rock furnishes information about the environments in which the organisms represented by the fossils lived and died.

5. The geologic processes on the earth now were also active at about the same rate in past geological ages.

6. The present physical features of the earth can be explained in respect to these geological processes, operating over long periods of the past.

7. Weather prediction is based on a knowledge of local and regional hemispheric, atmospheric conditions.

D. Basic Forces

1. Almost all conditions of earth matter may be described in terms of fields.

2. The earth has a gravitational field that is explained by the Universal Law of Gravitation.

3. The law of gravitation applies to all matter.

4. Gravity is influenced by the shape of the earth, its rotation, topography and the density of the crystal material.

5. The earth has a magnetic field that is similar to the one around a bar magnet.

6. The response of some apparent solid materials, including the earth's mantle, to long continued forces is like that of highly viscous fluids.

7. Gravity moves weathered rock material to lower elevations and ultimately to the sea through the media of water, ice and winds.

E. Matter and Energy

1. The earth is in radiative balance and its temperature, determined by its distance from the sun, is within the range that allows water to occur in all three states.

2. The unequal distribution of solar energy and the earth's rotation produce the general circulation of the atmosphere.

3. The physical and chemical conditions existing in the ocean are largely dependent on interactions with the atmosphere, lithosphere and biosphere.

4. The primary controls of evaporation are free water surface, energy, air temperature, air moisture and air motion.

5. The waters of the land may be accounted for by balancing income (precipitation), storage (surgace storage, capillary and gravity water) and outgo (evapotranspiration, streamflow, ground water flow)

6. The climate to a large degree determines which processes will be dominant in the evolution of landforms in a region.

7. The sun directly or indirectly supplies almost all of the energy available on the surface of the earth.

8. Available solar energy is a principle factor in the evolution and movement of weather systems.

9. Ocean water circulation is the result of uneven heating, basin shape, salinity gradients, wind direction, and rotation of the earth.

10. Air masses take their properties of temperature and moisture from the regions of the earth's surface with which they are in contact over long periods

11. The primary cause of condensation in the atmosphere is adiabatic cooling caused by the expansion of rising air.

12. Secondary causes of condensation such as dew, frost, and fog are the result of meteorologic processes active at or near the ground.

13. Extreme atmospheric disturbances are responsible for many unusual weather phenomena.

14. Collision of air masses lead to the development of fronts and frontal weather.

15. The principle of isostasy accounts for the balanced topography of the earth's surface.

16. Mountains originate throughout geologic time through such processes as faulting, folding, volcanism and continental drift.

17. The earth's crust is constantly shifting so that stress and strain placed on rock layers produce new structures.

18. The earth's crust consists of relatively thin skin surrounding an immense interior. It is logical to look to the interior for evidence of processes and conditions that control the overall surface configuration.

F. The Earth in Time and Space

1. Evidence of perhistoric life exists in the form of various types of fossils.

2. Most geologic artificts having built in "radioactive clocks" can be dated in terms of half-lives and years through the use of radioactive isotopes.

3. The sediment method of dating indicates a relation between layering and the age of sediments.

4. Geologic time has been arbitrarily subdivided into various units on the basis of both biological and geological events.

5. The geological time scale is used to relate geologic events and to arrange them in relative time sequence.

6. The relative age of fossils may be determined by the order in which the strata that contains them is deposited.

7. The study of fossils and their enclosing rock furnishes information about the environments in which the organisms represented by the fossils lived and died.

8. The structure, processes and evolutionary history of the earth were and are partially influenced by the earth's position in the solar system.

9. Recent evidence arising from studies of the ocean floor indicates that the continents and oceans were no always positioned as they are today.

LEVEL III - Physical Science, Space

A. Matter is Composed of Fundamental Particles

1. All matter in the universe is composed of the same fundamental particles.

   a) Atoms are formed from smaller particles including protons, neutrons, and electrons.

   b) The type of atom formed is dependent upon the number and arrangement of the fundamental particles.

2. The evidence indicates a relatively uniform composition of components of the universe.

   a) Spectroscopic analysis can be used to identify the presence of elements in a sample of matter.

   b) The chemical composition of the sun and stars shows strong similarities.

3. Energy is released during interactions between the fundamental particles.

   a) The sun's energy results from the fusion of atomic energy.

   b) During interactions of fundamental particles mass and energy may be interconvertible.

   c) Energy can be transmitted through space as electromagnetic radiation.

B. Matter in the Universe is Organized Into Identifiable Components

1. The earth is a component of the solar system.

   a) The members of the solar system are in constant motion.

   b) The motion of the planets has been described in mathematical expressions.

   c) The members of the solar system have district identifying features including size, color, orbital path and orbital period.

2. The solar system is a component of a galaxy

   a) Many galaxies exist in the universe.

   b) Galaxies have distinctive sizes and shapes.

   c) Evidence from other galaxies is useful in determining the history of the universe.

3. Comets and meteors appear periodically in view of the earth.

   a) Meteors are short-lived intrusions into the earth's atmosphere.

   b) Comets have distinctive shapes and predictable trajectories.

4. Stars resemble the sun in composition and history

   a) Stars are classified by their intensity and color.

   b) Evidence exists for the motion of stars.

   c) Stars vary greatly in size and distance from the earth.

   d) Instruments assist in gathering information from the stars.

C. The Behavior of Matter in the Universe Can Be Described on a Statistical Basis

1. The motion of the component bodies of the universe follows predictable periodic patterns.

   a) On the earth, day and night and the seasons result from the earth's motions relative to the sun.

   b) The earth's moon has definite motions relative to the earth.

   c) Measurements can be made to describe the motions of other bodies in the universe.

2. All measurement is subject to error.

   a) The occurence of an event is described in terms of its probability.

   b) The precision of a measurement is limited by the instrument used in making the measurement.

D. The Component Bodies of the Universe Interact in Response to Electromagnetic, Gravitational and Nuclear Forces

1. Scientific laws have been established to describe gravitational interaction

   a) The intensity of gravitational interactions can be determined mathematically.

   b) Weight is a common effect of gravitational interaction.

   c) The orbits of artificial satellites is determined by gravitational effect

2. The energy available in the universe results from nuclear interactions.

3. Electromagnetic radiation is the initial source of energy on earth.

E. All Interacting Units of Matter Tend Towards Equilibrium

1. The motion of objects in the universe has been explained in quantitative terms.

   a) No motion occurs without the application of a force.

   b) Motion resulting from the application of a force depends upon both the magnitude of the force and the mass of the object.

c) Motion resulting from the application of a force is continuous until affected by another force.

2. The sum of energy and matter in the universe remain constant.

3. Equilibrium in a system occurs when the energy content is at a minimum and the randomness of the system is at a maximum level.

F. Heat, Temperature and the Phases of Matter are Related to the Motion of the Fundamental Unit of Matter

1. The color of stars and galaxies is related to their temperature.

a) The age of stars may be determined from temperature calculations.

b) The relative motion of stars can be calculated with a knowledge of their temperature.

2. The relative density of stars and galaxies can be determined from temperature measurements.

3. The expansion of gases resulting from heat results in propulsion through space.

a) Rocket engine utilize the thrust of expanding gases.

b) Launching and control of exploratory rockets results from the thrust generated by expanding gas.

G. Matter is Subject to Changes With The Passing of Time

1. Historical concepts of the universe vary from modern theories.

a) Early astronomers devised an earth centered universe.

b) The development of instrumentation and mathematics changed the concept of the universe.

2. Evidence from observations form the basis for understanding change in the universe.

a) The Doppler effect helps to explain the concept of an expanding universe.

b) Observations of stellar changes help to explain the history of the earth.

LEVEL III - Physical Science, Ocean

A. Water is composed of definite fundamental particles and has characteristic physical and chemical properties.

1. Hydrogen and oxygen combine in fixed proportions to form water.

a. The elements forming water are composed of the fundamental particles protons, neutron and electrons.

b. The electrical charges within the atoms cause water molecules to have polarity.

c. Some characteristics of water are related to the polar nature of water molecules.

2. Ocean water is a solution containing many substances.

a. The concentration of solutes in the ocean varies from one location to another.

b. The type and amount of solutes in ocean water can be determined by laboratory analysis.

B. The content and structure of oceans may be classified as either physical or biological material.

1. The earth's crust consists of relatively thin skin surrounding an immense fluid interior.

a. Dynamic forces within the earth have contributed to the features of its surface.

b. Various features similar to landforms occur as parts of the ocean floor.

2. The earth's ocean water is classified into three major oceans and several marginal seas.

3. The ocean floor is covered by deposits of sediments originating from erosion, precipitation of dissolved material and from remains of marine organisms.

4. Local conditions within the oceans determine distribution and type of organisms able to exist at that location.

a. Marine organisms are classified as either plankton, nekton or benthos.

b. The occurance of large marine organisms is dependent upon the existence and distribution of plankton.

C. The occurence of events follows statistically predictable patterns.

1. Natural changes occur in the oceans which can be measured.

2. Sophisticated instruments have been developed to measure changes in the oceans.

3. Predictions can be made about expected changes in the oceans.

D. There are complex interactions between the component materials and forces present in the oceans

1. Concentration of magnetic forces occur within the earth

a. Geomagnetic reversals have occured during the earth's development.

b. Magnetic anomolies support the theory of continental drift.

SPECIFIC CONCEPTS IN OCEANOGRAPHY

Studies of the oceans help to extend man's knowledge of the earth.

Knowledge of the oceans helps with an understanding of weather and climate.

Major ocean currents affect the climates of many regions on earth.

Ocean currents can be related to differences in water temperature.

The ocean floor consists of extensive mountain ranges and deep valleys.

The oceans contain large quantities of valuable minerals.

Ocean tides result in daily changes along coastal areas.

The oceans contribute to the movement of moisture into the atmosphere and back again - called the hydrologic cycle.

LEVEL III - Chemistry

A. Fundamental Particles of Matter

1. Matter is composed of the fundamental particles, protons, neutrons, and electrons whose location and physical characteristics can be described qualitatively and/or quantitatively.

   a) Each of the fundamental particles has an identifying mass and electrical charge.

   b) The location of a particle is dependent upon several factors including mass, charge and energy considerations.

   c) The behavior of the particles is dependent upon mass, charge, energy considerations and the proximity of other particles.

2. The nucles of some atoms are undergoing continuous change in the number of fundamental particles they contain.

   a) Both energy and mass are released during these changes.

   b) Fission reactions occur when heavier nucles disentegrate to form lighter nucles and release both particles and energy.

   c) Fussion reactions occur when lighter nuclei combine to form heavier nuclei releasing both energy and particles.

3. Different kinds of matter can be formed during interactions of the fundamental particles of matter.

   a) The properties of matter are determined by the number, type and the arrangement of the fundamental particles from which it is composed.

   b) The properties of a sample of matter may describe physical characteristics or predict the result of a change in conditions upon the matter.

   c) Interactions between the fundamental particles of matter require energy changes.

4. Conservation of mass and energy are observed during interactions of matter

   a) The total amount of energy, and matter is considered to remain constant during interactions.

   b) Energy changes which occur during interactions between particles results in a rearrangement of the particles.

   c) Rearrangement of the particles involved in an interaction may result in a phase change or the formation of another kind of matter or both.

B. Bonding and Classification

1. Matter can be classified into different livels of organization based on physical and/or chemical properties.

   a) Most substances exist as aggregates of different kinds of matter.

   b) The properties of a material depend upon the type and organization of the substances of which it is composed.

   c) Many solids are composed of substances organized into definite crystalline patterns.

2. Matter can be composed of a substance either in pure form or in a definite fixed combination with other substances.

   a) The characteristics of the products formed may be different with variations in proportions of the component materials.

   b) Pure substances have identifiable physical and chemical properties.

   c) Statistical Nature of Matter

      1. The characteristics of matter are predictable within the limits of measurement.

         a) Standard units of measurement and notation facilitate the accumulation and dissemination of knowledge.

         b) Many characteristic quantitative descriptions of matter are derived from indirect measurements.

         c) Quantities of matter are expressed in standardized but arbitary units.

      2. A unique system of notation has been developed to describe useful characteristic quantities in chemical calculations.

         a) The gram-formula weight (mole) represents a quantity of a substance equal to its formula weight in grams and containing 6.023×10^{23} particles.

         b) A definite relationship exists between the mass and volume of a material (density)

         c) Symbols can be used to represent the materials involved in chemical interactions.

         d) Energy changes resulting from chemical interactions can be calculated and expressed as units (calories) of energy and these in turn related to bond energy, bond length and angle.

      3. All energy is quantized

         a) The energy emmited or absorbed by an atom is always quantized.

b) An electron can only be "statistically" described when considering it particle nature.

c) Electrons exhibit the wave characteristics expected of a particle of its mass-energy.

D. Chemical Changes

1. Interactions of matter are a result of structural and energy considerations of the reacting species.

a) As materials lose energy they become less able to engage in chemical interactions.

b) The location of the fundamental particles composing a substance determines its tendency to react with other substances.

c) Substances tend to become more stable when their component fundamental particles achieve specific configurations

2. Quantitative relationships exist between substances involved in chemical interactions.

a) In a chemical change, the reacting species are either combined or released in definite proportions.

b) The ratio of reacting substances in chemical interactions can be related to the structural organization of the fundamental particles in the reactants.

E. Driving Forces of Chemical Reactions

1. Chemical changes result from the interaction of electrostatic forces upon the charged fundamental particles within a substance. Energy changes occur when particles move due to the effect of these forces.

a) A spontaneous chemical change will always move in the direction of reducing the potential energy of the system to its lowest value.

b) A spontaneous chemical change will also always move in the direction of achieving maximum randomness of the system.

c) The gain or loss of energy by a reacting substance is frequently indicated by corresponding changes in heat content.

d) Activiation energy is required to cause the reactants to proceed from the reactant to product.

e) The rate and direction of a chemical interaction is affected by the concentration of the reactants and the products and by the available energy.

2. All chemical reactions tend toward a condition of equilibrium.

a) When equilibrium scours, a dynamic condition results where the rate of formation of the products is equal to the rate of formation of the reactants.

b) The dynamic condition of equilibrium is achieved when the tendencies toward minimum potential energy and maximum randomness are equal and opposite.

c) Chemical equilibrium can be described by a constant which is defined in terms of the concentration of reactants and products.

d) A system in chemical equilibrium can be shifted by a change in conditions effecting the relative tendencies to low potential energy and maximum randomness.

3. Acid-base reactions represent an important example of equilibrium reactions

a) Acids and bases tend to alter the normal concentration of H^+ and OH^- ions in aqueous solutions.

b) Generally an acid can be neutralized by a base and vice-versa.

c) pH values indicate the relative hydrogen ion concentration of an acid or a base.

4. Equilibrium plays a very important role in electrochemistry.

a) Electrochemical reactions are those in which electroms are exchanged between reacting spaces.

b) Electrochemical cells result when two species having different tendencies to lose electroms are allowed to react together. They may be used as a source of energy until equilibrium for the reaction is established.

c) Some chemical changes can be forced to occur by the application of electrical energy.

F. Kinetic Theory of Matter

1. The basic units of a material are in constant motion.

a) It is assumed that all matter is composed of unit particles that are in constant motion.

b) The motion of particles is affected by many factors including mass, energy content and electrical charge interactions.

c) The temperature of a material is directly proportional to the average kinetic energy of the particles of which it is composed.

d) The motion of a material's particles ceases in the absence of kinetic energy - this state exists at 0^oK.

2. Changes in energy content may cause a change in the organization of a material.

   a) A change in the energy content of a material may cause a phase change ot occur.

   b) The rate of collision between moving particles varies inversely with the mean distance between particles.

   c) Pressure results from collisions of moving particles with the wall of the containing vessel.

   d) Pressure is proportional to the number of particles, their average momentum and the size of the container.

G. Reaction Kinetics

1. Interactions of matter occur at different rates.

   a) Chemical reactions occur as the result of effective collisions between particles.

   b) The rate of chemical reaction will be affected by concentration of reactants, energy content of reacting substances and other characteristics of the particles involved.

   c) The rate of chemical reactions may be regulated with the addition of catalytic substances.

   d) Optimum reaction conditions will result in the maximum formation of product.

LEVEL III - Physics

A. Nature of the Universe

1. There are observable properties of the universe that exist for which there are no satisfactory models or theories.

   a) Matter-energy relationships, space, time, and change are fundamental to the existence of the known universe.

   b) Gravitational, electro-magnetic and nuclear forces influence matter.

2. All matter is in constant motion.

   a) All motion is relative.

   b) Motion can be described in terms of position, displacement, veolocity and acceleration.

   c) Mathematical models have been developed to describe motion.

B. Nature of Matter

1. All matter is composed of fundamental particles

   a) Each substance is composed of specific particles.

   b) The particles forming a substance have a definite arrangement.

   c) The organization of the particles of matter follows a predictable pattern.

2. Matter can be described in terms of its physical properties.

   a) Qualitative statements identify samples of matter.

   b) Measurable quantities have been derived to accurately describe substances.

3. The particles composing a substance are in constant motion.

   a) Phase changes occur as a result of changes in the motion of fundamental particles.

   b) Energy changes cause the motion of fundamental particles to change.

C. Nature of Energy

1. Definite describable relationships occur between energy and work.

   a) Motion occurs as an expression of kinetic energy.

   b) The position of an object can be described in terms of its potential energy.

2. Energy is a transferable quantity.

   a) The energy content of an object can be expressed as units of heat.

   b) Temperature is a measure of the average kinetic energy ot fundamental particles within a substance.

   c) Energy can be transferred as the result of collisions between particles or objects.

   d) Energy is transferred in units, i.e., photons, calories, BTU's.

   e) Energy can be transferred by electro-magnetic radiation.

3. Wave motion is a form of energy transfer

   a) Waves have characteristics which can be expressed quantitatively.

   b) Light is a form of electro-magnetic wave energy.

   c) Sound can be described in terms of wave energy relationships.

D. Interactions and Transformations

1. Matter is affected by the forces acting upon it.

   a) Gravitational force affects matter in a quantitatively discribable. manner.

   b) Electro-magnetic forces affect manner in a quantitatively discribable. manner.

   c) Nuclear forces affect matter in a predictable pattern.

   d) Motion results from the affect of forces upon an object.

   e) Motion resulting from applied forces can be described quantitatively.

2. Interactions without contact occur between objects as a result of field forces.

   a) Gravitation occurs as a force between all objects.

   b) The effects of gravitational forces can be calculated.

   c) A magnetic field may cause interaction between specific groups of substances

   d) Electrical fields may cause predictable interactions between specific groups of substances.

3. The total amount of matter and energy in the universe remains constant.

a) In interactions between moving objects the law of conservation of momentum is assumed to be true.

b) Matter and energy are interconvertible but the amount of matter and energy remain the same.

c) The total electrical charge in a system remains constant.

4. During matter-energy or charge transformation a system will tend towards a condition of equilibrium.

a) When equilibrium is reacted in a system, a condition of minimum energy will exist.

E. Statistical Descriptions

1. Uncertainty exists in all measurement.

a) Events or conditions can be described in terms of their probability.

b) Uncertainty exists as a fundamental property of the universe.

Level Objectives IV

for

Biology—, Exploratory

by Cathy Brooks, W.hs.
Dave Truelson, BGhs.

Level IV Objectives - Biology - Exploratory

The objectives mentioned in the following pages were prepared during a 1973 summer workshop. Eight major units were developed to follow in sequence for an exploratory biology course, wit the units listed being topical in nature. They were designed to give a general and flexible overview of an exploratory biology course as designated in the conceptual schemes - Level III The level IV objectives are divided into two groups: content (concepts and knowledge) and process (activity or manipulation).

These objectives were designed with no particular textbook or manual in mind, but with the idea of "laying the groundwork" for teachers to begin using objectives to instruct students. They are general enough in nature to give resource and instructional aid to any exploratory teacher in High School District 214.

It also must be remebered that these objectives are ones which the authors feel best suit our student's needs in our respective schools and the materials and resources available to us. Therefore, they are subject to constant and moderate evaluation throughout the year.

Catherine Brooks, Wheeling High School
David Truelsen, Buffalo Grove High School

Basic Units for Exploratory Biology

I. Effective Approach to Problem Solving
II. The Cell and its Physiology
III. Microbiology - Life in its Simplest Form
IV. Plant Physiology and Diversification
V. Animal Physiology and Diversification
VI. Human Physiology
VII. Preservation of Life - Reproduction, Genetics, and Evolution
VIII. Ecology - Maintaing a Balance

Unit I Effective Approach to Problem Solving

Process Objectives

The student should be able to:

1. state what a problem is after they have recognized that one exists through accurate observation
2. recognize that predictions are needed to solve problems
3. identify the lab equipment and describe specific purposes for each
4. measure length, width, and volume using the metric system
5. compare experimental results and recognize the need for organization of results
6. recognize that conclusions are based upon evidence collected
7. accept the idea that science is a thinking process used by man to solve problems about his natural world
8. recognize problems by observing discrepent events in the classroom
9. infer predictions to solve the above problems
10. perform various activities in which lab equipment is used including meter sticks, balanc and graduated cylinders
11. construct graphs and data charts using their experimental results and use them in formulating conclusions

Unit II The Cell and its Physiology

Content Objectives

The student should be able to:

1. demonstrate proper use and care of a microscope
2. identify the parts of a microscope and describe their functions
3. identify and describe the functions of the following: cell, cell membrane, cell wall, nucleus, cytoplasm, chromosomes
4. describe the process and function of diffusion
5. demonstrate or illustrate the process of cell division

Process Objectives

1. label a drawing of a microscope
2. prepare several wet mounts
3. perform observations of living and non-living cells, using the microscope

4. observe diffusion through a semi-permeable membrane
5. observe prepared slides of cells undergoing mitosis

Unit III Microbiology - Life in its Simplest Form

Content Objectives

The student should be able to:

1. recognize that living things, no matter how small, can be arranged into related groups based on body structure
2. identify the three shapes of bacteria and the various colonies they may form
3. describe bacterial reproduction and predict how it could affect other living things through disease
4. select suitable living conditions for bacteria
5. state how antibiotics affect bacteria
6. name several harmful and several beneficial activities of bacteria
7. describe the structure of a virus and its reproductive habits
8. compare algae, fungi, and protozoans according to structure, habitat, food-getting processes and harmful and beneficial activities

Process Objectives

1. arrange various objects into specific groups according to various characteristics
2. innoculate petri plates with various types of bacteria and observe their growth under various conditions
3. observe the shapes of bacteria under a microscope from slides they have prepared
4. observe the effectiveness of antibiotics by experimenting with them on their bacterial cultures
5. observe various specimens of algae, fungi, and protozoans for identification of the organisms, their structures, and surroundings

Unit IV Plant Physiology and Diversification

Content Objectives

The student should be able to:

1. identify the following plant parts and describe their functions: flower, leaf, root, stem, seed, fruit
2. name the two types of plant reproduction and describe how they differ in process
3. describe how food and water are transported within a plant
4. name the four things necessary for food production in a plant
5. state the simple equation for photosynthesis and recognize how the components are related
6. recognize how plants affect our environment
7. perform various experiments with photosynthetic plants to determine what factors are necessary for photosynthesis to occur
8. from these observations, construct a formula for photosynthesis

Process Objectives

1. grow their own plants, observe the parts of the plant, and observe the environment necessary for good plant growth
2. observe flowering plants to compare pollination with vegetative reproduction
3. observe functioning guard cells and stomates and capillary water movement through observations of leaves and root hairs

Unit V Animal Physiology and Diversification

Content Objectives

The student should be able to:

1. describe the difference between vertebrate and invertebrate animals
2. name the major characteristics of each invertebrate phyla and identify specimens from each
3. compare the various characteristics of the vertebrate classes according to reproduction and body structure
4. identify specimens from each vertebrate class

Process Objectives

1. observe and dissect various non-living specimens of vertebrate and invertebrate animals to formulate a list of characteristics for each
2. observe animal behavior in living specimens

Unit VI Human Physiology

Content Objectives

entify the various layers of skin and describe their functions in relation to one another
plain the role skin plays in the body's cooling process

3. define excretion
4. identify the function of the following parts of the excretory system: kidney, ureter, urethra, urinary bladder
5. describe how a muscle works
6. identify three types of joints in the body
7. define cartilege and state its functions within the body
8. trace the flow of blood through the body
9. name the three types of blood cells and state their functions
10. name and compare the four basic blood types and their characteristics
11. name and locate the endocrine glands
12. state the functions of the hormones they secrete
13. describe the process of breathing
14. state the function of the respiratory system
15. name the basic parts of the nervous system
16. name the parts of the brain and state the function of each
17. trace a stimulus-response reaction through the body
18. name five of the human senses
19. compare the organs that are used
10. recognize the limitations of the human senses
21. identify the harmful drugs and state some psychological and physiological effects
22. state several reasons why people take drugs
23. identify the various organs of the digestive system and state their functions
24. recognize the need for a balanced diet
25. state the six nutrients that are essential to a balanced diet
26. discuss the role of vitamins in maintaining a healthy body
27. functionally define metabolism
28. locate the endocrine glands on a drawing of the human body
29. perform various activities to observe how the human senses work and how they are limited
30. construct a chart composed of meals that would result in a balanced diet

<u>Process Objectives</u>

1. conduct an experiment to show the rate of evaporation for various substances
2. label a diagram of the excretory system
3. observe muscular reactions to various stimuli
4. observe a human skeleton showing the various types of bones and joints
5. type their own blood according to the ABO blood group
6. stain and observe blood cells
7. observe prepared blood slides under a microscope
8. measure their breathing rate after various activities
9. measure their lung capacity
10. demonstrate reflex actions of various muscles
11. observe the effects of various drugs on the heartbeat of a small invertebrate
12. list reasons that they believe people take drugs
13. through experimentation, observe the action of enzymes in food breakdown
14. test foods for their nutrient components

Unit VII. Preservation of Life - Reproduction, Genetics, and Evolution

<u>Content Objectives</u>

The student should be able to:

1. Compare and contrast the functioning male and female repoductive systems
2. recognize the warning signs of venereal disease and where treatment can be obtained
3. state several long term effects of venereal disease
4. define the following: gene, dominant gene, recessive gene, chromosome, trait, mutation, meiosis
5. describe the process of meiosis
6. recognize the role chance plays in heredity
7. state some traits and diseases that are governed by heredity
8. state which genes determine the sex of an individual
9. accept the idea that man uses heredity to improve his environment and state examples of how he does this
10. recognize that fossils furnish evidence that living things have changed through time

. describe how nature selects and helps only the fittest of a species to survive.

illustrate the process of meiosis

Process Objectives

1. observe charts, models, films, etc. on the human male and female reproductive systems
2. perform research on human traits that are governed by heredity
3. perform experiments in probability
4. observe fossils and the methods by which they were formed
5. imitate these methods to form their own fossils

Unit VIII Ecology - Maintaining a Balance

Content Objectives

The student should be able to:

1. define the following terms and describe their relation to one another: community, ecosystem, biosphere, biome, succession, producers, consumers, food web, ecology
2. recognize that all living things are constantly in need of energy and describe how this energy is obtained
3. adopt the idea of man changing his environment and the need to conserve our resources and the balance of nature

Process Objectives

1. observe the factors that make-up the community around them
2. construct a food web
3. observe the man-made changes in their community and other areas, that have resulted in ecological unbalance of the area
4. visit the biological communities in their area

Level Objectives IV for Biology, General

by Herb Dorn
BGHS

Level IV Objective for General Biology

This paper is an effort to formulate Level IV objectives which include the Level III conceptual schemes for General Biology. It is understood that these objectives will have to undergo constant revision as all curricular material must change to meet the changing needs of students. However, it is hoped that these objectives represent the basic needs of a citizen that can be provided by a required course in biology. They are not written too specifically so cannot be considered as limiting teaching methods or materials. It is not slanted toward any particular text but uses a variety of media. It differs from the usual biology course in that more emphasis is placed on health and human physiology.

Some objectives, particularly those in the affective realm, cannot be achieved by a single lesson but run through an entire unit or longer period of time. These are written only once; however, in order to make this instrument a more useful tool for teacher and student they appear in the order in which they would be used for individual lessons. Sometimes in the final analysis many specific concepts are relatively unimportant compared to the overall feelings and attitude that a student has about the subject. Often a more "enjoyable" activity will be preferred to one that presents more facts. Some of the affective objectives may be achieved more by the environment of the classroom, the informal personality of the teacher, or by projects and activities conducted outside of the classroom. These outside-of-class educational opportunities should be considered an essential part of the curriculum. Detailed objectives will be presented to the students before each topic.

Herb Dorn, Buffalo Grove High School

The student will be able to:

Unit 1. Introduction

<u>Process Objectives</u>

1. State the purposes and procedure for the course.
2. Identify and draw the commonly used lab equipment.
3. Set up and correctly use a hot water bath using a bunsen burner, ring stand, beaker, asbestos gauze, and estimate the time required to heat a test tube half full of water to 90° C.

Unit 2. Metric System

<u>Content Objectives</u>

1. Compare common metric units to the English System.

<u>Process Objectives</u>

1. Measure common lab objects by linear, volume, and weight in the metric system.
2. Convert from one unit to another in the metric system.

Unit 3. Microscope

<u>Content Objectives</u>

1. Identify the parts and describe their functions.

<u>Process Objectives</u>

1. Demonstrate proper use and care of the microscope.
2. Focus and draw several objects at specified magnifications.
3. Measure certain objects using the microscope.

Unit 4. Scientific Method

<u>Process Objectives</u>

1. Infer the contents of mystery cells by means of experiment.
2. Support the scientific method as a historically proven source of information.

Unit 5. Living and Non-Living

<u>Content Objectives</u>

1. Distinguish the living from the non-living.
2. Describe the historical basis for characterizing a thing as alive and for the source of these living things.

<u>Process Objectives</u>

Recognize experimental evidence for determining the existence of life in selected samples

Unit 6. Foods (Molecules of Living Things)

Content Objectives

1. Identify the presence of sugars, starches, proteins, minerals and certain vitamins that appear in living organisms by means of proper testing procedures; describe their function.
2. Construct some of the simpler forms of these molecules.

Unit 7. Cell

Content Objectives

1. Describe the parts of a generalized cell and state the functions of each part.
2. Recognize the cell as the basic unit of life.
3. Identify basic differences between cells such as between an animal and a plant cell.

Unit 8. Osmosis

Content Objectives

1. Construct a model of a cell to demonstrate diffusion through a membrane.
2. Predict the osmotic flow under various circumstances.
3. Label specified parts.
4. Demonstrate osmosis with Elodea, Allium, or other live specimen.

Process Objectives

1. Introduce nutrients to a cell and test for their diffusability.
2. Produce suitable slides of a plant and animal cell.
3. Focus under the microscope and draw them.

Unit 9. Mitosis

Content Objectives

1. Describe the process of animal and plant mitosis in a time continuum.
2. Locate cells of these stages in microscope slides and identify them.
3. Produce microscope slides of mitotic stages.
4. Compare the process of mitosis to meiosis.
5. Infer differences of nuclear material in meiotic figures.
6. Predict the results of faulty meiosis or mitosis.

Unit 10. Metabolism

Content Objectives

1. Identify the processes of metabolism and recognize some of the simpler processes on a molecular level.
2. Measure the metabolic rate of his body under various circumstances.

Meaning Statement

1. Accept habits which develop efficient metabolic processes.

Unit 11. Nutrition

Content Objectives

1. Compare the energy used to the energy supply injested by his body.
2. Select the proper foods to produce a balanced diet.

Unit 12. Nutrition

Content Objectives

1. Describe the processes of digestion of the different food molecules.
2. Identify the locations of the human body where these processes take place.
3. Locate the same and related structures in a preserved frog.
4. Demonstrate the chemical reactions of digestion of certain food molecules and the environment in which these chemical reactions take place.
5. Infer the results of abnormal function of various parts of the digestive system and proper remedies.

Unit 13. Blood

Content Objectives

1. Describe the operation and purposes of the human circulatory system.
2. Identify his blood antigens and blood cells by proper lab procedure.
3. Observe the movement of living cells in capillaries.
4. Name causes for malfunctions of the circulatory system.

Meaning Statement

1. Adopt habits that maintain normal function.

Unit 14. Respiration

Content Objectives

1. Describe the operation and purposes of the human respiratory system.
2. Measure the vital and reserve capacity of his lungs.
3. Identify causes for respiratory failure and adopt practices for the proper function

Process Objectives

1. Compare the rate of respirations at rest to the rate under conditions of stress.

Unit 15. Kidney

Content Objectives

1. Name the structures of the human kidney and describe its purpose and operation.
2. Predict the effects of varying concentrations and pressure of inputs.
3. Identify common malfunctions and select proper remedies.

Unit 16. Endocrine

Content Objectives

1. Illustrate the location and function of the endocrine glands in humans.
2. Demonstrate or predict the glandular operation under varying and abnormal conditions.

Unit 17. Skin

Content Objectives

1. Identify the structures of the skin and describe their operation.
2. Demonstrate the temperature regulating mechanism.
3. Recognize the causes of the wind-chill factor, temperature-humidity index, and acne.

Meaning Statement

1. Adopt habits that maintain the proper functions of the structure of th. skin.

Unit 18. Bones and Muscles

Content Objectives

1. Identify the major bones and muscles of the human body.
2. Recognize their function under normal and stressed conditions.
3. Select suitable procedures for maintaining their efficiency and care for injuries.

Unit 19. Nerve

Content Objectives

1. Identify the major parts of the human nervous system and describe their operation.
2. Demonstrate its speed and accuracy under varying conditions.
3. Name causes for injuries to parts of the nervous system.

Unit 20. Reproduction

Content Objectives

1. Describe the process of human reproduction and the physiological effects of puberty.
2. Select correct information over falacies.

Meaning Statement

1. Adopt an attitude of responsibility and acceptability of sexuality.

Unit 21. Genetics

Content Objec ves

1. Identif haracteristics that are inherited and predict their probability of occuring.
2. Illustr the genotypes of selected and random mating.

Meaning Statement

1. Adopt acceptable methods for preventing genetic failure.

Unit 22. Drugs

Content Objectives

1. Recognize the causes and effects of drug usage.

Process Objectives

1. Measure drug effects on Daphnia.

Meaning Statement

1. Support practises which employ the proper use of drugs.

Unit 23. Micro

Content Objectives

Name the types of micro organisms and describe their life cycles.
Compare the effectiveness of various antiseptics or antibiotics.

3. Compare the distribution of microbes from various locations.
4. Recognize the use of beneficial microbes.
5. Select proven methods for the prevention of disease by microbes.

Process Objective

1. Prepare microscope slides and identify some.

Meaning Statement

1. Support hygienic metho'' for the prevention of disease microbes.

Unit 24. Classification - Animals

Content Objectives

1. Classify the groups of living things by distinguishing characteristics.
2. Observe and illustrate the structure and behavior of protozoa and metazoa.
3. Recognize the diversity of animals and their usefullness or harm to man.
4. Describe the life cycles of representative animals.

Meaning Statement

1. Adopt the practise of proper care and culture of animals in the community and nation.

Unit 25. Plants

Content Objectives

1. State distinguising features of different types of vascular and non-vascular plants.
2. Name and identify the various structures of plants and their function.
3. Describe the types of plant cells, their function, and illustrate them from actual specime
4. Identify common plants and their usefullness or harm to man.
5. Recognize the diversity of plants and their adaptability to the environment.
6. Demonstrate the chemical needs, products, and processes of plants in various circumstances
7. Compare the life cycles of various plants.

Meaning Statement

1. Support the culture of suitable plants in the community and nation.

Unit 26. Evolution

Content Objectives

1. Compare the structures of animals as to their adaptability in the environment.
2. Describe environmental changes through time which correspond to changes in the numbers of and types of organisms present.
3. Estimate the probability of several mechanisms for producing these changes in organisms.
4. Infer the unity of living things by comparison on various levels; molecular, cellular anatomical.
5. Infer the causes for the races of man.

Unit 27. Ecology

Content Objectives

1. Describe the relationships of different organisms to the various biomes.
2. Deomonstrate the relationships of populations to environment.
3. Describe the effects of and test for pollutants.
4. Describe the flow of energy and nutrients through food webs.

Meaning Statement

1. Select and support decisions which advocate a continued balance in the use of natural resources and the numbers and types of organisms.

Level Objectives IV for Biology, General

by Charles Zeller
AHS

LEVEL IV OBJECTIVES FOR GENERAL BIOLOGY - ARLINGTON HIGH SCHOOL

PART I: LIFE: THREE BASIC PATTERNS by: Charles Zeller

CONTENT:

The three basic patterns of unity -- structure, function, and change -- are each taught in an individual unit. Unit One: Patterns of Structure has four chapters. Chapter 1 is "The Early Search for Structure". Chapter 2 is "The Structure of Cells". Chapter 3 is "The Molecules of Life", and Chapter 4 is "Organisms and Their Environments".

Structure refers to the way in which the body of an organism is organized. In Unit One the historical process is used. Investigations began long ago with crude dissections and highly imaginative interpretations. Eventually accurate technique and careful descriptions related organ systems, organs, and tissues. Later, with the invention of the light microscope, the cell, and several structures within it were discovered. In the twentieth century the electron microscope and the labor of many biochemists have given biologists a detailed knowledge of cell structures and the molecules of which they are composed.

Also, in this unit we will study "higher" levels of organization which include such units as populations and communities.

The major goal of Unit One is to help the student to understand how life is organized in complete hierarchy of organizational levels.

This is a division that defines unity. The unity of nature is shown by the basic similarities, or patterns in all living things. The emphasis on unity is somewhat new. Diversity is more apparent in nature, but after much study the benefits of unity as an organizational tool became visible.

Part One is the study of the three most fundamental patterns of unity. All life is organized into the same basic structural organization. All life carries on the same basic functions. All life is subjected to forces that have caused, and will continue to cause, changes in its structure and function. Thus, a study of these three fundamental patterns -- structure, function, and change -- form the basis for this introduction to the study of life.

THE STUDENT WILL BE ABLE TO:

UNIT ONE: PATTERNS OF STRUCTURE: CHAPTER 1: The Early Search for Structure

CONTENT:
1. Identify or define each of the following: microscope, anatomy, cell, botany, superstitions, Aristotle, Galen, daVinci, physiology, taxonomy, Leeuwenhoek, Hooke, Dutrochet, Bichat, structure, philosophy, zoology, natural philosophers, phenomena, humanist, Dark Ages, Post mortem, Vesalius, Fabricius, Harvey.
2. Name several scientists of the seventeenth century who used the microscope.
3. Identify the scientific methods of measurement.
4. Explain why the natural philosophers made progress in science.
5. Compare the method of the natural philosophers and the experimental method.

PROCESS:
1. Describe the experimental method.
2. Explain why in the 350 years following the sixteenth century the plant and animal collections in Europe greatly increased.

OPTIONAL ACTIVITIES:
1. Select an anatomy book and describe its format to the class.
2. Visit the Museum of Science and Industry and observe the human anatomy displays.
3. Examine and list the parts of the human torso models in the classroom.
4. Visit the Museum of Natural History and observe the mummies in the Egypt display.

5. Make a list of the masses of equal volume cubes found on the laboratory tables.
6. Explain the technique of using the triple beam mass balance.
7. Measure the materials given with a meter stick. List the measurements in meters, decameters, centimeters and millimeters.
8. Measure the volume of water held by selected beakers and flasks.
9. Calibrate a thermometer.

UNIT ONE: CHAPTER 2: The Structure of Cells

CONTENT:
1. Define the following: mitosis, microtome, phase-contrast, chromatic aberrations, spherical aberrations, electron microscope, ribosome, nucleus, cell wall, chloroplasts, mitochondria, chromosome, physiology membranes, and pathology.
2. Identify each of the following people and describe their contributions to Biology: Robert Brown, Walther Flemming, Rudolf Virchow, Louis Pasteur.
3. Match the parts of the cell from the diagrams of the cell in Chapter 2 with the names of each part. Match the organelle with the function of that organelle.
4. Compare the animal and plant cells. Describe the differences.
5. Explain how spontaneous generation of cells differs from mitosis.
6. Make a list of the cell structures that can be seen in the light microscope and which structures cannot.

PROCESS:
1. Adjust a microscope in order to observe a slide at low and at high power.
2. Clean a microscope and carry it.
3. Calculate the magnification of the low and high lens system.
4. Find and identify the nucleus in a stained onion epidermis.
5. Draw the structure of the squamous epithelium cell obtained by scraping the luccal mucosa and staining it with methylene blue.
6. Demonstrate the making of a hanging drop slide and a wet mount slide.

UNIT ONE: CHAPTER 3: The Molecules of Life

CONTENT:
1. Define each of the following: atom, compound, neutron, hydrogen, amino acid, bond disaccharides, electron, proton, electron cloud, oxygen, carbohydrate, polar, peptide bonds,molecule, cohesion, energy, nitrogen, monosaccharide, atom, nucleus, ion, carbon, element, protein.
2. Know how chemical bonds are formed and what electrons have to do with chemical bonds. Know the relationship of opposite charged particles (protons +, electrons -) to chemical bonds.
3. Describe the human body from the chemical point of view. Start at the atomic level and describe the atoms that are most common in biological systems. Know how proteins, carbohydrates, and fats make up biological systems. Describe proteins, carbohydrates and lipids; know their structures and give examples of each.
4. Know what man needs to live and why. Know how man gets energy.

PROCESS:
1. Draw a model of hydrogen and label it.
2. Draw the structure of the generalized amino acid.

UNIT ONE: CHAPTER 4: Organisms and Their Environment

CONTENT:
1. Define the following: individual, population, community, ecosystem, biosphere, organization, structure, abiotic, biotic, ecologist, management area, gene, gene pool, typology, diatom, and vitamin B-12

2. Make a list of the hierarchy of levels of organization.
3. Make a chart showing all the factors that cause the poisonous tides and the factors that prolong and finally destroy the poisonous tide cycle.
4. Explain why a population may be considered a gene pool; tell how the gene pool relates to species, time, and place.
5. Name the four major terrestrial ecosystems.

PROCESS:
1. Write a short paragraph showing interdependent populations in a lake. For example, what fish eat what other fish and what fish eat plants.
2. Compare the biosphere to the ecosphere; compare in writing the ecosphere to the population.
3. Describe by means of a graph what would happen to the flies in a test tube containing a small amount of food, and a male and female fly. Put the number of flies and the amount of food on the "y" axis and the time on the "x" axis.

OPTIONAL ACTIVITIES:
1. Take a survey of a block. Find out the number of people, males and females, adults and children, that live in each house. Poll the kind, number and sex of pets. Add individual data to the class data and determine the average number of each category in the data per block in town.
2. Set up five foot by five foot quadrants in a vacant lot or overgrown area. Make a list of the number of different plants. Count each kind. Use a key to identify the kinds of plants.
3. Do a random sampling of the dandelions in the school yard and tell how it was done.
4. Do a population study of the animals found under a fallen log in a local woods or lot, or a population study with a string of mouse traps.

PART I: UNIT TWO: PATTERNS OF FUNCTION

CONTENT:

In biology the term "function" refers to the work that goes on within an organism's body. The orderly way functions are carried out is remarkable. For instance, we are seldom aware of heartbeat, etc. In fact, it is only when these functions become disorderly that we are aware of them. "Illness" and "disease" -- even "death" -- are the terms we use to describe various states of disorder in bodily functions.

The major goal of Unit Two is to help the student understand the basic functions within an organism. These are the functions of energy, transformation, regulation, and reproduction, which are ultimately responsible for the orderly way in which all other functions are carried on. Just as the cell is the basic unit of structure within organisms so also, it is the basic functional unit within organisms.

THE STUDENT WILL BE ABLE TO:

UNIT TWO: CHAPTER 5: Energy and Organisms

CONTENT:
1. Define each of the following: energy, autotroph, heterotroph, work, carbon 14 label, enzyme, substrate, coenzyme, respiration, ATP, synthesizing, chloroplasts, chlorophyll, activation energy, catalyst, cofactor, anaerobic, photosynthesis, chemical bond energy, fluorescence, mitochondria, active site, control, phosphate groups, and fermentation.
2. State the reactants, products, and place of reaction of photosynthesis. State what gas is released in photosynthesis. State the energy source of photosynthesis; explain how order is related to the energy of photosynthesis.
3. List the differences and similarities in aerobic and anaerobic respiration. State which process yields the most energy. Explain any linkage between the two forms of respiration. Know where a eukariot takes place in aerobic respiration.

PROCESS:

1. Diagram the molecule of ATP. Put special bonds in the energy rich sites.
2. Have a class debate: Is ATP a high energy molecule? If so, how does it form?
3. Diagram the activation energy necessary for an enzyme-catalyzed reaction versus the same non-catalyzed reaction.

OPTIONAL LABORATORY:

1. Demonstrate the different velocity of reactions using $2H_2O_2 \rightleftharpoons 2H_2O + O_2\uparrow$ with and without catalysts. Example: manganese dioxide, and peroxidase.
2. Demonstrate the kinds of pigments in a leaf by paper chromatography. Use the procedure and materials the instructor has provided.
3. Demonstrate the action of lysozyme or muracidase by disruption of bacterial cells.

UNIT TWO: CHAPTER 6: Master Molecules Control The Cell

CONTENT:

1. Define the following: genetics, heredity, chromosome, biochemist, enzyme, acetabularia, gene, hypothesis, pneumococcus, bacterial capsule, transforming factor, transformation, DNA, nucleic acid, nucleotide, helix, Crick and Watson model, hydrogen bond, polyribosomes, RNA, triplets, operon model, structural genes, regulatory genes, operator, template, x-ray diffraction, neurospora.
2. Identify these men and the work they have accomplished: Watson, Crick, Wilkin; Breadle and Tatum; and Avery, mcLeod and McCarty.
3. Tell the importance of nucleic acids and how the importance was discovered.
4. Describe the Crick and Watson model of DNA.
5. Describe the genetic code. Be specific on what the symbols of the code are, and what determines a triplet message.
6. Identify what the sequence of nucleotides has to do with the information in DNA.
7. State how DNA differs from RNA in structure. What are the three different kinds of RNA? Explain the function of each of these kinds of RNA. Show how RNA bases copy the DNA bases.
8. Explain the Protein Synthesis Model and how information is carried from the nucleus to the cytoplasm. State a proposed function of the polysome.
9. Evaluate the protein synthesis model as a scientific model. Write a paper explaining the Operon Model and how it uses both structural and regulatory genes.

PROCESS:

1. Demonstrate the techniques necessary to stain the mitochondria in the flight muscles of the house fly.
2. Estimate the size of the mitochondrion seen through the microscope.
3. Assemble the DNA model kits.
4. Separate DNA from yeast cells.

UNIT TWO: CHAPTER 7: Life Reproduces Itself

CONTENT:

1. Define the following: reproduction, intracellular, nucleic acids, proteins, environment, enzyme, organelle fission, organelle DNA, non-chromosomal gene, egg, parthenogenesis, binary fission, mitosis, chromatids, centriole, cell's poles, mitotic spindle, centromere, regeneration, fertilization, hermaphrodites, zygote, kinetochrome, nucleolus, meiosis, metaphase, homologous, anaphase, diploid, telophase, asexual, sexual, vegetative reproduction, crossing over, spores, monoploid sperm, pH, division plate, reshuffling.
2. Express an opinion on the quote by Weisz at the beginning of Chapter 7. Is "living matter more durable than the strongest steel", as Weisz says? What characteristics of life enable Weisz to make his statement?

3. Make a list of the different levels at which reproduction (making more of the same) takes place.
4. Compare and contrast in writing binary fission and mitosis.
5. Describe what happens to chromosomes during mitosis.
6. Describe the different ways asexual reproduction can take place. Does the organism that reproduces by asexual reproduction ever die?
7. Compare the shuffling of cards with the reshuffling of genes in the gene pool.
8. Identify the runners on the strawberry plant.

PROCESS:
1. Cut planaria into pieces in the lab and allow to regenerate. Culture peices of potato to show vegetative reproduction. Take cuttings and place into rooting compound and record the results.
2. Set up a system to cultivate Rhizopus and find a way to observe the spores.
3. Have a classroom debate over the topic: living genes control intracellular reproduction; or, subcellular structures have genes.

OPTIONAL LABORATORY:
1. Female frogs can be caused to ovulate by the student injecting pituitary hormone into it. Frog sperm can be obtained by the student by "milking" a male frog. Observe and describe in a temporal order the sequences of events occuring after fertilization of the frog egg.
2. Make a slide of an onion root tip and find mitosis. (Lab 7-1) Observe the stages of mitosis in prepared slides.

UNIT THREE: PATTERNS OF CHANGE

CONTENT:

Once a structure is known and its mechanism explained, it is only logical to wonder how it came to exist as it is.

By asking "how come" questions, biologists imply that valid explanations can be found for these questions. To find explanations for such questions, one must look back through the history of life.

The history of life shows that vast changes have occurred. What evidence supports this conclusion? What forces caused changes? How did life originally occur? These are typical questions to be answered before we account for any structure or function.

THE STUDENT WILL BE ABLE TO:

UNIT THREE: CHAPTER 8: Evidence of Change

CONTENT:
1. Define the following: evidence, fossil, trilobite, decomposer organism, biosphere, erosion, paleontology, strata, sediment, chronological, radioactive dating, isotopes, half life, a geological era, a geological period, terrestrial, vertebrates, extinct, immutable, population, generation, staphylococcus aureus, virulence, gene, domestic, species, evolution, theory of evolution, theory, fact of evolution, homologues, embryology
2. Make a list of direct evidence and another list of indirect evidence (Chapter 8). Explain to the rest of the class the difference between direct and indirect evidence.

PROCESS:
1. Have a class debate on the subject of the theory of evolution. Is it different from the fact of evolution?
2. Debate evolution versus creationism from the facts and the theory available.
3. Debate the question: "Is Evolution A Theory?"

4. Make a linear graph of the geologists' timetable. Place an arrow on the graph where we think life began. Put an arrow on the graph representing the first life on Land. Put a third arrow on the graph representing the first man or man-like form. Prepare a fraction by placing in the numerator the number of years man has been on the Earth and in the demoninator the age life has existed on Earth. Make another fraction with the same numerator but as a denominator use the age of the Earth.

OPTIONAL LABORATORY:
1. Treat E. coli cultures with different time exposures of black light (U.V.) Then replate them on minimal media plates. Also, plate them to observe colony counts. Find different forms of colonies if they exist. Is there any change in the colonies on the minimal media?
2. Observe and record the increase in the strucutral complexity in the fertilized chicken eggs.

UNIT THREE: CHAPTER 9: Darwin And Natural Selection

CONTENT:
1. Define the following: artificial selection, natural selection, evolution, adaptation, gene, acquired characteristics.
2. Write a short paragraph listing the contributions and theories for each of the following scientists: Charles Darwin, Jean Baptiste de Lamarck, Alfred Russel Wallace, Malthus.
3. Explain why Darwin favored the idea of evolution. Include in this answer what Darwin observed in island populations and the fossil records.
4. Compare and contrast in writing the work of Darwin and Wallace.
5. Explain Lamarck's theory of evolution. Identify the differences between Lamarck's theories and Darwin's theories.
6. "Nature does the selecting by allowing only the fittest to survive and reproduce": Give your reasons in writing for accepting or not accepting this statement.

PROCESS:
1. Debate whether or not Darwin would be a good geneticist by today's standards.
2. Laboratory: Demonstrate the technique of taking plaster casts of fossils.

OPTIONAL LABORATORY:
1. Take a field trip or local walk to find and collect fossils.
2. Observe and record microscopic structure of plant branches and leaves.

UNIT THREE: CHAPTER 10: A Modern Perspective

CONTENT:
1. Define the following: mutation, biogenesis, chromosomes, abiogenesis, polyploidy, evolution, sexual reproduction, niche, isolating mechanism, adaptation, colchicine.
2. Write a small paragraph about each of the following people: Louis Pasteur, Stanley J. Miller, Dr. Harold Urey, Sidney Fox, Francesco Redi.
3. Answer the following questions: What causes variations in population? How do new species arise? How might life have originated?

PROCESS;
1. Make Pasteur flasks and some flasks without the swan neck. Record the change in the contents of the nutrient broth.
2. Repeat Redi's classic experiment with jars full of meat, some covered with gauze. Leave them in a place where there are flies.
3. Make a book report of "Origin of Life" by John Keosin
4. Make yeast cultures and watch them reproduce under the microscope. Stain them with congo red to see which are alive.

CONTENT:

1. Define or identify the following terms: taxonomy, binomial, structure, Linnaeus, outline, species, taxa, natural, convergence, type organism, kingdom, systema naturae.
2. Write a paragraph about John Ray and Carolus Linnaeus.
3. Compose ten questions that describe how classification is done today.
4. Tell how genetics influences classification today.

PROCESS:

1. Place museum jars out on the laboratory tables and mark them numerically. Each group will decide whether each specimen is a plant or an animal. Make a list of specimens that seem to be related. Make a list of the least complicated to the most complicated.
2. Use dicotimus keys to classify some local trees.

PART II: PATTERNS OF STRUCTURE AND FUNCTION IN ORGANISMS

CONTENT:

Three basic functions -- energy transformation, regulation, and reproduction -- are carried on by the cell. There are other functions that are necessary to enable an organism to carry on its basic function.

Transport is an example of a secondary but necessary function. Energy is transformed in the mitochondria of the heterotrophic cell. This is a basic function: energy transformation. But oxygen must be present to receive the electrons in the mitochondria for the energy to be transformed. In some animals the oxygen must be inhaled from the atmosphere by the combined breathing functions of lungs, associated muscles and tubes. Then the oxygen must be absorbed by the blood, pumped to the area of the cell, transported across the capiliary cell membrane barrier and diffused into the cell, and ultimately into the mitochondrion.

There are other functions just as important as transport functions. Digestion prepares large masses of food molecules so that they may be absorbed and transported to the cells. Many important functions are involved in communication between the millions, billions, and trillions of cells in multicellular organisms. Nervous systems and hormonal communications serve these functions. The functions of defense and repair, which enable the organism to fight off foreign invaders and repair damage often stand between life and death. However, death is still the ultimate fate of every organism.

The functions of reproduction and development enable the organism to perpetuate itself before the forces of disorder wreak their havoc. Of all the functions, perhaps, the function of development is the least understood.

The nature of the individual organism depends upon the function and interaction of its genes with its environment. Environment varies, but the gene complement is inherited after recombination and perhaps mutation. A basic knowledge of genetics--the science that attempts to understand the function and interaction of genes and environment--provides an ideal capstone for the knowledge of the basic functions in Part Two.

PART II: UNIT FOUR: LIFE IN ITS SIMPLEST FORMS

CONTENT:

In the 1600's Leeuwenhoek discovered an important fact about life on our planet: Most of it is invisible.

Microbiology has grown into a tremendously important branch of biology. Unit Four will help the student understand why the study of the microbe is of such importance. First the Virus. The virus has not only created much valuable medical knowledge, but also has given us an understanding of cellular control mechanisms that is of fundamental importance to all fields of biology.

After viruses we study bacteria and other single-celled organisms. These microorganisms are important from an experimental point of view because their cellular machinery is exposed directly to whatever environment the investigator wishes to create.

THE STUDENT WILL BE ABLE TO:

CONTENT:

1. Define the following: virus, bacteriophage, lyse, antibody, antigen, vaccine, protein, nucleic acid, smallpox, cowpox, x-ray diffraction, symmetry, polyhedrons, adenovirus, T_4, lysogenic, tissue-culture technique, penicillin, streptomycin, interferon, tobacco mosaic virus.
2. Have a debate on the nature of the virus: "The Virus is Alive". Bring into the discussion the topic of the Crystals of TMV produced by Wendell M. Stanley.
3. Explain how Avery, MacLeod and McCarty discovered the transforming factor was DNA.
4. Explain how Hershey and Chase found that it was the DNA core that was infectious in the bacteriophage.

PROCESS:

1. Draw the structure of three different viruses or bateriophage.
2. Make a model of the T even bacteriophage out of cardboard.
3. Plate E. coli with different concentrations of virus to show the highest concentration, complete lysis; at the lowest, no lysis. This can be used as a titer of infective units of the bacteriophage.
4. Do calculations to show how tall a man would be if he were magnified like the image in an electron microscope. Example: 20,000 to 200,000 times.

UNIT FOUR: CHAPTER 13: Life In The Simplest Cells.

CONTENT:

1. Define the following: osmosis, flow, active transport, diffusion, absolute zero, concentration gradient, contractile vacuole, plasma membrane, digestion, extracellular enzyme, intracellular, pseudopods, lysosomes, microorganism, decomposition, organic, carbon cycle, solute, pores, plasmolysis, nitrogen cycle, nitrogen fixation, plasmodium, semi-permeable, turgid, protozoa, malaria, toxin, nodules, trichonympha, ATP, mitochondria.
2. Draw a model of the cell membrane. Explain the phenomenon associated with the membrane.

PROCESS:

1. Set up an experiment that will show the process of osmosis.
2. Streak a plate.
3. Make a pure culture.
4. Do an experiment to show the effect of antibiotics on common bacteria.
5. Make a heat fixed slide of bacteria (non-pathogenic). Stain bacteria with several common techniques and observe the end product under the microscope.
6. Use the stage micrometer and eye piece micrometer to standardize a high power lens. Measure some of the bacteria on a prepared slide.
7. Make a microbial garden to observe the action of microbes on food substances. Relate these to the digestive process.
8. Examine the intestinal flora of the termite.
9. Observe and draw the live specimens of protozoa found in the lab.
10. Observe the demonstration of the decomposition of milk, and of a dead bird.
11. Observe legume nodules.

PART III: PATTERNS OF INTERACTION BETWEEN ORGANISMS AND ENVIRONMENT

CONTENT:

Part III relates something of how organisms interact with their environment. Much of this is "new" biology almost entirely an activity of twentieth-century investigators. Wide divergence in techniques have been employed by modern biologists to observe and study organisms' interactions with their environment.

LEVEL OBJECTIVES IV

for

Biology, General

by Robert Scherer
FVHS

Level IV Objectives - General Biology

This paper represents an effort to formulate Level IV objectives (content and process) which encompass the Conceptual Schemes of the Level III objectives for general biology. Eight major themes have been selected which seem to tie in all of the proposed concepts organized under the Level III objectives. These are:

1. Ecological relationships
2. Cells and molecules
3. Diversity in plants and animals
4. Functioning plants and animals
5. Human physiology - health and drugs
6. Genetics
7. Reproduction in plants and animals
8. Evolution and life in the past

These eight major topics are presented in this paper as they would fit into a plan constructed for use with the BSCS Green version biology text. The Green version is weighted toward an ecological approach, however this plan could be modified to fit any individual teacher's interests or texts, with the emphasis shifted within the eight major topics to suit their needs. This work, therefore, is presented with the hope that it could serve as a guide for any biology teacher in any District 214 school, with the understanding that it may be modified as they see fit.

Robert H. Sherer, Forest View High School

Section 1. The World of Life - The Biosphere
Chapter 1. The Web of Life

Content Objectives

The student should be able to:

1. recognize and identify a producer organism
2. recognize and identify a consumer organism
3. identify a consumer organism as to first order, second order, or third order
4. describe a balance in nature by using the terms "producer" and "consumer"
5. construct a food chain by using examples of producers and consumers
6. construct a food web by using examples as in #5 above
7. identify the source of energy involved in food chains and webs
8. identify the cycling of elements in nature
9. identify characteristics whichseparate living things from non-living
10. identify parts of the microscope

Process Objectives

1. observe accurately by identifying characteristics of organisms, both plant and animal
2. set up a seed germination experiment with variables which will test hypotheses
3. record accurately the data obtained
4. graph the data obtained and draw conclusions
5. set up an experiment to show relationships between producers and consumers(snails and elodea) draw valid conclusions from the results obtained and record
6. adjust the microscope for useage
7. properly focus the microscope
8. prepare materials for microscopic examination
9. determine magnification with the microscope
10. determine size measurement with the microscope
11. demonstrate proper care and handling techniques with the microscopes

Chapter 2. Individuals and Populations

Content Objectives

1. distinguish between an individual and a colonial organism
2. identify a problem in population
3. define density as used in population problems
4. identify factors affecting population density and change
5. state the meaning of "species"
6. define the terms "sterile" and "fertile" as applied to organisms
7. demonstrate the meaning of species by separating various names, pictures, or actual living organisms into their specific categories

Chapter 2.

Process Objectives

1. demonstrate the ability to work problems in population density
2. construct a graph showing an actual or hypothetical problem dealing with population growth and draw inferences from same
3. demonstrate the ability to construct a semi-log graph using the same data
4. set up an actual experiment on population growth using living material (i.e. yeast organisms) and carry through similar steps as in 1, 2, & 3 above

Chapter 3. Communities and Ecosystems

Content Objectives

1. describe the component parts in the make-up of a biotic community
2. describe examples of competition between organisms in nature
3. describe examples of ecological niches
4. demonstrate the ability to identify examples of predator and prey relationships; parasite and host relationships
5. demonstrate the ability to identify examples of commensalism and mutualism
6. show by diagrams or an outline a working knowledge of biological succession from a pioneer stage to a climax community

Process Objectives

1. construct, either diagramatically or by models, a food web that might typify a biotic community

Section 2. Diversity Among Living Things

Chapter 4. Animals

Content Objectives

The student should be able to:

1. state the various taxonomic levels in a classification outline
2. identify characteristics of organisms which place them in their respective taxonomic category
3. identify the major characteristics of the chordate animals
4. identify the major characteristics of the invertebrate animals
5. group a number of organisms into taxonomic groups from observing their structural characteristics
6. list several examples for each of the major animal groups in the Phylum Chordata
7. repeat #6 above for the invertebrates

Chapter 5. Plants

Content Objectives

1. state reasons for using scientific names for organisms
2. state the rules involved in classification and binomial nomenclature
3. identify the major characteristics of the Tracheophytes
4. distinguish between terms "monocot" and "dicot" angiosperms
5. identify various gymnosperms by means of structural characters
6. identify examples of lower Tracheophytes (ferns, etc) by means of structural characteristics
7. recognize representative non-vascular plants
8. describe the importance of non-vascular plants to man

Process Objectives

1. identify parts of a flower by means of dissection
2. select and group from a number of representatives into monocot and dicot groupings
3. construct a dichotomous key using various representative plants
4. prepare microscope slide of lower plants for study
5. record the anatomy of lower plants through microscopic examination

Chapter 6. Protists

Content Objectives

1. describe examples of historical work in microbiology
2. identify some of the scientists who pioneered microbiology
3. identify representative examples of protists
4. describe the structure of a typical bacterium
5. identify various growth habits of bacteria
6. recognize the characteristics of various groups of protists
7. describe the importance of the protists to the environment
8. state the ideas involved in "spontaneous generation"

Chapter 6.

Process Objectives

1. set up an experiment to culture various microorganisms
2. prepare slides of various microorganisms for microscopic examination and record the observed examples
3. prepare a bacterial slide and stain for microscopic examination
4. demonstrate the proper technique for preparing culture plates of bacteria
5. set up an experiment that will negate the theory of spontaneous generation

Section 3. Patterns in the Biosphere

Chapter 7. Patterns of Life in the Microscopic World

Content Objectives

The student should be able to:

1. identify the relationships between microorganisms and disease
2. state various means of transmission of disease organisms
3. describe man's efforts in controlling disease organisms, both historically and present-day
4. recognize the component parts of soil, both living and non-living
5. state the importance of living microorganisms found in the soil
6. describe the nitrogen cycle and describe the steps involved
7. recognize that microorganisms may be both harmful and/or beneficial to mankind

Process Objectives

1. set up an experiment that will show the relationship between man's environment and the bacteria present
2. carry through an experiment to analyze a soil sample and identify its constituent parts

Chapter 8. Patterns of Life on Land

Content Objectives

1. describe environmental conditions which limit an organism's existence
2. list physical conditions which serve as barriers for various organisms
3. define the geographic range of various examples of organisms due to environmental conditio
4. describe the environmental factors which determine a biome
5. recognize the major biomes of the world
6. identify ways in which man has altered various terrestrial ecosystems

Process Objectives

1. set up an experiment with organisms (seeds) that will test their tolerance to various environmental factors
2. construct graphs which show the results obtained and state conclusions
3. construct and interpret climatograms for various biomes

Chapter 9. Patterns of Life in the Water

Content Objectives

1. recognize and identify the physical and biological characteristics of various fresh-water systems
2. classify representative forms of life from fresh-water ecosystems
3. state the effects of pollution on fresh water systems
4. recognize and identify the physical and biological characteristics of a marine environmen
5. classify representative forms of life from a marine ecosystem

Process Objectives

1. systematically analyze various samples of organisms from fresh-water systems
2. diagram various food webs from fresh water systems
3. diagram various food webs from a marine ecosystem
4. systematically analyze various samples of organisms from a marine ecosystem

Chapter 10. Patterns of Life in the Past

Content Objectives

1. state the significance of the fossil record as evidence of life in the past
2. describe an ecosystem of the past from the fossil record

Process Objectives

1. construct a food web of the past from the fossil record
2. with the information provided, chart the progressive changes in time that appeared in some organism (eg. the horse)

Chapters 10 - 11

Content Objectives

The student should be able to:

1. identify some of the early men and their efforts which have led to today's knowledge of the cell
2. state the cell theory and explain its meaning
3. recognize the identifiable structures of a typical cell
4. site the differences and similarities between plant and animal cells
5. identify the physiological concept of diffusion and osmosis
6. identify the physiological concept of mitosis
7. state the significance of mitosis to the living organism
8. identify types of cell differentiation and the concept of tissue
9. show the phenomenon of diffusion and osmosis as a cell-model set-up, and draw inferences to the living cell
10. identify various stages of mitotic division by use of the microscope and prepared slides, or fresh-mount slide material

Process Objectives

1. prepare microscopic slides of both plant and animal cells
2. demonstrate the ability to properly stain the slide mount
3. observe the slide and record by sketches and labeling

Chapter 13. The Functioning Plant

Content Objectives

1. identify the major parts of a higher plant, ie. leaves, roots, stems
2. identify the structural anatomy of a leaf, both internal and external
3. identify the structural anatomy of roots
4. identify the structural anatomy of stems
5. identify some of the men and their early efforts leading to today's knowledge of photosynthesis
6. identify the basic ingredients for photosyntheses to occur
7. be able to state the steps involved in the basic idea of photosynthesis

Process Objectives

1. examine prepared slides of a leaf cross-section under the microscope - sketch and label the identifiable parts
2. examine prepared slides of a root cross-section under the microscope - sketch and label the identifiable parts
3. examine prepared slides of a stem cross-section under the microscope - sketch and label the identifiable parts
4. set up an experiment to demonstrate transpiration in leaves
5. set up experiments with living plants to show evidence supporting the basic steps in photosynthesis
6. set up an experiment to extract pigments in plants by means of chromotography

Chapter 14. The Functioning Animal

Content Objectives

1. identify the major systems in higher animals
2. identify the structural anatomy of the systems noted
3. describe the functioning of the various systems noted
4. examine materials microscopically and macroscopically to distinguish anatomical structures of organs and tissues

Process Objectives

1. show, by means of various activities, a knowledge of the functioning of various systems
2. demonstrate comprehension of the systems of animals through the dissection of the frog and/or other representative animals

Chapter 15. Behavior

Content Objectives

1. be able to define terms used in discussing behavioral activity, ie. tropism, taxis, innate, etc.
2. state examples of behavioral activity which relate to adopted terminology
3. establish hypotheses for various plant and animal behavioral experiments

Process Objectives

1. set up various experiments which tend to support the hypotheses; obtain results and draw conclusions

Section 5. Continuity of the Biosphere
Chapter 16. Reproduction

Content Objectives

The student should be able to:

1. distinguish between sexual and asexual reproduction and describe examples of each
2. state the principles involved in meiosis
3. identify various patterns of reproduction from the simple to the complex in plants
4. identify various patterns of reproduction from the simple to the complex in animals
5. identify structures of human male and female anatomy by use of labeling diagrams
6. describe the function of structures in the human reproductive system
7. define terminology used in the study of human reproduction
8. identify the sequence of events from conception through the gestation period in mammals
9. describe the sequence of events involved in the menstrual cycle
10. identify purpose and significance of methods of birth control
11. identify kinds and prevention of venereal disease

Process Objectives

1. select from numerous examples of specimens to distinguish as to sexual or asexual methods of reproduction
2. set up experiments which support the ideas of asexual reproduction (i.e., plant cuttings, yeast budding, etc.)
3. conduct an experiment to illustrate embryological development (i.e., chicken eggs)

Chapter 17. Heredity

Content Objectives

1. describe the main ideas and efforts of Gregor Mendel's work
2. write or state the basic principles of Mendelian genetics
3. identify and describe various human traits which relate to the laws of heredity
4. define mutation and give examples
5. describe the significance of the DNA molecule as it relates to genetics
6. conduct experiments to illustrate the frequency of human traits in a population
7. demonstrate the structure and function of the DNA molecule by means of models

Process Objectives

1. work various examples of genetic problems by using the Punnett square method
2. conduct experiments with living organisms (Drosophila, albino plants, etc.) to support Mendel's laws of heredity
3. conduct experiments on probability (flipping pennies, etc.)

Chapter 18. Evolution

Content Objectives

1. identify the men and their theories involved in evolution
2. site examples which show that change has occured in the structure of organisms through the use of fossils and diagrams

Process Objectives

1. demonstrate how change can occur in the frequency of an organism through the use of models (e.g. white and dark moths)
(refer to Chapter 10 objectives for further work)

Level Objectives IV for Physical Science, Exploratory

by Robert Russell
AHS

Physical Science, Exploratory   Level IV Objectives (Physical Science a Laboratory Approach, Addison-Wesley)

The Level IV behavioral objectives for exploratory physical science are organized into the topic headings listed in the "Format for the Science Curriculum in District 214". These headings may be found in the "Format" under "Course Objectives-Level III, Exploratory PhysicalScience". The exploratory physical science objectives given here are completed only through the first 3 topic headings and are still being worked on by the author. The text book that will be used by the author at Arlington High School is "Physical Science - A Laboratory Approach" by Marean and Ledbetter (Addison-Wesley)

Robert Russell, Arlington High School

The Nature of Science

Process Objectives

The student should be able to:

1. define physical science in his own words
2. identify and define the following terms: problem, hypothesis, attack, observations (5 senses) and conclusion
3. define and identify examples of direct and indirect observation
4. recognize the difference between a qualitative and a quantitative observation
5. use indirect observation to determine how many spots are on a marked sugar cube
6. define the three metric prefixes commonly used: centi-, milli-, kilo-
7. define the terms: volume, matter, mass in their own words
8. read accurately and with the proper unit: a balance, a graduated cylinder, and a metric ruler
9. record lab data observations, calculations, and conclusions in a neat, orderly, readable form
10. record all measurements made in the lab with the correct label or unit
11. recognize the three basic units of measurement in the metric system: length=meter, volume=liter, mass=kilogram
12. classify a set of objects into a logical taxonomy system
13. convert a given metric unit into a different size metric unit
14. experimentally determine the volume of an object: irregular shapes-water displacement and regular shapes-metric rulers. Also, determine which method is more precise
15. recognize the difference between inductive (patterns in data) and deductive reasoning (predicting future from results of inductive reasoning)

Investigating the Structure of Matter

Content Objectives

The student should be able to:

1. distinguish between faulty conclusions and correct ones by Aristotle and other early scientists
2. recognize early theories on the structure of matter
3. recognize the important points on the following theories on the structure of matter: particle theory, continuous theory, particle-continuous theory
4. state a definition of density
5. identify the distinction between mass and weight
6. identify the distinction between density and specific gravity
7. recognize the terms: element, mixture, and compound

Process Objectives

1. adjust, light, and properly use a bunsen burner
2. adjust and properly use safety goggles during dangerous experiemnts
3. make complete and thorough observations using as many of the 5 senses as possible
4. use diagrams and sketches in observations
5. rephrase problems in his own words to make clear in his own mind what the problem is asking

6. answer questions about experiments he or she performs in the lab
7. define model as it is used in science
8. determine experimentally the mass and volume of several metals (Pb, Zn, Al, Sn, Cu, Fe) and calculate the density
9. experimentally determine the density of the various forms of sulphur
10. experimentally determine how the mass of a floating object is related to the mass of the liquid it displaces
11. construct and calibrate a hydrometer
12. use a hydrometer to determine the specific gravity of a liquid

Learning More About Matter from Solutions

Content Objectives

The student should be able to:

1. define terms: solute,solvent, solution, mixture, suspension, and dispersion
2. identify samples of suspensions, dispersions, and solutions
3. distinguish between unsaturated, saturated, and supersaturated solutions
4. recognize the characteristics of a physical change
5. recognize general characteristics of a crystal
6. distinguish between a concentrated and a dilute solution
7. list three methods that would increase the rate of dissolving of a solid in a liquid
8. recognize the difference between the rate of dissolving and the rate of crystallization in a given saturated, unsaturated, or supersaturated solution

Process Objectives

1. take experimental data and set up a graph using expanded scales
2. determine experimentally several properties of liquid mixtures (solution, dispersion, suspension)
3. determine the specific gravity of a solution as more solute is added and prepare a graph of specific gravity versus concentration

Level Objectives IV for Physical Science Exploratory

---energy, matter & change---

TOWNSEND

by Karin Schloegl.. BGHS

The following student behavioral objectives were written during a summer workshop (1973). They are based on Unit I: Light (Chapter 1-5) and Unit II: Electricity (Chapter 6-8) in Energy, Matter, and Change by Ron Townsend, a text that will be used by various schools in the district The objectives are separated into two categories- content and process. The former should describe the concepts students will learn and the latter are actual manipulations that the student will learn to do. These objectives are intended to be a first draft only- subject to constant and extensive revision during the school year. Any comments or suggestions you may have are welcome. Please feel free to USE these objectives in any manner you wish, they are not intende to be a model all Physical Science-Exploratory teachers should follow.

Since Level IV Objectives should relate to the other Levels in the "Format for the Science Curriculum in District 214", I respectfully submit my opinion that Level II Objectives for Physical Science: Exploratory as they appear in the Format, should be revised to fit any text, i.e. to be more general. I am sure that with only slight revision the following objectives will be a logical consequence of any new Level III statements.

Thank you for any time, thought, and/or considerations you may give these objectives.

Karin Schloegl, Buffalo Grove H.S.

Chapter 1 - Why Color?

A. Content Objectives

The student will be able to:

1. operationally define the following terms: 1. filter, 2. prism, 3. spectrum, 4. diffraction grating, 5. opaque, 6. transparent, 7. reflection, 8. absorbtion, 9. pure dye (pigment)
2. state the colors that make up white light
3. describe and explain in terms of a particle theory of light, what happens when:
   a. white light passes through various colored filters
   b. white light shines on various colored surfaces
   c. colored light shines on various colored surfaces
4. state or describe Newton's particle model of light
5. explain whether filters add or subtract color from white light
6. define and identify the additive and subtractive primary colors
7. expalin why the additive primary colors produce white light when mixed
8. explain why the subtractive primary colors produce black when mixed.
9. describe how the eye perceives color
10. recognize the fact that in order to see, light has to be present
11. describe and explain the appearance of the spectrum when it is reflected off a colored surface
12. recognize and expaline the Young-Helmholtz theory of color, and its variations and contraditions
13. recognize and describe Edwin H. Land's experiment of obtaining a colored projection from black and white slides.

B. Process Objectives

The student should be able to do the following:

1. use a diffraction grating or a prism to break white light into a spectrum
2. describe what happens to white light when it is passed through transparent squares of certain colors
3. predict what will happen to the spectrum bands if transparent squares of certain colors are overlapped
4. perform an experiment to demonstrate what happens to the bands of the spectrum when the spectrum is reflected off a colored surface
5. perform an experiment to demonstrate what happens when colored light strikes a colored surface
6. mix chalk of 2 colors to produce a third color
7. describe what happens when colored chalks (or paints) are mixed in the lab
8. blend light of two colors to produce a third color
9. predict what will happen if light of given colors is blended
10. distinguish between blending red, green, and blue lights and mixing yellow, cyan (blue-green) and magenta chalk or paints

11. Lighten or darken the shade of any color by mixing in white or black
12. Obtain any color by mixing the three primary colors in varying amounts.

Chapter 2 - Mirror Reflections

A. Content Objectives

The student will be able to:

1. recognize that in order to see, light must be reflected to the eye
2. recognize that an object reflects light in all directions
3. recognize that light can only bounce off the surface of a mirror
4. state the relationship between the angle of reflection, the angle of incidence, and the
5. use the particle model of light to explain the above relationship between the angle of incidence and the angle of reflection
6. explain and give examples of why only some surfaces reflect light to cause images
7. state the size, position, and location of virtual images in a flat mirror
8. explain and compare the production of mirrors in antiquity and today
9. state how flat mirrors reflect light
10. state how concave mirrors reflect light
11. explain what type of light beams cross the focal point of a concave mirror
12. state the effect the curvature of a concave mirror has on the focal length
13. state how two beams will be reflected from a concave mirror if they pass through the focal point before being reflected
14. describe and explain the relationship between the position, size, and location of an object and its image in a concave mirror
15. explain which types of images, real or virtual, may be projected on a surface and why
16. describe and explain the relationship between the position, size, and location of an object and its image in a convex mirror

B. Process Objectives

The student should be able to do the following:

1. operationally define the following terms: 1. mirror, 2. image, 3. angle of reflection, 4. angle of incidence, 5. incidence ray, 6. reflected ray, 7. normal, 8. virtual image, 9. real image, 10. ray diagram, 11. concave mirror, 12. flat mirror, 13. convex mirror, 14. focal point, 15. focal length
2. construct the angle of incidence and angle of reflection for a light beam given a flat mirror and a protractor
3. perform an experiment that demonstrates the rule of reflection for any flat mirror
4. perform an experiment that demonstrates three properties of virtual images made by a flat mirror
5. use parallel beams of light to find the focal point of a concave mirror
6. calculate the focal length of a concave mirror given the mirror position and 2F, 3F, etc.
7. use a concave mirror to produce virtual and real images
8. perform an experiment that demonstrates three properties of real images made by a concave mirror
9. perform an experiment that demonstrates three properties of virtual images made by a concave mirror
10. complete ray diagrams of virtual and real mirror images given the object, mirror, angle of incidence and reflection

Chapter 3 - Images Through a Pinhole

A. Content Objectives

The student will be able to:

1. explain why an image projected through a pinhole is reversed in upside-down
2. explain, using shadows, whether light always travels in straight lines
3. state several experiments which raise questions about the particle theory of light
4. explain whether waves move water across the surface
5. compare the pattern formed by a wave passing through two small openings to the pattern obtained when light passes through two small openings
6. explain diffraction in terms of waves
7. state Young's wave theory of light

B. Process Objectives

The student should be able to do the following:

1. use a box, pinhole, and flashlight to produce pinhole images
2. make predictions about the size, sharpness, and position of pinhole images given image distance, object size, and object distance
3. trace the path of a light ray from an object through a pinhole
4. operationally define: 1. light diffraction, 2. camera, 3. light interference, 4. wave, 5. wavelength, 6. frequency
5. draw diagrams of a) a wave interfering with another, b) a wave passing through one small opening, c) a wave passing through two small openings

Chapter 4 - Lenses

A. Content Objectives

The student will be able to:

1. describe how a lens improves on a pinhole for a camera
2. state two qualities which determine the effect lenses have on light
3. state the relationship between the angle of incidence and angle of refraction
4. state the relationship between the angle of incidence and angle of total reflection
5. describe the use of total internal reflection
6. state that light travels faster in air than in any other material
7. explain how refraction and the speed of light in different materials contradicts Newton's Particle Theory of Light
8. discuss how the wave theory of light explains phenomena such as refraction, interference, and diffraction using water waves as a model
9. explain why there are two focal points (and length) for lenses and their relationship
10. explain what happens to light beams which a) strike the surface of a double-convex lens parallel to each other and b) go through the exact center of a double-convex lens
11. predict how and where a double-convex lens will form images
12. state the three things needed to make ray diagrams with double-convex lenses
13. explain why double-convex lenses form real images
14. explain how a virtual image may be obtained with a double-convex lens
15. state the relationship between the curvature of the double convex lens and its focal lent size of image, distance of image from lens and whether a real or virtual image is formed
16. describe how far-sighted and near-sighted people see objects and how lenses can correct their vision

B. Process Objectives

The student will be able to do the following:

1. operationally define these terms: 1. lens, 2. normal, 3. i, 4. r, 5. refraction, 6. angl of refraction, 7. index of refraction, 8. total internal reflection
2. find the angle of the incident beam at the flat surface of a glass block and a container of water
3. show on a diagram where the two i's and r's occur as a light beam strikes a glass block at an angle
4. use experimental observations to describe what happens to light as it passes from air through another substance
5. list, sketch, or name different shaped lenses
6. use a double-convex lens to project an image on a card
7. draw ray diagrams of images formed with double-convex lenses
8. demonstrate the relationship between the distance of an object from the lens and the size of the image
9. demonstrate the relationship between the distance of the image from the lens and the distance of the object from the lens
10. use parallel beams of light to find the focal points of any double-convex lens
11. perform an experiment to demonstrate the kind of images made by a couble-convex lens
12. using two lenses to construct a simple telescope and microscope and draw simple ray diag

Chapter 5 - The Brightness of Light

A. Content Objectives

The student will be able to:

1. state and explain the relationship between light intensity and distance

2. explain the function of various parts on a camera
3. state Planck's and Enstein's contribution to the theory of light
4. state when flashbulbs should be used
5. describe a laser, its function and usage

B. Process Objectives

The student should be able to do the following:

1. use a light meter to measure the intensity of light
2. perform a simple experiment demonstrating the relationship between light intensity and distance
3. operationally define: 1. light intensity, 2. f stop, 3. shutter, 4. shutter speed, 5. photo-electric effect, 6. packets, 7. photons
4. to answer the question "What is Light" using experimental evidence

Chapter 6 - Measuring Electricity

A Content Objectives

The student will be able to:

1. explain why pulses are counted when measuring electricity
2. state how the terms conductor, insulator, and circuit are related
3. explain and show how a voltmeter is attached differently from an ammeter in a circuit
4. explain what conditions need to exist in order for a current to flow
5. explain what happens when more bulbs are added to a one battery circuit
6. explain why ammeter reading change when different bulbs are used in a circuit
7. explain whether the position of the ammeter in the circuit makes a difference in its readings
8. explain what happens as more batteries are added to a circuit
9. explain how static electricity is different from current electricity
10. explain how lightening is produced
11. explain the function of a lightening rod
12. state how energy is related to wattage
13. explain how a kilowatt-meter works
14. state the relationship between watts, amps, and volts
15. state the relationship between high and low resistance and number of amps passing through
16. state the relationship between amps, volts, and resistance
17. explain how and why an extension cord (wire) increases in temperature when connected to a high-powered appliance
18. state whether resistance is always the same in a given appliance
19. state what the total resistance is in a series circuit
20. state the advantage of parallel circuits
21. compare the amperage, wattage, resistance, and voltage in parallel and series circuit
22. state and explain that connecting too many appliances in parallel is dangerous
23. state the function and explain the operation of fuses and circuit breakers
24. explain why a circuit breaker is safer than a fuse
25. state the advantages/disadvantages of batteries connected in series and in parallel
26. briefly outline the history of the light bulb

B. Process Objectives

The student should be able to do the following:

1. operationally define the following terms: 1. battery, 2. electric pulse counter, 3. puls 4. coulomb, 5. electric current, 6. ammeter, 7. amperes (amps) 8. circuit, 9. filament, 10. electricity, 11. switch, 12. conduction, 13. insulators, 14. energy, 15. volt meter 16. volts, 17. static electricity, 18. wattage (watt), 19. kilowatt, 20. kilowatt hour, 21. kilowatt meter, 22. resistance, 23. ohms, 24. fuse, 25. circuit breaker, 26. incandescent light bulb, 27. carbon arc lamp, 28. gas discharge lamp
2. recognize and use the symbols used in connection with circuits
3. identify materials that hold opposit static charges
4. connect an electrical circuit following a shorthand diagram
5. draw a diagram of any electrical circuit containing batteries and bulbs or resistors
6. use an ammeter to measure the electric current in any combination of bulbs and batteries in a circuit
7. demonstrate the correct connection of an ammeter and voltmeter in a circuit

8. use a voltmeter to measure the volts used by any combination of bulbs and batteries in a circuit
9. find the resistance of a user, in ohms, given the number of volts it uses and the current in amps
10. sketch and explain the function of a Lyden Jar
11. identify (calculate) the wattage of various appliances
12. read a kilowatt meter
13. calculate their electric bill
14. calculate watts, amps, or volts, given the other two quantities
15. calculate ohms, volts, or amps, given the other two quantities
16. identify the two ways in which resistances may be hooked into a circuit
17. trace the path of electricity through a series and parallel circuit
18. identify the amperage in all parts of a given series circuit
19. connect bulbs and batteries in parallel circuits and in series circuit
20. describe some differences between the brightness of identical bulbs in parallel and and series circuits, given the volt meter and ammeter readings for each circuit
21. make and test a hypothesis about any differences between circuits with batteries in parallel and circuits with batteries in series

Chapter 7 - Electricity and Magnetism

A. Content Objectives

The student will be able to:

1. differentiate between the geographic and magnetic poles
2. explain which end of a magnet will point toward the two geographic poles
3. explain how a compass or dipping needle works
4. state the relationship between the strength of a magnetic field and distance
5. state whether an electric current can cause a magnetic field
6. state what happens to the magnetic field when the current through a wire is reversed
7. discuss the contributions of Galvani, Volta, Oersted, and Ampere to electricity
8. state two ways for reversing the magnetic field and current in a coil of wire
9. state the factors that affect the strength of an electromagnet
10. state the relationship between electricity and magnetism
11. discuss how electromagnets are used in the telegraph and telephone
12. list and explain the junction of each part in a triode
13. state some disadvantages of vacuum tubes
14. discuss the fundamental principles of radio and television

B. Process Objectives

1. Operationally define these terms: 1. magnet, 2. pole, 3. geographic poles, 4. magnetic poles, 5. magnetic compass, 6. field lines, 7. magnetic field, 8. electromagnet, 9. cell, 10. battery, 11. electromagnetic effect, 12. Voltaic pile, 13. Edison effect, 14. electron 15. vacuum tube, 16. diode, 17. triode, 18. grid, 19. semiconductor, 20. solid state, 21. transistor
2. sketch the magnetic field around a magnet using either iron filings or a compass
3. construct a simple magnetic compass and use it to tell direction
4. differentiate between the magnetic field around a straight wire and a loop of wire through which a current is flowing
5. trace the current and give the direction of the magnetic field, using the left-hand rule, for a a) straight wire, b) single loop of wire, c) coil of wire
6. identify the north and south pole of a coil of wire
7. build an electromagnet, given wire, a metal core, and batteries
8. map the magnetic field around an electromagnet
9. experimentally determine the factors that affect the strength of an electromagnet
10. predict the effect on the strength of an electromagnet given a change in the current through the coils, in number of coils, or in size of the core
11. use a magnet to produce an electric current in a wire coil

Chapter 8 - The Whirring of Motors

A. Content Objectives

The student will be able to:

1. explain how electromagnetism can produce rotating motion
2. explain how an electromagnet can be used as a meter
3. name and explain the function of each part of an electric motor
4. explain the difference between a generator and a motor
5. explain how horsepower is related to the output of a motor
6. describe the difference between an A-C generator and a D-C generator
7. explain the relationship between the speed of the armature and the amount of power put out by a generator
8. describe how alternating current is produced in a) coal burning, b) water-using, and c) nuclear power plants
9. explain how the current is transfered from the power plant to your home
10. explain why current is sent through wire at high voltage, low amperage
11. discuss the invention and development of the elctric generator and motor
12. discuss the advantages/disadvantages of nuclear, coal burning, or water using power plants
13. state reasons why power plants generate AC current and not DC current
14. discuss how power plants affect the environment

B. Process Objectives

The student should be able to do the following:

1. operationally define these terms: 1. electromagnet, 2. electric motor, 3. split-ring commutator, 4. brushes, 5. armature, 6. generator, 7. horsepower, 8. transformer, 9. direct current, 10. alternating current
2. build an electric motor, given the parts of a motor
3. demonstrate how a simple motor operates
4. change a small electric motor to an electric generator
5. measure the amount of electrical energy per second used by a small electric motor
6. measure the current produced by a small electric generator
7. write a paper discussing some aspect of the relationship between electrical energy and the environment (The Energy Crisis)

Level IV Objectives for Physical Science, General

by Milt Volpe
AHS

Physical Science - General
Milton Volpe, AHS

Level IV Objectives

Concepts

A. Scientific Method
1. Become knowledgeable about the advantages and disadvantages of the scientific method
2. Learn how the scientific method is used in chemistry, physics, and other physical sciences
3. Whether a method of obtaining information is "scientific" is determined by whether the method uses scientific method
4. The use of measurement by the scientific method makes it an extra-powerful method of obtaining information
5. Measurement relies on the existance of certain "units" of measurement. It is especially important to be familiar with the metric system and the English system of units, and with the inter-conversion of units from one system to another, and within one system

B. The Nature of Matter
1. Matter is anything that takes up space and has mass. Whatever has these characteristics is defined as "matter"
2. Weight is the force of gravity exerted between objects having mass
3. Observable characteristics of matter (called "properties) are used to identify different types of matter. Most of these properties can be measured
4. It is important to be able to recognize such properties as: a) density, b) color, c) hardness, d) freezing and boiling temperatures, e) magnetism
5. The property of "density" includes both mass and volume. There is a conceptual relationship between the density of a material, the "density of population", and the "density" of a classroom of students
6. A change in properties of a substance can be either a "physical" or a "chemical" change
7. There are three "states" of matter, gas, liquid, or solid, which can be characterized basically by the spacing of the molecules or atoms that make up the substance

C. The Structure of Matter
1. Understand the relationship between "mixtures" and "simple substances"
2. Understand the relationship between mixtures and compounds, and between elements and compounds
3. Be able to define and understand the terms "atom" and "molecule".
4. Become familiar with a special type of mixture, the solution:
   a) know the meaning of such terms as, solute, solvent, homogeneous, dilute, saturated, e
   b) know how the rate of solution of solids depends upon temperature, particle size, stirring
   c) know how the solubility of gasses depends upon temperature
   d) recognize and understand that solutions can be formed by combining any two of the three states of matter

D. Atomic and Molecular Structure
1. Know that the fundamental particles of matter are protons, neutrons, and electrons
2. Know some of the important properties of these particles (their masses, electric charges)
3. Protons and neutrons can combine to form the "nucleus" of an atom, nucleus, in combinatio with one or more electrons, forms an atom. In any atom, the number of electrons equal the number of protons.
4. The basic distinction between any two elements lies in the fact that the atoms of each element contain a unique number of protons or electrons
5. The force that holds the electrons to the nucleus of an atom (the electron "binding force" is electrostatic. It is this force which constrains the motion of atomic electrons to orbits around the nucleus
6. Obtain an understanding of how electron orbits which lie at different distances from the nucleus can represent different energies
7. Know the rules for fitting electrons into orbits for the first 20 elements. Recognize that these rules result from the very small size of the fundamental particles as well as from electrostatic repulsion between electrons
8. Know the "octet" rule and its application in the formation of compounds
9. From application of the octet rule and the use of atom diagrams, achieve an understanding of the terms: "molecule", "ion", "ionic bond", "covalent bond", "valance", "chemical equation", "chemical formula"

E. Chemistry
1. Through the atomic diagram representation, become acquainted with some common, simple, chemical reactions
2. By study of the diagrams in 1. above, understand and be able to use the rules for writing chemical equations
3. Know the symbols, names, valances for the first 20 elements
4. Know the arrangement of elements in the Periodic Chart and be able to give reasons for the arrangement
5. Use knowledge of atom diagrams, valence, and electrostatic forces to form an understanding of the structure of the water molecule and the hydrogen bond
6. Understand the relationship between hydrogen bonding and the observable properties of water such as: its action as an electrolyte, the decrease in density when water forms ice, the effect of pressure on ice
7. Understand the "lonely molecule" theory and how it can be applied to surface tension and absorption. Water has a high surface tension because of hydrogen bonds
8. Be able to use the kinetic-molecular theory to explain how a liquid like water produces cooling by evaporation

F. Water Production, Purification, and Treatment
1. Understand the nature of hydrostatic (water) pressure and use it to explain how a water "table" is made
2. Know the various methods by which potable water is obtained
3. Know how artesian wells are formed and used
4. Know why water has to be purified for use, some methods of purification, and what impurities can be and have to be removed from water to make it drinkable
5. Know and understand the importance of the various steps in community water purification
6. Know how and understand why water is treated with a fluoride
7. Know and understand some of the common methods of softening water (including the ion-exchange method)
8. Know chemical equations for softening hard water by ion-exchange and by a chemical method

G. Environmental Pollution
1. Use as an example, a simple picture of a closed-environment system to achieve an understanding of how to couteract the natural pollution, by living organisms, of their environment
2. Be able to define "Pollution"
3. Form an understanding of the inter-relationship of sunlight, nitrogen oxides, ozone, and hydrocarbons in "photo-chemical smog"
4. Understandsome of the simple chemistry involved in the formation of some pollutants
5. Know and be able to balance some representative chemical reactions which are important in pollution
6. Know and understand the processes involved in some anti-pollution devices
7. Understand the importance of weather conditions in inhancing or diminishing the effects of pollution

H. Work, Power, and Energy
1. The scientific definition of work is force X distance. There should be developed an understanding of the similarities and differences between this scientific work and the ideas of this concept that is used in everyday life
2. Energy is the capacity to do work and power is the rate of doing work. Again, these concepts and their relationship to our everyday use of these words should be understood
3. The concepts, "potential energy", and "kinetic energy" should be understood. Both are examples of types of energy and can be inter-converted
4. Some understanding and knowledge about other types of energy and their inter-conversion should be developed

I. Forces
1. A "force" is simply a push or a pull. This concept should be compared with the everyday use of the term
2. The idea of a force having both an "amount" (magnitude) and a direction should be underst[ood]
3. The concept of a "net" force should be understood
4. The differences and similarities between "force" and "pressure" should be understood
5. An unbalanced force produces a type of motion called acceleration. The relationship between acceleration and velocity, and between force and acceleration should be understoo[d]

6. There should be developed some familiarity with certain selected forces, such as gravity and electrostatics
7. The relationship between the electrostatic force and the electric charge on objects should be understood
8. The importance of electrostatic forces in forming atomic structure should be understood

J. Wave Motion and Sound

1. Waves represent one way in which energy is transmitted from one point in space to another Waves do not transmit matter
2. Generally waves are disturbances in a "medium"
3. There should be developed a certain understanding of wave types and properties
4. The relationship between the nature and transmission of sound and waves should be underst
5. Methods of measuring the speed of sound should be understood as well as the relationship between the speed of sound and echos
6. Certain important terms that describe sounds, such as loudness, pitch, ultrasonic, etc. should be known and related to the corresponding properties of sound waves

K. Sound and Music

1. Noise and music can be differentiated by differences in their wave patterns
2. Sound or music is produced by the vibrations of materials. The nature of these vibration and of their reinforcement by tubes and "sounding boards" is basic to the production of musical sounds
3. The relationship between the properties of the vibrating object (such as density, length, etc) and the sound produced, should be understood
4. There is a definite relationship between the sound produced and the dimensions of the reinforcing tubes or sounding boards used in the instrument

L. The Nature of Light

1. We try to determine what the nature of light is by becoming familiar with its properties. Some properties indicate that light is made up of waves, others that it is a group of particles
   a. interference of light is similar to interference of any kind of wave
   b. light travels through space, does not need a medium; this indicates that light is composed of particles
   c. photo-electric effect - particles
   d. polarization - waves
   e. reflection - waves or particles
   f. refraction - waves or particles
   g. color - waves, but can be particles, too
2. For objects to be visible they must either create light or reflect light
3. Light is produced by an inter-conversion of energy
4. Light polarization results from a "combing-out" process applied to the light waves. Polarized light is made up of transverse light waves, the displacement being in one plane
5. There is a direct relationship between certain properties of light and the corresponding wave properties
6. The brightness of a light source is related to the amplitude of the wave that hits the eye or to the number of particles emitted per unit area of its surface
7. The illumination of a surface varies inversely as the square of the source-surface distan It varies directly as the source brightness
8. When light is reflected from a smooth surface, the angle of incidence equals the angle of reflection, for any surface
9. A curved, smooth surface can be broken up into many tiny flat mirrors. Therefore, light reflection from a curved mirror can be understood as being the result of reflection from those flat mirrors
10. There are certain rules which result from the considerations in statements 8. and 9. that enable us to find the image of any object placed before a concave or convex mirror

M. The Refraction of Light

1. Light is "refracted" (or bent) surfaces of media in which light travels at different speeds
2. Light refraction can be crudely understood by considerations of the rolling motion of rows of particles as they move from relatively smooth to relatively rough surfaces
3. The greater the relative speed of light in two media, the greater is the refraction of light at the surface of the media

C. The Structure of Matter

1. Be able to identify and give examples of "mixtures","simple substances", "elements", "compounds"
2. Be able to use the terms "atom" and "molecule" properly

D. Atomic and Molecular Structure

1. Be able to draw "atom diagrams" both for single atoms of the first 20 elements and for simple chemical reactions among those elements
2. Be able to draw atomic diagrams for some simple compounds

E. Chemistry

1. Be able to "balance" chemical equations
2. Be able to write formulas for some simple chemical compounds made up of simple ions or certain polyatomic ions

F. Environmental Pollution

1. Classify the different types of pollution with respect to origin (auto, industrial, etc.) and polluted medium (air, water, etc)

G. Work, Power, and Energy

1. Should be able to identify examples of energy as being "potential" or "kinetic"
2. Should understand through experimentation how the pendulum inter-converts potential and kinetic energy
3. Should be able to do simple mathematical problems involving work, energy, and power

H. Forces

1. Be able to represent a force as an arrow having the proper length and direction
2. Be able to construct the proper net force from two given ones in certain simple examples
3. By means of experiments, form an idea of how the strength of the electrostatic force varies with distance

I. Wave Motion and Sound

1. Be able to use equations relating the speed of sound with distance and time on one hand, or with wavelength and frequency on the other
2. Be able to identify examples of waves as being transverse or longitudinal, frequency or amplitude modulated, etc.
3. Be able to construct a wave diagram from displacement-time or displacement-distance data
4. Be able to combine two given wave diagrams to show simple examples of the interaction or "interference" of waves

J. Sound and Music

1. Be able to use the relationship between velocity of sound, frequency, and the length of a closed-end resonating tube
2. Be able to recognize a "beat tone"
3. Gain some experience with pure tones, chords, scales, musical instruments, forced vibrati
4. Gain some experience with resonance of sound waves through experiments

K. The Nature of Light

1. The brightness of a light source can be determined by a comparison method using surface illumination
2. Given the proper quantities, the brightness of a test lamp should be calculable
3. The relative illumination of a surface, as the source distance varies, should be calculab
4. Construct the image of any object placed before a concave, convex, or flat mirror by using the law of reflection
5. Construct the image of any object placed before a concave, convex, or flat mirror by usin using the rules of ray-tracing
6. Identify any image as "real" or "virtual"; erect or inverted

L. The Refraction of Light

1. Trace light rays from an object through blocks of transparent materials to discover how light is refracted
2. Be able to calculate indexes of refraction from information about the speed of light
3. Become familiar with the terms: "focus", "focal length", "convex", "concave", "converging" "diverging", and others used in optics
4. Construct images of objects placed before one or two lenses of various types by the metho of ray-tracing
5. Become familiar with images formed by lenses by actual experiments

M. Color

1. Name the colors of the rainbow in order of increasing frequency

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5. Become familiar with images formed by lenses by actual experiments

M. Color

1. Name the colors of the rainbow in order of increasing frequency

2. Become acquainted with the visible spectrum through experiments
3. Identify certain elements by their flame colors
4. Learn that the colors of the rainbow can be recombined to give white light by means of a demonstration

Meaning Statements

A. Scientific Method

1. The scientific method is a practical way of investigating all sorts of problems. As such, it is generally useful and important in the lives of all students
2. The use of the metric system and the inter-conversion between the metric and English systems of units will soon become commonplace
3. The physical sciences affect our daily lives not only through the practical knowledge they provide, but also through the effect this knowledge has upon the economics, art, and literature of our society

B. The Nature of Matter

1. The properties of matter determine the uses to which substances are put
2. Certain scientific terms, such as "density" are used in non-scientific areas when a precise meaning is needed
3. Common terms such as "freezing" and "boiling" have precise scientific meanings that are useful to know

C. The Structure of Matter

1. Knowledge of how complex, common materials are made up of simple compounds or elements provides us with a unifying picture of nature and an understanding of manufacturing processes
2. We deal with many examples of mixtures and solutions on a daily basis. The common process of dissolving sugar in a drink such as iced tea or coffee involves a number of scientific principles of solution

D. Atomic and Molecular Structure

1. Today, the use of the terms "atom", "nuclear", "electron", etc. are within the common experience of all. In order to be considered "educated", and to be able to properly interpret and evaluate newspaper reports on many vital subjects, a knowledge and understanding of the structure of atoms and sub-atomic particles is needed
2. Electricity and electrical phenomena are so important today that it is necessary to understand that the source of all electricity is certain sub-atomic particles present in all atoms

E. Chemistry

1. All of the chemical products that we use are manufactured by processes which essentially transfer electrons from one atom or molecule to another. This process is the basis for the chemical industry
2. Many commonplace acts, such as lighting a match, are essentially chemical processes
3. Many commonplce events, such as the evaporation of water from a lake, cooling by evaporation, the lubrication of an ice-skate blade by melted ice, can be understood from a knowledge of atomic structure, and the kinetic-molecular theory

F. Water Production,Purification and Treatment

1. The relationship between community development and water supply is so close that it is very important to have a knowledge and understanding of water supply, purification and treatment
2. In view of the great interest and importance of combatting water pollution, a knowledge of the science of water purification is needed for every educated citizen
3. Water treatment for"softening" or other purposes is a commonplace and important example of applied science
4. The fact that water is so important to all of us makes necessary a fairly complete and detailed knowledge of the water molecule and its chemistry

G. Environmental Pollution

1. It is of great importance that the future citizens of our country understand the causes, the hazards, and the methods available to combat environmental pollution
2. It has become possible for man to travel under conditions in which he must provide for himself an environment which will permit him to survive. A knowledge of the components of this environment, and of the devices and methods for removing pollution from this environment, would provide important information for all citizens
3. Nature is constantly producing pollution and removing it. A scientific knowledge of these processes will help us to utilize natural methods of combatting pollution to the fullest extent

H. Work, Power, and Energy
1. Our lives are vitally affected by the practical consequences of these concepts through the use of machines and many types of energy
2. As individuals we use machines, simple and complex, daily
3. Our concern for the conservation and proper distribution of energy must be preceded by a clear understanding of work, power, and energy
4. The interconversion of one type of energy with another is basic to our civilization

I. Forces
1. This is another concept which has daily applicability to our lives
2. "Everyday" examples of practical uses of the combination of forces can be found in the airplane, sailboat, bridges, athletics, etc.
3. One of the most basic forces in all of nature is the elctrostatic force

I. Wave Motion and Sound
1. Waves of many types are part of our common day-to-day experience
2. The quality of sound is basically due to the properties of waves
3. Radar, sonar, earthquakes are all wave phenomena
4. An understanding of the properties of waves and sound is basic to an understanding of the workings of the ear, the telephone, etc.

K. Sound and Music
1. Many musical terms, such as "fundamental", "overtone", "pitch", etc. can be related to the properties of sound-producing vibrations and waves
2. The type of musical instrument is directly related to the type of sound-producing vibratio that is used
3. Musical sounds and intervals, such as "beat tones", "chords", the "tempered scale", and the "octave", are all the result of certain relationships among the frequencies of the individual waves which form the sounds
4. Sound recording and reproduction involves the combination of many concepts basic to the understanding of sound and music. Among them are resonance, and wave and vibration characteristics
5. Musical essentials include rhythm, melody, and harmony, all of which are variations of wave characteristics

L. The Nature of Light
1. Optical instruments of all types utilize the refraction, reflection, dispersion, and other properties of light for useful purposes
2. Natural events, such as mirages, colored objects, rainbows, etc., result from certain unique properties of light
3. Practical considerations of home lighting and the care of the eyes, can be served best by knowing something about the properties of light

M. The Refraction of Light
1. It is important to have a basic understanding of the most common types of optical instruments such as the eyeglass, magnifying glass, camera, telescope, and microscope. The operation of these instruments can be easily explained from the rules of refraction
2. The way that the appearance of objects changes when viewed through columns of water of air is a result of light refraction

N. Color
1. Science and art are closely related through the nature of light and color
2. The four-color printing process is a good example of mixing pigments
3. The basic simplicity of nature is well illustrated by realizing that such different-appearing things as light, radio waves, and radio active rays are all fundamentally the same kind of energy

Level Objectives IV

for

Physical Science, Chemistry

by John Aschenfelter
WHS

Chemistry: A Science of Matter and Energy Unit I

Content Objectives

1. The student will be able to recognize definitions of the terms science chemistry, matter, inertia, element, compound, mixture, symbol, formula, substance, heterogeneous, homogeneous, solution, metal, nonmetal, energy, physical property, chemical property, physical change, chemical change, theory, volatile, sublimation, viscosity, malleability, ductility, electrical conductivity, crystal structure, exothermic, endothermic, oxide, precipitate, "inert" gas, metalloid, diffusion, activation energy, catalyst, density, atom, molecule, physical state, cryogenics, chemical equilibrium
2. The student will comprehend the Law of Definite Proportions
3. The student will be able to comprehend the Kinetic Molecular Theory and use it to explain phase changes, Brownian motion, diffusion, gas pressure, etc.
4. The student will be able to state the difference between physical and chemical properties and determine into which of the two categories a given property fits better
5. The student will be able to state the difference between physical and chemical change and determine into which of the two categories a given change fits better
6. The student will be able to state the similarities and differences among elements, compounds, and mixtures and determine into which of the three categories a given material fits best
7. The student will comprehend the differences between accuracy and precision in measurement
8. The student will be able to state several criteria for determining whether or not a chemical change has occurred
9. The student will comprehend that one of the driving forces of a chemical reaction is the tendency toward minimum energy
10. The student will understand that chemical changes involve conversions of both mass and energy from one type to another but that in those changes the total amount of mass and the total amount of energy are conserved
11. The student will know that the physical and chemical properties of a substance can be used to identify it and distinguish it from other materials
12. The student will be able to state the effect of extremely low (cryogenic) temperatures on several types of matter
13. The student will understand that the rate of a chemical reaction does not affect the total amount of energy consumed or liberated
14. The student will understand that, in principle, all chemical reactions are reversible and that in closed systems many of them attain equilibrium

Process Objectives

1. The student will realize that sciences are interdependent and that dividing them up into "courses" is only a way to classify aspects of science for study
2. The student will understand the development, usefulness, and limitations of a scientific theory
3. The student will be able to select the material best suited for a given use when given a list of chemical and physical properties of several materials
4. The student will be able to suggest plausible methods for separating the components of a binary mixture
5. The student will be able to locate several physical and chemical properties of a substance when given the name of the substance and appropriate reference materials (including the Handbook of Chemistry and Physics)
6. The student will be able to experimentally determine the density of a solid which is denser than and inert toward water
7. The student will be able to determine the volume (to the nearest 0.5 ml) of a liquid in a 50 or 100 ml graduated cylinder
8. The student will be able to determine the mass (to the nearest 0.01 g) on a platform balance
9. The student will be able to determine the mass (to the nearest 0.1 g) on the Autogram balance
10. The student will understand that measured digits are known as significant figures and will be able to properly add, subtract, multiply, and divide measurements

11. The student will be able to calculate the percent error of the result of an experiment when given the "accepted value"
12. The student will be able to calculate the density, volume, or mass of an object when given two of those three values
13. The student will understand the structure and operation of a Bunsen burner
14. The student will be able to demonstrate the "popper" technique of pouring an acid from an acid bottle
15. The student will demonstrate his understanding of the dangers of open flames and acids by wearing safety glasses when using them
16. The student will be aware that burns due to contact with hot equipment and acids are to be immediately flushed with large quantities of cold water
17. The student will know to use weighing paper between a chemical and the pan of a balance

Objectives for Unit II - Atomic Theory and Atomic Structure

Content Objectives

1. The student will be aware of the contributions to our present atomic theory which were made by Dalton, Thomson, Rutherford, Bohr, and Schroedinger
2. The student will be able to recognize definitions of atom, electron, proton, neutron, isotope, shell, subshell, orbital, atomic number (Z), atomic mass number (A), nucleus, ground state, excited state, photon, nucleon, atomic mass unit
3. The student will understand that the atom has at its center a compact, dense, positive nucleus
4. The student will understand that Quantum Mechanics provides a model for determining the region (orbital) in an atom where an electron has a high degree of probability of existing
5. The student will be able to list the first four subshells of an energy level in order of increasing energy content
6. The student will comprehend the statements of the Modern Atomic Theory
7. The student will comprehend the process by which atoms absorb and emit photons of energy

Process Objectives

1. The student will experimentally collect data on objects that cannot be directly observed
2. The student will be able to perform an experiment to determine the approximate diameter of a molecule
3. The student will be able to write numbers representing very large or very small values in scientific notation
4. The student will be able to experimentally determine the relative masses of various objects
5. The student will be able to determine the number of protons, neutrons, and electrons in a neutral atom if given values of Z and A
6. The student will be able to calculate the maximum number of electrons for a given shell or subshell
7. The student will be able to calculate the maximum number of orbitals for a given shell or subshell
8. The student will be able to write the detailed electron configuration for a given element with the aid of an orbital chart

Objectives for Unit III - The Periodic Table and Valence

Content Objectives

1. The student will recognize definitions of the terms class property, subclass, empty class, null class, period, family, valence, ionization potential, electron affinity, transition element, inner transition element
2. The student will be aware of significant contributions to the classification of elements which were made by Dobereiner, Newlands, Meyer, Mendeleev, and Moseley
3. The student will understand that most properties of elements vary periodically when the elements are arranged according to increasing atomic number (Modern Periodic Law).
4. The student will understand that a more chemically active halogen will replace a less chemically active halogen from a water solution of the compound of the less active halide
5. The student will know that halogens are more soluble in carbon IV chloride than they are in water

6. The student will know that fluorine is the most powerful molecular oxidizing agent
7. The student will understand that an element's ionization potential and electron affinity depend upon nuclear charge, the number of shielding electrons, and the atomic radius
8. The student will understand that metals are characterized by low ionization potentials (and positive valences) and nonmetals are characterized by high electron affinities (and negative valences).

Process Objectives

1. The student will be able to determine the class properties, subclasses, null classes, and empty classes for a variety of entities
2. The student will understand that classification is an important task of the scientist
3. The student will be able to properly graph data
4. The student will comprehend the differences among direct, inverse, and periodic relationships and be able to classify relationships into those categories
5. The student will be able to locate on the Periodic Table the alkali metals, alkaline earth metals, halogens, "inert" gases, transition metals, inner transition metals, period 1 to 7, groups IA to VIIIA, and the B groups
6. The student will be able to suggest a probable valence for an A family element with the aid of a periodic table

Objectives for Unit IV - Chemical Bonds, Formula Writing, and Naming Compounds

Content Objectives

1. The student will recognize definitions of the terms ionic bond, covalent bond, polar covalent bond, single bond, double bond, triple bond, metallic bond, van der Waals' forces, electronegativity, ion, radical, Lewis dot symbol
2. The student will be aware of the relative melting points, solubility in water, and electrical conductivity of water solutions of ionic, covalent, and polar covalent substances
3. The student will understand that for a solid to conduct electricity that it must contain mobile elctrons and that for a solution to conduct it must contain mobile ions

Process Objectives

1. The student will be able to use the octet rule to predict the number of electrons an atom is likely to gain, lose, or share when it bonds with other atoms
2. The student will be able to predict whether the bond between two atoms will be ionic, nonpolar covalent, or polar covalent if given a periodic table or a table of electronegatives
3. The student will be able to make a plausible guess as to the type of bonding in a compound as a result of experimentally determining its melting point, solubility in water, and the electrical conductivity of its aqueous solution
4. The student will be able to construct the Lewis dot symbol for a given element
5. The student will be able to write the formula of a given compound with the aid of a valence sheet
6. The student will be able to name a given compound when given its formula and a valence sheet

Objectives for Unit V - Equation Writing and Chemical Calculations

Content Objectives

1. The student will know that chemical reactions can be classified into various types including composition, decomposition, single replacement, and double replacement
2. The student will be able to recognize definitions of precipitate, reactant, product, yields, coefficient, (l), (s), (g), formula mass, mole, decant, Avogardro's number, hydrated, anhydrous
3. The student will comprehend the Law of Conservation of Mass
4. The students will know that hydrogen, oxygen, nitrogen, fluorine, chlorine, bromine, and iodine are diatomic

Process Objectives

1. The student will be able to balance the equation for a chemical reaction when given the reactants and products
2. The student will be able to predict the products of a chemical reaction if given the reactants and the Physical Science Study Guide on Equation Writing

[illegible] ...tion as composition, dec[illegible]

3. The student will be able to classify a chemical reaction as composition, decomposition, single replacement, or double replacement
4. The student will be able to perform the glowing splint test for oxygen
5. The student will be able to calculate the formula mass of a substance, the mass of a given number of moles of a substance, and the number of moles of a substance represented by a given mass of the substance if given a periodic table or a list of atomic mass
6. The student will be able to determine the number of molecules represented by a given number of moles or a given mass of a given substance
7. The student will be able to experimentally determine the iron:copper mole ratio in a singl replacement reaction between iron and copper II sulfate
8. The student will be able to decant a liquid from a solid
9. The student will be able to determine mole ratios and mass relationships from chemical equations
10. The student will be able to calculate the percent composition of a given compound with the aid of a periodic table or a list of atomic masses
11. The student will be able to experimentally determine the percentage of water in a hydrated compound

Objectives for Unit IV - Water and Its Elements (not completed at this time)

Level Objectives IV for Physical Science, Physics

by Robert Russel
AHS

Physical Science - Physics

Level IV Objectives

The following behavioral objectives were done during a one-week workshop (June 18-22,1973). The objectives contain all the personal biases of the author and are meant to serve only as an example for other teachers in District 214. The objectives are organized into categories and an attempt has been made to relate each Level IV objective to the Level III conceptual schemes under Level III Physics listed in the "Format for the Science Curriculum in District 214". The outline numbers at the end of each objective statement refer to the format (blue cover).

The author feels these objectives will be subject to constant revision and updating as they are used throughout the year. It is also the personal feeling of the author that these objectives can be passed out to the students before they begin their study of physics in order to give them more direction in their efforts to learn physics.

Robert Russell - Arlington High School

Observing Phenomena (Measurement, Slide Rule)

Content Objectives

The student should be able to:

1. recognize the definitions for matter, mass, volume, density, and weight (A-2)
2. distinguish between the meaning of the terms mass and weight (A-1)

Process Objectives

1. define science in his own words (A-10)
2. recognize the areas of science that physics covers (A-10)
3. multiply, divide, take square roots and cube roots, and square and cube numbers on a slid rule faster than can be done by hand (A-5)
4. estimate answers to all math problems (A-3)
5. use scientific notation in solving problems with very large or very small numbers (A-3,5)
6. define measurement (A-1)
7. recognize the meaning of the term parallax and avoid this phenomena in making measurement (A-4)
8. use a metric ruler to measure distances (A-4)
9. recognize the definitions for the three standard units of measure: mass-kilogram, volume-liter, length-meter (A-1)
10. use a balance to measure mass (A-4)
11. use a graduated cylinder to measure volume (A-4)
12. determine the volume of an object by water displacement (irregular shape) and direct measurement (regular shape) using formulas (A-4)
13. recognize the limits of precision of a measuring device (A-4)
14. determine experimentally the density of several substances (example - wood, glass, metal, rubber, etc.) (A-4)
15. calculate relative error (%error) by comparing experimentally determined answers with accepted values provided by the instructor in the density determinations in objective 14 (A-5)
16. define metric prefixes: centi-$\frac{1}{100}$, kilo-1000, and milli-$\frac{1}{1000}$ (A-7)
17. convert from one unit in the metric system to another unit (example 4cm = 40mm = 0.04m)(A

Vectors and Forces

Content Objectives - The student should be able to:

1. define and recognize a scalar quantity and a vector quantity (A-9)
2. define force (A-2)
3. solve force problems using vectors and the parallelogram method (A-1)
4. list the three primary sources of a force, (nuclear, electro-magnetic, gravitational)

Process Objectives

1. use vectors(arrows)to represent the quantity of a force and its direction of action (A-1)
2. use force tables to demonstrate how the parallelogram method can be successful in predicting forces(A-1)

3. determine the actual path of an airplane in a given crosswind situation using vectors (A-10
4. determine the relationship between the force exerted on a spring and how far it stretches. Show results graphically (A-8,5)

Interactions and Transformations (Newton's Laws of Motion)

Content Objectives

The student should be able to:

1. define velocity, speed, and acceleration (D-2)
2. recognize Newton's 3 Laws of Motion (D3,4,5)
3. define momentum (D-5)
4. state Newton's 1st Law (D-3)
5. determine which of Newton's 3 Laws are responsible for explaining a motion of an object or objects in a particular situation (D-3,4,5)
6. determine the following for falling objects using the appropriate equations: final speed, distance covered, and time it takes to cover a certain distance (D-2)
7. recognize the definitions for: 1 newton, 1 dyne, and 1 pound (D-1)
8. solve problems using the inverse square relationship in Newton's Law of Gravitation ($F \propto \frac{1}{d^2}$) (D-6a)

Process Objectives

1. transpose an equation (example - solve for X in the equation $Y = \frac{X}{d^2}$).
2. measure speed of an object in the lab (D-1)
3. calibrate a ramp for rolling a ball down in terms of the speed imparted to the ball when it leaves the ramp and use this information to determine the acceleration due to gravity (D-2)
4. determine the relative error between the experimental value of acceleration due to gravity and the accepted value supplied by the instructor (E-1)
5. experimentally determine acceleration using Newton's 2nd Law of Motion and compare answers with predicted values of acceleration (D-1)
6. experimentally determine momentum of two balls before a collision and after a collision and compare the two momentums (D-5,9a)

Heat and Temperature

Content Objectives - The student should be able to:

1. recognize the important points in the Molecular-Kinetic Theory as it applies to heat energy (C-3)
2. use the Molecular-Kinetic Theory to explain changes in the state of matter, (example: solid $\longrightarrow$ liquid, liquid $\longrightarrow$ gas) (C-3, B-3)
3. define the term calorie, temperature, and heat (C-3a)
4. determine if there is any relationship between heat capacity of a metal and its density using the results of process objective #4
5. explain what absolute zero on the Kelvin temperature scale means according to the molecular kinetic theory on heat (C-3b)
6. recall the three ways in which heat is transferred (conduction, convection, and radiation (C-3c)
7. distinguish between conduction, convection, and radiation (C-3c).

Process Objectives

1. read a centigrade thermometer (C-3b)
2. measure experimentally the number of calories gained or lost by a sample of water [use the relationship that: Heat = (Mass of water sample) X (Temperature change of water sample)] (C-3a,3b)
3. determine experimentally how many calories of heat are needed to melt 1 gram of ice (C-3a)
4. determine experimentally the heat capacity of several different metals (C-3a)
5. convert between the Kelvin temperature scale to the centigrade temperature scale (use $°K = °C + 273$) (C-3b)
6. experimentally measure the changes in the volume of a gas (air) with changes in temperature in order to determine absolute zero (use capillary tube sealed at one end and a bead of mercury trapped in the middle) (C-3b)

Gas Laws

Content Objectives

The student should be able to:

1. define the term air pressure (E-2c)
2. recognize how a barometer measures pressure (E-2b)
3. recognize the relationships between pressure, volume, and temperature for a gas (E-2c)
4. use the relationships between pressure, volume, and temperature for a gas to predict changes (E-2c)
5. take data from instructors demonstration of Charles Law and Boyles Law and determine the relationship between: pressure and volume; and temperature and volume (E-2c)
6. determine the new volume of a gas if given; constant pressure, old volume, old and new temperatures (Charles Law application) (E-2c)
7. determine the new volume of a gas if given: constant temperature, old volume, old and new pressures (Boyles Law application) (E-2c)
8. determine the new pressure of a gas if given: constant temperature, old pressure, old and new temperatures (Gay-Lussac Law application)
9. recognize standard pressure (760 mm of Hg) and standard temperature (0°C = 273°K = 32°F) (E-2c)

Process Objectives

1. read air pressure from a barometer (E-2b)

Work and Power

Content Objectives

The student should be able to:

1. define work as it applies to physics (Work = Force X distance) (E1-a)
2. recognize how much force one newton ($\frac{Kg \cdot m}{s^2}$), 1 dyne ($\frac{gr \cdot cm}{s^2}$) and 1 pound represent (C-1
3. define power as it applies to physics (Power = work done per unit of time (C-1)
4. recognize the value of one horsepower ($\frac{500 \text{ ft} \cdot \text{lb}}{\text{sec}}$) (C-1)
5. define machine (C-1)
6. recognize the six simple machines on which all machines are based (wheel and axle, pulley lever, wedge, inclined plane, and screw) (C-1)
7. recognize how James Joule determined the mechanical equivalent of heat (C-3a)

Process Objectives

1. determine the amount of work done on an object given the force applied and the distance t object was moved (C-1b)
2. determine his horsepower when walking and running up a flight of stairs (C-1)

Electricity

Content Objectives

The student should be able to:

1. define what electricity is according to theory concerning electricity (C-1d)
2. recognize the definition of static electricity (C-1d)
3. recognize that (according to theory) when an object gains electrons it is said to be negatively charged and when it loses electrons it is said to be positively charged (C-10)
4. recognize what an electroscope is used for (C-10b)
5. recognize the definition of the term grounding in terms of electricity (C-10)
6. recognize the definition of the term direct current (D.C.) electricity (C-10iii)
7. recognize how a magnet can be used to produce electricity and how electricity can be used to produce a magnet (C-10)
8. recognize the definition for alternating current (A.C.) electricity (C-10)
9. recognize how alternating current electricity is produced through electromagnetic induction (C-10b)
10. recognize the basic parts of an electric generator (C-10)
11. recognize the term galvanometer; what it is used for and how it works (C-10)
12. recognize the definitions of the following terms: 1 ampere, 1 coulomb, electromotive force, and one volt (C-10e)

13. define resistance as it relates to electricity(C-10ii)
14. state the relationship between resistance and good or poor conductors of electricity(D-10di
15. use the results of objective P5 to formulate Ohm's Law (C-10di)
16. use Ohm's Law to determine one of the three varibles if the other two are given (C-10)
17. recognize the relationship between the resistance of an electrical conductor and its temperature (C-10)
18. recognize the definition of one watt (C-10e)
19. recognize that the power of an electric circuit is measure in watts (C-10e)
20. calculate the number of watts in an electrical circuit by multiplying volts X amperes (C-10
21. recognize that energy in an electric circuit can be measured in watt-hours (C-10)
22. calculate the number of watt-hours or kilowatt-hours (C-10)
23. recognize what a fuse is used for in an electrical circuit (C-10)

Process Objectives

1. determine experimentally the relationship between positively and negatively charged objects (C-10a)
2. determine the effect of the number of turns in coil of wire on the strength of the electro-magnet that is produced. Show graphically (C-10d)
3. determine the effect of the speed at which a bar magnet is thrust in and out of a coil of wire on the strength of the electro-magnet. Show graphically (C-10d)
4. measure some weak electric currents with a galvanometer (C-10d)
5. determine experimentally the relationship between volts, amperes, and resistance(ohms) in an electrical circuit (C-10di)
6. use a monthly electric bill to illustrate computation of charges based on cost per kilowatt-hour (C-10)

Level Objectives IV for Chemistry

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....at AHS for Chappin Text..

Level IV Objectives for Chemistry
H. Jones, AHS

THE STUDENT WILL BE ABLE TO:

CHAPTER 1: INTRODUCTION

PROCESS:

1. Recognize that there is both human and mechanical error involved in reading all measuring instruments.
2. Do a representative number of mathematical calculations showing the uncertainty of the final answer.
3. Calculate the energy of a chemical reaction and state the answer with the ± uncertainty for the heat of combustion of a candle.
4. Express a measurement in the proper number of significant figures.
5. Identify the number of significant figures in any numerical value.
6. Learn and apply the rules of significant figures in carrying out a mathematical operation.
7. Demonstrate a competency to read the common laboratory instruments to a proper number of significant figures.

CHAPTER 2-3; GAS BEHAVIOR

CONTENT:

1. Interpret pressure as being due to collisions of particles on a surface.
2. Be aware of the factors that alter both the magnitude and number of collisions which strike a surface in a given time.
3. Demonstrate an understanding of Dalton's Law by applying it in problem solving situations.
4. State Avogadro's hypotheses and what factors led Avogadro to them.
5. Identify the factors which make up the kinetic energy of a particle.
6. Determine the velocity ratio of any two gases when compared to each other.
7. Be aware of the probable distribution of velocities between gas molecules having the same mass and held in a container at a given temperature.
8. Demonstrate an understanding of Avogadro's hypothesis through problem solving.
9. Calculate the mass of a single gas molecule from laboratory data.
10. Show how the system of molecular weights was determined.
11. Determine the mass of a molecule of an unknown gas.
12. Identify that a mole, the gram atomic/molecular weight of a substance, contains 6.0×10^{23} particles.
13. Identify that a mole of any gas occupies a volume of 22.4 liters at S.T.P.
14. Solve gas law problems involving variations in pressure, volume, temperature, and utilize the gas law constant in problem solving.

PROCESS:

1. Determine the density of a gas in the laboratory.
2. Read a barometer.

CHAPTER 4: THE MOLE AND CHEMICAL EQUATION

CONTENT:

1. Determine the simplest formula for a compound from data providing its percentage composition.
2. Compute the mole weight from the formula for any compound.
3. Write and balance simple equations and identify common reactions such as acid-base, oxidation, etc.
4. Solve (a) weight-weight (b) weight-volume (c) volume-volume using the equation for any reaction.
5. Know what is meant by the term molarity and be able to solve the problems using the concepts related to this term.

CHAPTER 4 (Cont'd)

PROCESS:
1. Determine an empirical formula of a compound in the laboratory.
2. Determine the molar volume of a gas in the laboratory.

CHAPTER 5: FORMULA WRITING

CONTENT:
1. Determine the common valence of an element from the periodic table.
2. Write the formulas for common binary compounds using the periodic table.
3. Write the correct formulas for the ternary acids and identify the radicals that each possesses along with the appropriate names and valences, for the upper and lower valences.
4. Write and name the compound that forms when a metal ion combines with the radical that exists in each of the ternary acids, or replace the hydrogen in the acid.

PROCESS:
1. Produce PbI_2 in laboratory from measured quantities of Pb and I_2 for determination of the formula.

CHAPTER 6: LIQUIDS AND SOLIDS

CONTENT:
1. Write the explanation for deviations of real gases from the behavior expected of an ideal gas.
2. Define critical temperature for gases and relate it to the strength of attractive forces between molecules.
3. Give explanations for condensation and evaporation.
4. Define vapor pressure and be able to identify the relationships between vapor pressure and equilibrium, temperature, and atmospheric pressure (boiling point).
5. Write general characteristics of solids and liquids.
6. Define the water of hydration and do associated lab.
7. Give explanations for the melting of solids.
8. Graph and interpret heating curves.
9. Define calorie.
10. Work problems using $\Delta H = m \Delta TSH$, molar heat capacities, ΔH_f, and ΔH_v.
11. Distinguish between and be able to define gravitational and coulombic forces and work problems using $F = k \frac{q_1 q_2}{d^2}$
12. Differentiate between ionic and covalent bonding and in some cases predict ionic or covalent character based on location in the periodic table.
13. Differentiate between ionic and molecular solids in terms of structure and melting point considerations.

PROCESS:
1. Determine the formula of a hydrate in the laboratory.
2. Determine the heat of combustion of a candle in the laboratory.

CHAPTER 7: NOBLE GASES, SALT FORMERS AND PERIODICITY

CONTENT:
1. Give physical and chemical characteristics of the inert gases, halogens, and alkali metals.
2. Discuss periodicity (with respect to melting point and boiling point) and its causes as found in the periodic table.
3. Know the contributions of both Mendeleev and Moseley to the present day table.

CHAPTER 8: ELECTRONS, PROTONS, NEUTRONS, AND NUCLEI

CONTENT:

1. Define the properties and list the location and characteristics of electrons, protons, and neutrons and be able to relate some of the historical events that led to these conclusions.
2. Discuss the photoelectric effect.
3. Write a short definition and give properties of α β and γ rays.
4. Interpret and write nuclear notation $({}^{A}_{Z}X)$
5. Write and balance common nuclear equations including fission and fusion.
6. Define isotope and be able to write and interpret the accepted notation for identifying isotopes.
7. Distinguish between atomic and molecular weights.
8. Calculate the average atomic weight given % composition of isotopes.

CHAPTER 9: HYDROGEN, QUANTA, AND THE BOHR ATOM

CONTENT:

1. List the characteristics of the isotopes of hydrogen.
2. Identify endothermic and exothermic reactions given the ΔH.
3. Identify the properties of H_2 gas.
4. Describe the characteristics and identify the regions of the electromagnetic spectrum.
5. Work problems (including exponential notation) using $c = \lambda\nu$
6. Be familiar with the rudiments of quantum theory.
7. Work problems using the relationship $E = h\nu$
8. Interpret the significance of atomic spectra and predict some elementary spectral lines.
9. Describe the rationale behind the idea of electron energy levels.
10. Describe the major tenents and shortcomings of the Bohr model.
11. Use the relationship $E_n = \frac{-313.6}{n^2} \frac{\text{Kcal}}{\text{mole of } e^-}$ to calculate energy levels.

PROCESS:

1. Use a hand spectroscope to view the spectra of various gases.

CHAPTER 10: DUALITY, UNCERTAINTY, AND ELECTRON ORBITALS

CONTENT:

1. Write electron configurations for elements using the periodic table.
2. Recognize that an orbital is a region in space where you have a high probability of finding an electron and be able to sketch an s and a p orbital.

CHAPTER 11: CHEMICAL BONDING AND MOLECULAR SHAPE

CONTENT:

1. Describe the rationale in the increase in ionization energies when discussing 1st, 2nd, and 3rd ionization potentials.
2. Describe general trends in ionization energies.
3. Determine the radius of an atom given density and Avogadro's number.
4. Construct Lewis dot structures for elements and simple compounds.
5. Discuss the differences and physical and chemical characteristics of ionic and covalent bonds.
6. Discuss and identify the types of hybridization, double and triple bonds.
7. Write the role of electronegativity in bonding and be able to apply the electronegativity scale.
8. Explain the differences in electronegativities of the elements.

9. Predict shapes of molecules such as: H_2, F_2, BeH_2, BF_3, CH_4, NH_3, and H_2O.
10. Account for deviations from predicted bond angles due to differences in electronegativities.

CHAPTER 12: WATER

CONTENT:

1. Using the electron configuration of water be able to show the causes of the polar nature of water.
2. Be prepared to relate the physical and chemical properties associated with water to the di-pole nature of water.
3. Demonstrate how the bond angle in the water molecule is determined, and the affect this angle has upon the chemical actions of water and similar molecules.
4. Know the probable origin of Van der Waals forces and be aware of how these forces influence the boiling points of the compounds in which they predominate and compare this to other forces.
5. Know what produces a hydrogen bond and the contribution that this bond has upon the physical and chemical properties of the substances where this type of bond prevails.
6. Be able to relate the properties of hydrogen peroxide to its molecular structure.

CHAPTER 13: CHEMICAL ENERGY

CONTENT:

1. Interpret and calculate from laboratory data the number of calories produced in a chemical reaction.
2. Correctly use the terms delta H and be able to express it for exothermic and endothermic reactions.
3. Correctly use and apply the term enthalpy and relate it to the formation or the breaking of chemical bonds.
4. Use Hess' Law to calculate the heat produced or absorbed when two or more compounds react.
5. Use Hess' Law to determine the heat of formation or the heat of combustion of a compound using appropriate supplementary data.
6, Know the meaning of enthalpy, enthropy and free energy and the symbols which represent each. Show the inter-relationship of each.
7. Know how to predict the spontaneity of a reaction based upon free energy.
8. Construct potential energy diagrams for exothermic and endothermic reactions.
9. Understand the influence that a catalyst has upon a reaction with reference to: (a) activation energy-forward, (b) activation energy-reverse (c) the ΔH (d) the potential energy diagram.

PROCESS:

1. Determine an unknown ΔH by combining the ΔH values of two known reactions.
2. Determine heat of formation of calcium hydroxide using lab techniques combined with the use of a chemical handbook.

CHAPTER 14: CHEMICAL KINETICS

CONTENT:

1. Identify the factors which influence the rate of a chemical reaction. (Number of bonds, etc.)
2. Be familiar with the idea of reaction mechanisms and show how these are determined and how they tend to establish the rate.
3. Show the influence of concentration and temperature upon the reaction rate.
4. Develop the rate laws of a chemical reaction from laboratory data.
5. Understand what is meant by activation energy and how it can be expressed on a potential energy diagram.

6. Recognize that a broad distribution of energies generally exists within a material when it is heated to a given temperature and that only a small fraction of the total number of molecules of the material will have sufficient energy to activate a chemical reaction. (threshold energy)

PROCESS:
1. Determine the influence temperature and concentration have in the rate of reaction in the laboratory.

CHAPTER 15: CHEMICAL EQUILIBRIUM

CONTENT:
1. State the conditions that are necessary for a system to be considered in equilibrium.
2. Write the equilibrium law expression from a given chemical reaction.
3. Calculate the value for the equilibrium constant if given the concentrations of the species at equilibrium.
4. Calculate the concentrations at equilibrium when given initial concentration and the equilibrium constant.
5. Explain how equilibrium concentrations are altered by changes in concentration, temperature, volume, pressure or addition of a catalyst.
6. Use LeChatelier's principle in predicting changes in equilibrium.
7. Determine the equilibrium constant from analyzing a chemical reaction in the laboratory.

PROCESS:
1. Use the spectronic 20 to measure concentrations of solutions.

CHAPTER 16: SOLUBILITY

CONTENT:
1. Know the meaning of the terms solute, solvent, solvation energy, hydration energy and crystal energy.
2. State whether the dissolving process will be exothermic or endothermic by comparing crystal energy with hydration energy.
3. State ways of increasing or decreasing solubility of gases in liquids and of solids in liquids.
4. Know various units commonly used to express solubility.
5. Explain why electrolytes alter the freezing point of solutions to a greater degree than equal concentrations of non-electrolytes.
6. Recognize that a saturated solution is another example of an equilibrium condition and be able to write the solubility product expression for the dissolving of a solid.
7. Calculate the solubility of a solid in moles/liter or grams/liter if given the Ksp of a solid.
8. Calculate the Ksp of a solid given the solubility in moles/liter or grams/liter.
9. Compare relative solubilities of two or more solids when given their solubility product constants.

PROCESS:
1. Determine the mole weight of an unknown compound using the freezing point depressi[on] method.
2. Determine the solubility product constant of a solid.

CHAPTER 17: ACIDS AND BASES

CONTENT:

1. Know some of the common properties of acids and of bases.
2. Identify the acid and the base in a chemical reaction according to the Bronsted-Lowry theory.
3. Name the conjugate acid-base pairs for acids.
4. Describe laboratory methods to determine relative strengths of acids or bases.
5. Use the table of K_a values to predict relative strengths of acids or bases.
6. Use the table of K_a values to predict which salts would be most effective in altering the hydrogen ion concentration during hydrolysis.
7. Write neutralization reactions between acids and bases.
8. Recognize that the dissociation of water is an equilibrium condition and when acids or bases are added they alter the concentration of both the hydrogen ion and the hydroxide in the water.
9. Calculate the hydrogen ion and OH^- concentrations in water after a given concentration of a strong acid is added.
10. Calculate the pH or pOH of strong acids or bases in water solutions if given their concentrations.
11. Calculate the pH or pOH of weak acids or bases in water solutions if given their concentration and the ionization constant.
12. Determine the hydrogen ion and the hydroxide ion concentrations when acids and bases are mixed in unequal proportions.
13. Explain why a buffer solution can maintain a nearly constant pH.

PROCESS:

1. Use indicators in the laboratory to determine the hydrogen ion concentration and use this information to find the ionization constant of an unknown acid.
2. Use burets to determine the molarity of an unknown acid or base by titrating against a standard.

CHAPTER 18: OXIDATION - REDUCTION

CONTENT:

1. Analyze a given equation and write the oxidation and the reduction half-reaction.
2. Consult the table of oxidation potentials and for a given electrochemical cell predict direction of electron flow, voltage of the cell, write equations for the anode and cathode reactions and calculate the mass changes that occur at each electrode when given the number of electrons transferred.
3. Explain how the cell potential can be altered by changing the concentrations of the species in solution and the condition that exists when the cell is dead.
4. Predict whether a redox reaction will occur spontaneously from information given in the table of standard oxidation potentials.
5. Balance oxidation-reduction reactions by the valence-electron method.

PROCESS:

1. Construct an electrochemical cell, measure its cell potential, direction of electron flow with a voltmeter, and write chemical equations for changes that are occuring at the electrodes.

CHAPTER 19: ELECTROLYTIC REACTIONS

CONTENT:

1. Know the difference between the terms electrolytic and electrochemical cell.
2. Identify all ions in an electrolytic solution, consult the table of oxidation potentials and predict the most likely product to plate out at the anode and cathode.
3. Predict, using the table of oxidation potentials, the voltage necessary to plate out various metals in an electrochemical cell.

CHAPTER 19 (Cont'd)

4. Apply Faraday's Laws to problem solving situations such as: given amps and time calculate the mass or volume that would plate out.

PROCESS:

1. Determine the percent of iron in a sample by titrating against a standard sample of known normality.
2. Use normality in problem solving situations.

Level Objectives IV for Chemistry

by Dale Hugo
PHS

Level IV Objectives - Chemistry
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Chapter 1. Experimentation and Chemistry

The student shall be able to:

C1. List the steps of the scientific method

P2. List the basic metric units of mass, length, and volume

P3. List the decimal equivalents of the metric prefixes kilo, centi-, milli, and micro

P4. Convert any measurement in English units to metric units

P5. Convert any metric measurement to a different expression of the same metric unit

P6. Make temperature conversions among °F, °K, °R, and °C

C&P7. Recognize and operate laboratory measuring instruments

Chapter 2. Mathematical Concepts

The student shall be able to:

P1. Give the number of significant figures in any number

P2. Express problem results in correct significant figures

P3. Express any number in exponential notation

P4. Use the slide rule to multiply, divide, square, cube, square root and cube root, and set up proportions

Chapter 3. Matter

The student should be able to:

C1. Define: matter, amorphous, homogeneous, heterogeneous, phase, substance, mixture, and energy

C2. List and describe the four physical states of matter in terms of the kinetic theory

P3. Classify examples as to phase

C&P4. Recognize and define interfaces

Chapter 4. Compounds, Chemical Symbols, and Formulas

The student should be able to:

C1. Match the name of the element with its symbol for the most common elements

C2. Recognize that formulas represent compounds

C3. Identify common oxidation numbers for monatomic and polyatomic atoms or compounds

P4. Name compounds when given the formula

P5. Use correct prefixes and suffixes in formula names

P6. Differentitate between molecular and empirical formulas

P7. Balance and name the four basic types of equations

C8. Define endothermic and exothermic reactions

Chapter 5. The Mole

The student should be able to:

C1. Define gram molecular and ionic weight

C2. Relate Avagodro's number to atomic weights and its actual value

C3. Demonstrate how Avagodro's number can be arrived at

P4. Calculate %-age compositions of any compound

C5. State the empirical formula of any organic or inorganic compound

P6. Use the factor label method in mass-mass calculations

C7. Reproduce a rough diagram of a calorimeter

C8. Select the correct definitions of calorie and Calorie

C9. Associate heats of fusion and vaporization with melting-freezing and evaporating-condensing processes

P10. Identify from graphs if a heat of reaction is endothermic or exothermic

Chapter 5. The Mole (continued)

C11. Relate heat content to enthalpy
C12. Associate heat content with + and - kcal/mole
C13. Relate $\Delta H = H_{products} - H_{reactants}$ to balanced equations

Chapter 6. Atomic Structure

The students should be able to:
C1. Write a brief paragraph on the history of the atomic theory
C &
P2. State Dalton's law and give an example by means of a balanced equation
C3. Give an example of the law of definite proportions
C4. Explain how different elements of all types are composed primarily of only three basic subatomic particles
C5. Illustrate the law of multiple proportions with a practical example
C6. Explain how the cathode ray tube, Crookes tube and the Millikan apparatus give additional information about the electron
C7. Identify the correct mass and charge of the three fundemental particles
C8. Recognize and define isotopes
C9. Explain the difference between atomic mass and atomic number
C10. Draw a simple diagram to explain how a mass spectrometer determines atomic mass
C11. Using scientific notation, give the dimensions of an atom and its nucleus
C12. Compare and contrast the Bohr atom with the modern concept of the atom
C13. Relate the frequency of the wave to its energy, $E = hv$
C14. Relate the wavelength of the wave to its frequency, $\lambda v = c$
C15. Write a short paragraph explaining how the quantum theory was verified by the photoelectric effect

Chapter 7. Locating the Electron

P1. Calculate the wavelength of any object at any given velocity
C2. Explain why the wave-particle duality of nature does not enter into macro computations
C3. Define the Heisenberg uncertainty principle in their own words
C4. Explain the wave-nature of the elctron
C5. Differentiate between resonance and destructive interference
C6. Calculate principle quantum numbers of electrons
C7. Relate principle quantum numbers to the rows on the periodic chart
C8. Sketch the probability shapes of the s, p, and d orbitals
C9. Use Pauli exclusion principle to show that only 2 electrons of opposite spin can occupy suborbital
C10. Reproduce the diagram of the diagonal rule
P11. Draw the electron dot (also called Lewis dot) structures for any element, compound, or ion

Chapter 8. Organization of the Elements (Periodic Table)

The student should be able to:
C1. Explain how Mendeleev used the periodic chart to predit the nature of undiscovered elements successfully
C2. Show how Moseley's chart was an improvement on Mendeleev's
P3. Label a skeleton structure of the periodic chart according to basic groups such as families of elements, valences and groups such as halogens, transition metals, etc.
P4. Predict oxidation numbers while knowing the group that the element occupies
C5. Explain how the inert gases can actually be made to combine chemically with other elements

Chapter 9. The Chemical Bond

The student should be able to:

C1. Explain how interatomic forces affect bond length, covalent radii, Van der Waals radius and bond angle

P2. Predict bond angles using AXE notation (suggest using Gillespie, Journal of Chemical Education, 40, 293, (1962) VSEPR

C3. Identify the factors which determine ionization energy

P4. Arrange selected pairs of atoms in order of decreasing polarity and indicate which of the atoms is the more electronegative

C5. Write a short paragraph explaining the special properties of metals as compared with amorphous solids such as sulphur or carbon

Chapter 10. Kinetic Theory

The student should be able to:

C1. Explain the kinetic theory in terms of molecular motion

C2. Relate the kinetic theory to pressure

P3. Read pressure in terms of mm of Hg on both a manometer and barometer

C4. Explain the difference between heat and temperature

C5. Explain heat transfer in terms of the kinetic theory

C6. Relate the kinetic theory to the three (four if plasma is included) states of matter, solid, liquid, and gas

P7. Determine the velocities of atoms at certain temperatures using the kinetic theory formula

C8. Explain how the value for absolute zero is determined even though it has never been reached (achieved) in the laboratory

Chapter 11. Solids and Liquids

The student should be able to:

C1. Explain why gases and liquids are both considered fluids

C2. Sketch a diagram illustrating the differences between van der Waals and other bonding forces

C3. Define dynamic equilibrium

C4. Relate vapor pressure to molecular motion

P5. Identify the triple point on any phase diagram

P6. Use a phase diagram to explain sublimation and liquifaction, also critical temperature and pressure

C7. Explain how hydrogen bonding changes the properties of substances such as water from what would be predicted for a non-polar substance

C8. Diagram the effect of hydrogen bonding on the structure of ice

Chapter 12. Crystals

The student should be able to:

C1. Associate macrostructure of natural and artificial crystals with the shape of the unit cell

C2. Match the shape of seven crystal systems with their names, angles between the cell axes, and the lengths of the unit cell axes

P3. Construct a simple model of the three cubic unit cells

P4. Diagram or label a diagram of an x-ray diffraction apparatus

C5. Explain that altho diamonds and graphite are both composed of pure carbon, they differ because of lattice arrangement

P6. Identify the difference between edge dislocation and screw dislocation when shown a sketch of the crystal defect

C7. Associate isomorphic and polymorphic with specific examples of crystals

P8. Calculate the formula of any hydrated crystal when given the molecular weight of the anhydrous salt and the weight of a sample before and after heating

P9. Identify from a phase diagram when supercooling has occured

Chapter 13. Gases

The student should be able to:
C1. Relate the gas laws to the kinetic theory of matter in that gas particles are in motion, the fundamental assumption
C2. Write a short paragraph explaining how an ideal gas differs from a real gas
P3. Calculate with the combined gas laws, Charles', Boyles and Gay-Lussac's law as well as Graham's Law of diffusion
P4. Obtain pressure readings of gases from Hg and aneroid baronmeters as well as open and closed manometers
P5. Convert air pressures among pounds of pressure, mm of Hg, cm of Hg, millibars, and atmospheres
C6. Explain the differences between ideal and real gases in terms of van der Waals forces
C7. Relate Avagodro's hypothesis to molar volumes of gases
P8. Calculate molar density and use PV = nRT
C9. Define limiting reactions

Chapter 14 Solutions

The student should be able to:
C1. Explain why some substance will react with one another only in solution
C2. Show with diagrams or sketches how a polar molecule (water) dissolves an ionic substance
P3. Predict from knowing if a solvent and solute combination being polar or non-polar will result in a solution
C4. Give examples of solids, liquids, and gases in solutions
C5. Relate immiscible liquids to interfaces
C6. Explain solution equilibrium on the basis of the kinetic theory of molecular motion
P7. Produce a crystal by seeding a supersaturated solution
C8 Associate solution rates to the kinetic theory; that is, the greater the number of collisions, the faster the substance is likely to dissolve
C9. Relate entholpy to gaseous solubility in water
C10. Give examples of solubility explained on the basis of increased entropy
P11. Purify a substance by distillation and explain how substances can be separate from others by fractional distillation
C12. Discuss how solutions conduct electricity
P13. Write an ionic equation
P14. Calculate molarity, normality, and mole fraction when given the weight, volume and molecular weight of a solution
P15. Calculate molecular weight using freezing point depression with Raoult's law
P16. Using a phase diagram, predict changes in freezing and boiling point due to the addition of different concentrations of solutes

Chapter 15. Reaction Rate and Chemical Equilibrium

The student should be able to:
C1. Explain equilibrium in terms of free energy
P2. Balance equilibrium reactions and equations
C3. List all factors affecting reaction rate
P4. Graphically depict how activation energy changes can affect the number of molecules reacting
P5. Label a potential energy diagram with products, reactants, activation energy, potential energy, and activated complex. Then identify if its an endothermic or exothermic reacti
C6. Relate the above diagram to a complete balanced equation
C7. Relate the law of mass action to standard form of writing reaction rates; products over reactants
C8. Express *K* as a function of product over reactant concentrations when given the balanced equation
P9. Predict the reaction rate when given the equilibrium constant
C10. Explain how pressure relates to LeChatelier's principle
C11. Associate equilibrium reactions vs. those which go to completion with closed and open systems

Chapter 16. Acids, Bases and Salts

The student should be able to:

C1. Compare and define the three acid-base theories; Arrhenius, Bronsted-Lowry and Lewis theory
P2. Name common Binary and ternary acids
C3. Explain that the addition of a common ion shifts the equilibrium toward the reactants while the K_a remains the same
P4. Derive the quadratic equation
P5. Use the quadratic equation to calculate concentrations of polyprotic acids
P6. Determine pH knowing concentrations
C7. Recognize that low pH indicates acidity, high pH indicates basic solutions, and pH in the range of 7 that of neutral solutions
P8. Use equivalent weights to calculate normalities
P9. Predict the outcome of titrations using $v_a \times N_a = V_b \times N_b$

Chapter 17. Oxidation-Reduction

C1. Define oxidation-reduction, oxidizing agent, reducing agent, eletrolysis, cathode and anode
P2. Assign oxidation numbers to each element in compounds, ions and free elements
P3. Identify the oxidizing and reducing agents in a reation
P4. Balance redox equations when given all the formulas
P5. Predict yield from a reation using gram equivalent weights

Chapter 18. Electrochemistry

C1. Associate electrochemical reactions with "batteries" that produce electric currents
C2. Explain the need for a salt bridge
P3. Calculate force using the Coulomb Law for static charges
C4. Explain that electrolytes conduct electricity by movement of charged particles
P5. Calculate plating reaction results using Faraday"s laws
P6. Predict voltage from a cell by knowing the standard oxidation potentials for half reactions
C7. Describe corrosion as an electrochemical reation

Chapter 19. Nuclear Chemistry

The student should be able to:

C1. Describe radioactivity as a spontaneous, random process
C2. Explain the importance of $E = mc^2$
C3. Discuss the nature of alpha, beta, and gamma radiation
C4. Explain that a Geiger counter detects radiation by measuring the amount of ionization in a gas tube
C5. Discuss the use of nuclear half-life as a dating device
P6. Determine stability of nuclides
C7. Describe the difference results of air and ground bursts and atomic and thermonuclear weapons

Chapter 20. Hydrocarbons

C1. Define organic chemistry, hydrocarbon, alkane, alkene, alkyne, isomers, functional groups, and polymerization
C2. Describe the tetrahedral structure of the methane molecule and the hybridization that causes it
P3. Determine the IUPAC names for any of the isomers of decane
P4. Determine the IUPAC names for alcohols, ketones, aldehydes, esters, ethers, organic acids, aliphatic and aromatic rings with functional groups
C5. Describe the benzene ring as a resonance structure
P6. Use organic model sets to construct any compound that can be given an IUPAC name

Chapter 20 Hydrocarbons (continued)

C7. Relate the bonding of organic compound to electronic structures
C8. Relate electronic structure to molecular architecture

Chapter 21. Derivatives of the Hydrocarbons

The student should be able to:

C1. Recognize functional groups when they are substituted for hydrogen atoms on a carbon
C2. List characteristics of properties of derivatives; e.g. ethers are volatile and explosive
C3. Identify substitution, addition, elimination, esterification and saponification reactions when given only the left side of an equation
C4. Explain how synthetic rubber and plastics are made

Chapter 22. Complex Ions and Coordination Compounds

C1. Define complex ion
C2. Associate the characteristics of complex ions with those of solutions on a kinetic molecular level
C3. Define ligand, coordination number and terms like "square-planar"
P4. Build models of coordination complexes with a model set and name the structure he has built
P5. Draw a simple diagram illustrating bidentate, tridentate and quadridentate ligands
P6. Name and diagram from the name ligands using table 22-1
C7 Associate ligands and their colors with spectroscopy
C8. Explain that coordinate covalent bonds exist when both the electrons in a shared pair come from the same atom in a coordinated complex
C9. Associate complex stability with other concepts of chemical equilibria
C10. Recognize the importance of coordinated compounds in biochemistry

Chapter 23. Colloid Chemistry

The student should be able to:

C1. Compare colloidal properties to solutions and suspensions
P2. Classify at least four examples of types of colloids as to continuous and dispersed phase (table 23-2)
C3. Explain that gas-gas mixtures are always solutions due to the kinetic motion of gases which cause universal mixing
C4. Define sols
P5. Explain how to prepare a sol
C6. Explain the difference between absorption and adsorption
C7. Explain the Browninan motion in terms of kinetic theory
C8. Discuss the application of colloidal chemistry in electrophoresis

Chapter 24. Analysis

The student should be able to:

C1. Relate an analytical problem to the appropriate instrument

Suggested Activities and Labs for Smoot, Price and Barrett

Chapter 1 Experimentation and Chemistry

Experiments:

#1 and in the appendix give lab quiz over I through V which involve the use of lab equipment. Caution: Experiment #1 gives inadequate precautions to students on the use of $AgNO_3$. Expt #2

Additional activities:

Teach the use of the slide rule. Have the math-oriented students program the computer to print out the four temperature scales in 20° intervals for temperatures from absolute zero to +200° C.

Chapter 2 Mathematical Concepts

Experiments: None
Additional activities:

Using the temperature conversion charts, introduce your most useful conversion formula; mine is a) add 40, b) multiply by 5/9 or 9/5, c) subtract 40.
Introduce factor-label method of canceling units.
Convert the speed of light into fulongs/fortnight.
Express the national debt in terms of megabucks.

Chapter 3 Matter

Experiments:

#3
The whole chapter is very similar to the material in "Focus" and could easily be omitted if the students do not need the review.

Chapter 4 Chemical Symbols and Formulas

Experiments:
Experiment #4 (Use Mg granuals as pilferage of the Mg ribbon is always a problem).
Additional activities or suggestions:
I plan to give a diagnostic quiz before going into this chapter since its quite probable they still can write formulas after physical science.
A review worksheet may be all that's necessary
Express H_2O as Dihydrogen oxide and see if it's recognized.

Chapter 5 The Mole

Experiments: #5 - #10
Additional work:
Have them express the mole as 6.023×10^{23} of anything.
For advanced students: How much gas can be produced by a mole of beans?

Chapter 6 Atomic Structure

Experiments:

Replace the Cu in CuCl and $CuCl_2$ with Al foil by boiling and show using Dalton's law that atoms combine in whole number ratios.

Additional work: Review dyne and erg.

Chapter 7 Locating the Electron

Demonstration:

Spectrum from gas discharge tubes in spectrometer

Activities:

Hand out spectrum wall chart of all electromagnetic radiations and have them fill it out

Do worksheet on converting v to λ and λ to v using Chicago area radio stations.

Wave mechanics worksheet.

Chapter 8 Organization of the Elements (Periodic Chart)

Experiment: #11

Additional work: introduce the molecular model sets and use them to illustrate types of bonds and structures.

Chapter 10 Kinetic Theory

Demonstration: Experiment #14

Possible demonstration: Brownian Motion Apparatus

Chapter 11 Solids and Liquids

Experiment: #15

Additional work: relate phase diagrams to metallurgy and show triangular graph eutetic phase diagrams.

Chapter 12 Crystals

Experiments: #16, 17, & 18

Additional work: Styrofoam models of crystals. Holden film: Crystals

Show metallurgical photomicrographs from personal collection of crystal structure of metals.

Chapter 13 Solutions

Experiments #19 through 23. ChemStudy baggy experiment.

Films: Gases and how they combine.

Chapter 14 Solutions

Experiments #24 - 26

Additional work: purification by recrystalization.

Chapter 15 Reaction Rate and Chemical Equilibrium

Experiments: # 27 and #28, also Iodine Clock reaction

Demonstration: "H-bomb" of singing flame.

Chapter 16 Acids, Bases and Salts

Experiments: #29 - #32
Additional work:
Show computer program to calculate pH.

Chapter 17 Oxidation-Reduction

Experiments: #33 and #36.
Additional work:
Use "slide rule" equation comparator.

Chapter 18 Electrochemistry

Experiments: #35 and #36.
Additional work:
Demonstrate plating of Cu, Sn and/or Ag.

Chapter 19 Nuclear Chemistry

Experiments: Use Geiger counter in stock room.
AEC transparency set. AEC booklets. Men and Molecules cassette tapes.

Chapter 20 Hydocarbons

Experiments #37
Additional work:
Organic molecule sets, Space Filling Models.
Nomenclature drills.
Oxygenated hydrocarbon lecture.

Chapter 21 Derivatives of the Hydrocarbons

Experiments: #37 continued.
Additional work:
Paper chromatography, clinical chemistry, instrumentation; IR GC, and NMR, and E3RS.

Chapter 22 Complex Ions and Coordination Compounds

Experiment: Silver amine, Copper sulfate w/ammonia, probably several available with the Spectronic 20.
Additional work:
independent study, Jahn-Teller work and A. L. Companion's Chemical Bonding goes into detail on a high school level

LEVEL OBJECTIVES IV for

Physics

by Don Hruby
JHHS

FORWARD

The goal of this workshop in writing level IV physics objectives was: to write as many specific behavioral objectives compatible with the adopted major conceptual schemes as one work week would allow.

Behavioral objectives have been written to cover approximately 50% of the subject matter content of a comprehensive junior-senior level high school physics course. In writing these objectives I followed the basic three part format of stating (1) what it is that the learner is to be able to do, (2) the setting or means contributing to his learning, and (3) the criteria for defining what is acceptable achievement. The objectives are presented in the sub-packages (as parts of the eventually defined total-package). D. Hruby, JHHS

SUB-PACKAGE

#1. Kinematics - 20 objectives dealing with the language of motion.

#2. Kinematics Addendum - 10 objectives dealing with the way of Galileo.

#3. Dynamics - 15 objectives dealing with the causes of motion.

#4. Dynamics Addendum - 2 objectives dealing with some significant historical elements.

#5. Understanding Motion - 18 objectives dealing with projectiles, circular motion, reference frames, simple harmonic motion.

#6. Motion in the Heavens - 18 objectives dealing with historical treatment of development of ideas about motions of celestial bodies.

#7. The Newtonian Synthesis - 12 objectives dealing with pulling things together dynamically, Universal Gravitation.

#8. The Conservation Laws - 22 objectives dealing with development of the concepts of mass, momentum, mechanical energy, and total energy.

#9. Kinetic Theory of Gases - 13 objectives dealing with heat and the first and second laws of thermodynamics.

In reflecting back over some thoughts and observations while writing these objectives, I would like to enumerate the following (not in any preferred order).

1. There was no commitment to write all the objectives that support the more general on In fact, my philosophy would be to focus on certain high points only, thus, leaving enough unplugged holes to allow each instructor his own preferred input. The object presented are only to serve as models. The sequence chosen is parallel to the Proje Physics course.

2. Process objectives are mixed in with content objectives. This has the advantage of putting them in appropriate sequence along with content. Process objectives are identified by a P, content by a C, and meaning by M.

3. Many of the objectives encompass certain historical and humanistic elements needed by relate physics as a human endeavor. They too, appear in useful sequence. In the format these would be in the area of meaning.

4. Most of the stated objectives lend themselves to direct formulation of examination questions, but that was not the intent.

5. All of the objectives are suitable for handing over to the student. He has a right to know what is expected of him.

6. There is overlap with other courses offering certain elements of physics education. Degree of depth and change of perspective to meet new goals of learning remain flexible.

7. Such objectives have much potential for proficiency testing of "advanced" students.

8. Such objectives have much potential for development of individualized learning packs.

9. I felt a great temptation to write "should learn" rather then "will learn" but did not yield to it.

10. I do not believe I referred to preferred systems of units to be used.

11. The word "learner" is used over and over again - - it means teacher as well as student.

#1. <u>KINEMATICS</u>

C1 The learner will be able to state reasons why (historically) the study of motion proved to be a fruitful beginning point for the study of nature. After appropriate assigned reading and/or class discussion, the learner will be able to list examples of motion in nature in seemingly varying degrees of complexity and importance to man - his welfare and/or his curiosity. The examples given by the learner are to indicate his present knowledge of accessibility and feasibility for man's detailed observation at various points in time (historically).

P2 - - - identify the <u>unique</u> feature of a stroboscopic exposure of a moving object which allows a quantitative analysis to be made. To make this judgment, the learner will be given a variety of time exposures, multiple exposures, and stroboscopic exposures of various moving objects.

P3 - - - determine the <u>average speed</u> of an object between successive exposures on a stroboscopic picture. Given _____ different stroboscopic pictures, the learner will be able to determine the correct average speed for _____ percent of the examples.

M5 - - - reasons for studying motion in a laboratory setting, rather than the natural motions themselves. Throughout his studies of motion, the learner will be personally involved in the designing of motion experiments, the taking and analyzing of photographic and other recorded data. After a reasonable amount of personal experience, the learner will be able to list _____ reasons of his own for studying motion in a laboratory setting.

P6 - - - calculate an average speed, given distance, and time data. Given _____ realistic sets of data, he will compute correct answers (and supply proper units) with _____ percent accuracy.

C7 - - - to define "average speed" and "time interval". After exposure to these terms through reading, discussion, graphical analysis, and problem solving, he will be able to describe _____ examples of real live motions using these terms.

C8 - - - explain in his own words the approximation (or assumption) we make when we use the concept of "average speed". Through involvement in the alternatives of reading and/or laboratory work and follow through analysis, the learner will be able to express either orally or in written essay from the equivalence of "average speed" and constant speed during a given time interval.

P9 - - - construct a distance versus time graph for the motion of an object moving with constant speed. The learner will plot data from his own experimentation as well as data obtainable from _____ other sound(s).

P10 - - - determine the slope of a straight line graph. Numerous examples will be shared with him via text and visual experiences. Given _____ speed vs time graphs he will be able to determine the correct slopes (+ and/or -) and with proper physical dimensions with _____ percent accuracy.

P11 - - - determine the speed of an object from the slope of a distance-time graph. Numerous examples will be shared with him via text and visual experiences. Given _____ speed vs time gra he will be able to determine the correct speed (and proper unit) with _____ percent accuracy.

P12 - - - construct a speed vs time graph for an object moving with uniform speed. The learner will plot data from his own experimentation as well as data obtainable from _____ other sources.

P13 - - - interpolate and extropolate with graphical data. Numerous examples of graphical data will be observed and analyzed (via various visual media) that will provide experiences in this skill. The learner will be able to respond correctly within the limits of reasonable error to _____our of _____ interpolation problems and _____ our of _____ extropolation problems.

C14 - - - define instantaneous speed in terms of the limit concept. After appropriate reading and pre and post discussions on the topic (with visual aids) the learner will be able to relate in his own words (oral or written) the definition of instantaneous speed in terms of the limit concept.

P15 - - - calculate by the slope method the instantaneous speed at any point on a distance-time graph for the motion of an object. Given distance-time graphs for the motions of various objects (from the learners own experimental data and/or that of other experimenters) the learner will determine by the slope method instantaneous speeds at various points on these graphs with _____ percent accuracy (within the limits of reasonable on expected error).

C16 - - - distinguish between the average speed over an interval and the instantaneous speed at a point. Related textbook study (or other reference) and examples presented by the instruct via graphical analysis will be reviewed. The learner will demonstrate his understanding by reporting _____ illustrative examples of his own choice.

C17 - - - define acceleration in terms of speed and distance and also in terms of speed and tim After exposure to this term through reading, discussion, examination of the phenomenon itself, graphical analysis, and problem solving, he will be able to describe given accelerations as related to corresponding regular speed and distance changes and also related speed and time changes. (Example: $4^{m}/sec$ each successive second, etc.).

P18 - - - construct a speed-time graph for the motion of an object. The learner will plot data from his own experimentation and/or data from _____ other source(s).

P19 - - - to determine the acceleration at a given time by the slope method from a speed vs tim graph for the motion of an object. Given speed-time graphs for the motions of various objects (from the learners own experimental data and/or that of other experimenters) the learner will determine by the slope method instantaneous accelerations at various points on these graphs with _____ percent accuracy (within the limits of reasonable or expected error).

C20 - - - distinguish between average acceleration over an interval and instantaneous acceleration at a point. Related text or reference study examples presented by the instructor via graphical analysis, and class discussion will be directed towards enlarging upon the learners awareness of the inter-relation and similarities of all the previous motion concepts studied so far. The learner will demonstrate his understanding by reporting _____ illustrative examples of his own choice.

#2. KINEMATIC ADDENDUM

M Rationale - Galileo's study of freely falling bodies was an important bit of basic research. Because his view of the world, his way of thinking, his use of mathematics, and his reliance upon experimental tests set the style for modern science, these aspects of his work are as im-...t as the actual results of his investigation. Therefore, sufficient class time should be devoted to emphasis on the way Galileo presented his arguments.

To appreciate significance and nature of Galileo's work, it is worthwhile to examine the previous system of physical thought.

M1 - The learner will be able to relate the system of physical thought dating back to approximately 2,000 years prior to Galileo's time and expressed in the writings of Aristotle. He will demonstrate his "grasp" of this system of thought by being able to list at least five main points of contention and apply them towards the explanation of natural phenomena that would seem to be acceptable in Aristotelian times. Furthermore, the learner will also be able to list at least two reasons why the above views were accepted for almost 1,500 years and more.

M2 - - - begin (or further) to develop an awareness of the background influences in Galileo's life. The learner will demonstrate development of his awareness through classroom discussions with his classmates (all of whom will have availed themselves of various alternative ways of learning about Galileo) regarding the life and times of Galileo.

M3 - - - become familiar with the style of Galileo's writing by being assigned selections from "Two New Sciences".

M4 - - - begin to gain insight into what was involved in overthrowning the firmly established doctrines of Aristotelian "science". (This overthrow demanded an unusual combination of mathematical talent, experimental skill, literary style, and tireless campaigning to discredit Aristotle's theories).

Given time to study Galileo's approach to his experimental work and perhaps repeating one of Galileo's famous experiments - (studying the motion of a ball down an inclined plane with use of a water clock for example), the learner will be able to understand a chief reason for Galileo success in discrediting Aristotle's theories. (He exposed Aristotelian theory at its weakest point; he showed that physics can deal better with the world around us if we realize that the world of common observation is not the simple starting point the Aristotelians thought it to be On the contrary, the world as we ordinarily observe it is usually quite complex. Only after you understand each of the different effects by itself should you go back to face the complexities of the ordinary case.) At various points throughout this physics course the learner will be abl to demonstrate his understanding of this fact by listing specific examples of where complex happ ings are best understood through control and examination of each of the most simple effects that make up the whole.

M5 - - - explain how one can allow trivial results to mark or obscure significant ones. The learner will be given the assignment of reading the dialog between Simplicio and Salriati ("Two New Sciences") regarding comparative observations of heavy and light weight falling bodies Other examples of apparently obscured truths will be drawn out through class discussion. The learner will demonstrate his cognizance of this possible situation by explaining (orally or in writing) at least three case histories from real life where the truth appears in danger of being obscured by trivial observations.

M6 - - - list the steps taken by Galileo in choosing a definition of <u>uniform acceleration</u>. The learner will be able to list in his own words the equivalent of the following steps.

a. Galileo first analyzed the mathematics of a possible, simple type of motion (which we now call uniform acceleration or constant acceleration).
b. Then he proposed that heavy bodies actually fall in just that way.
c. Next, on the basis of this proposal, he derives a prediction about balls rolling down an incline.
d. Finally, he shows that experiments bear out these predictions.

NOTE: He could not test his hypothesis directly for free fall due to the short time intervals involved. The inclined plane approach helped by permitting longer time intervals.

C-P-M7 - - - test Galileo's hypothesis about uniform acceleration by working with tools similar to those of a seventeenth-century scientist. The learner will make quantitative measurements of the motion of a ball rolling down an incline as described by Galileo. From these measure- [illegible] the learner will be able to decide for himself whether Galileo's definition of accelera- [illegible] is appropriate or not. He will base this decision on the accuracy of his results as well as his estimate of the validity of the process Galileo used in obtaining his data and forming his conclusions.

M8 - - - comprehend that more precise measurements do not always lead to more significant conclusions. With more modern equipment the learner will verify Galileo's conclusions and also obtain an actual value for acceleration in free fall (near the earth's surface).

P9 - - - be cautious of Galileo's conclusions in the perspective of doubts about measurement accuracy and other factors such as frictional effects contributing to the ball sliding as well as rolling. The learner will be challenged (but not required) to design further refinements to the design and measurement problems related to testing Galileo's hypothesis. Evaluation of the learner's accomplishments will take into consideration his demonstrated prowess at experimental design and subsequent interpretation of his results relative to the accepted standard.

M10 - - - enumerate some of the consequences of Galileo's work on motion. After class discussion and "digestion" of related reading material (not to mention first hand experience employing scientific procedures to test Galileo's hypothesis) the learner will be able to list at least three consequences of Galileo's work on motion.

#3 DYNAMICS

C1 The learner will be able to state and "understand" operational definitions for force, mass, and weight. After classroom discussions and demonstrations related to the learners already acquired intuitive learning about these concepts, he will demonstrate his "understanding" by describing orally or in writing - situations that illustrate the distinctions between force, mass, and weight.

C2 - - - distinguish between kinematic concepts or dynamic concepts. After reviewing many examples of terms and questions related to motion, the learner will classify them into categories of kinematics or dynamics with 100% accuracy.

C3 - - - define a vector quantity and a scalar quantity. After reviewing many illustrative examples of these quantities and the need for making the distinction between them, the learner will classify them into their proper categories with 100% accuracy - also be able to state the two ways in which a vector can change.

P4 - - - add and subtract vectors by a scale drawing (graphical) method. With the use of compass, protractor, ruler, (metric or otherwise), and sharp pencil point, the learner will be able to determine the vector sum of two, three, and four vector quantities respectively to a reasonable degree of accuracy (with proper labels and units expressed) with _____ % correct results on any practical lab drawing test - similarly for vector difference problems.

C5 - - - state and "understand" the conditions necessary for forces to be in equilibrium, (concept of the "resultant"). After related demonstrations, lab work, and numerous illustrative examples presented via miscellaneous visual media the learner, when given vector diagrams which illustrate forces that are in equilibrium, as well as others with forces that are not in equilibrium, will be able to distinguish between them _____ percent of the time and express himself orally or in writing as to the reasons for making such distinctions.

C6 - - - state how Newton's first law of motion (Law of Inertia) applies to objects in motion and at rest. After being exposed to and analyzing the motion of many objects at rest, or moving at a constant speed in a straight line, and after becoming cognizant of the forces acting on these objects during constant motion or changes in motion, the learner will be able to express in his own words the apparent qualitative relationship between forces in equilibrium and the effect of these conditions on motion.

C7 - - - state and "understand" Newton's second law of motion. Given time and opportunity to explore in the laboratory how acceleration changes as a function of force (constant mass) and how acceleration changes as a function of mass (constant force), the learner will arrive resulting functional relationships consistent with those expressed in his text or other erence. (Note: to"understand" that F=ma will require precluding background development of these concepts is the constant attention given to proper dimensions or units).

C8 - - - state the mathematical relationship among force, mass, and acceleration. (See parenthetic comments with C7 above).

P9 - - - calculate the third quantity when given any two of the three quantities: force, mass, and acceleration, and verify that the units (dimensions) are correct. The learner will demonstrate satisfactory capability when he responds with _____ percent accuracy on quizzes limited exclusively to this one kind of performance.

C10 - - - give a quantitative definition of mass. The learner will express himself correctly in writing as to his "understanding" of the establishment and need for a standard of compariso for masses in the metric system - that is, he will state specifically (and quantitatively) what the standard kilogram is. Given _____ examples of situations where masses are accelerate by a unit force and given the resulting respective accelerations, the learner will be able to determine respective masses relative to a standard of comparison with _______ percent correct results.

C11 - - - define the unit of force in metric system units. With reference to Newton's second law of motion (F=ma) the learner will be able to explain why one unit of force in the metric system must have the derived units $1\ \frac{kg\text{-}m}{sec^2}$.

(Note: Actually F=kma where k is a constant of proportionality conveniently set=1. The concept of constant of proportionality should be developed between dynamics objectives 6 and 7).

C12 - - - state in physical terms the definition of weight. After study (through reference material) and discussions in class covering such topics as free fall, gravitational attractio inertia, proportionality of weight and mass, and reference frames, the learner will be able to express himself knowledgeably as to a definition of weight in physical terms.

C13 - - - explain why objects of different mass fall with the same acceleration in free fall. The learner will be able to incorporate his understanding of weight and mass proportionalitie along with Newton's second law of motion and utilize these concepts in explaining why the acceleration due to gravity is a constant in a given location.

C14 - - - demonstrate that forces always occur in pairs. (Newton's third law of motion. Through laboratory experimentation the learner will learn that whenever two bodies interact (or a field and a body) that the forces they exert on each other are equal and in the opposite direction. The learner will demonstrate his understanding of this phenomenon by being able to relate _____ situations where pairs of forces can be evidenced.

C15 - - - solve problems which require the use of both the second and third law of motion. The learner will be able to make quantitative determinations of resulting distances and directions traveled by objects of different mass set into motion by forces acting in opposite directions - collisions and explosions. He will be able to achieve _____ percent accuracy on a test representative _____ different but conceptually related situations.

#4 DYNAMICS ADDENDUM

C1 The learner will be able to relate the Aristotelian "common sense" notions for maintaining uniform motion and acceleration. Given _____ examples of everyday occurrences of motion the learner will be able to give "Aristotelian explanations for the occurrences for _____ percent of these situations.

C2 - - - summarize in his own words the reasoning that Galileo used in arriving at the decription of motion now referred to as "Newton's First Law of Motion". The learner will indicate his understanding of Galileo's thought experiment by outlining the essential points of contention in writing and reporting the extrapolated "consequences" of motion forever on ictionless surface.

#5 UNDERSTANDING MOTION

PROJECTILE MOTION

C1 - The learner will be able to break down a complex system of motions into a series of simpler motions. Given a complex system of motions such as a rocket flight to the moon, the learner will be able to isolate and list certain distinct parts of the motion (e.g. upward acceleration, curv path at uniform speed, acceleration away from path, etc.) subject to further detailed analysis (i.e. employing concepts of kinematics, dynamics, and vectors.

P2 - - - describe projectile motion in terms of its independent motions. Given stroboscopic pictures of an object's trajectory (either from his own experiments or those of others) the learner will be able to determine graphically and computationally, displacements, velocities, and accelerations - both x and y components of motion - at various positions along the trajecto The learner will be able to calculate correct results for five points along a given trajectory with 70% acceptability.

P3 - - - be able to draw both a displacement vector and a velocity vector diagram for the motion of a projectile at any position. Given worksheets depicting a stroboscopic record of positions of objects during travel along its trajectory, the learner will measure displacements, determine average velocities for time intervals, determine velocity change increments for successive inte vals and correctly how graphical (vector) representation of these quantities on the worksheet. Drawings must be to some indicated scale and correctly labeled.

P4 - - - demonstrate that the horizontal and vertical components of projectile motion do not depend on each other. Given a stroboscopic photograph of two balls released simultaneously - one simply dropped and the other projected horizontally to one side - the learner will quantitative company incremental changes in displacement and velocity in both the vertical and horizontal directions. He will base his conclusions on the demonstrated results of his determinations.

P5 - - - describe mathematically the path of a projectile. Using previously developed equation for projectile motion the learner will be able to relate actual position (or displacement) date to an actual plotting on graph paper (to scale) of a realistic trajectory (baseball, football, rocket, etc.).

MOVING FRAMES OF REFERENCE

C6 - - - describe the motion of an object from different frames of reference (different points of view). Given three different examples of an object in motion relative to a base platform, the learner will be able to predict how the motion of the object would appear to observers on the platform, on the object, and to observers moving past the object (on another platform and relative to the observers platform) with uniform velocity.

C7 - - - state in his own words the Galilean Relativity principle. The learner will enter into discussion with the class and the instructor about the status of the laws of mechanics in reference frames moving relative to each other. The intent here is to raise meaningful questions and venture answers based on knowledge and attitudes gained so far in the course.

CIRCULAR MOTION

C8 - - - describe the conditions necessary for uniform circular motion (i.e. what an object has to be doing to be said to be in uniform circular motion. Given stroboscopic exposure data the learner will be able to determine from position (displacement) and time data whether an object is undergoing uniform circular motion or not.

C9 - - - define frequency and period as they are related to uniform motion and to each other. The learner will demonstrate his mastery of these terms through successful determination of actual frequency and period values through measurements from experimental data of his own and/o that of others.

[illegible] - - draw the instantaneous velocity vector and the instantaneous acceleration vector at any point an object moving in uniform circular motion might be along its path. Given the circular path and the necessary position (displacement)vs time data, the learner will be able, for any one point along that path, to be able to draw the instantaneous velocity vector and the instantaneous acceleration vector at that point (correct scale and labeling to be indicated for each vector drawing).

C11 - - - draw a vector diagram which shows the change in velocity for an object moving in uniform circular motion. Given the circular path and the necessary displacement vs time data, the learner will be able to draw instantaneous velocity vectors at two nearby points along the path and subtract (vectorally) the velocity at the first position from that of the second position. He will correctly label this vector difference (change in velocity) as to scale and units.

C12a - - - calculate the magnitude of the acceleration vector in uniform circular motion. Given the magnitude of the change in velocity (as determined by the means referred to in Objective #1) and the time interval related to that change, the learner will be able to calculate the magnitude of the corresponding acceleration. (Note: another goal here is to learn that the resulting value is the average acceleration during the time interval and the same as the instantaneous acceleration at the midpoint of that time interval. Of course, acceleration is a vector quantity and its direction is the same as that of the change in velocity vector, which is coincident to the radius vector of the path at the midpoint of the time interval and directed toward the center of the circle. This acceleration directed toward the center of the circular path is named centripetal acceleration.

C12b - - - calculate the magnitude of the centripetal acceleration of an object moving in uniform circular motion (at the same rate and along the same path as in #12 above). Given the equation $a_c = \frac{V^2}{R}$ (the derivation of which should be an optional goal for students) and instantaneous velocity and corresponding radius vector magnitudes, the learner will be able to calculate the correct value (and determine units) for the resulting centripetal acceleration. (Note: The resulting value from this calculation can be compared with that done in connection with objective #12a above).

C13 - - - experience the application of Newton's second law as a vector law in explaining the relationship between centripetal acceleration and centripetal force. Give three stroboscopic exposures of the same mass undergoing uniform circular motion (as a result of three separate and different deflecting forces but same path radius) the learner will be able to arrive at a functional relationship between F_c and the resulting a_c.

C14 - - - recognize that centripetal force is a real force and that centrifugal force misconceptions arise as a result of faulty reference from considerations. After exposure to selected visual aids and points of discussion, the learner will recognize that motion in another frame of reference can seemingly be accounted for by a fictitious force - that point of view is all important in distinguishing between fact and fiction. (Note: I don't know as yet how I would really know whether or not the learner grasps this point).

SATELLITE MOTION

C15 - - - state the conditions necessary for a satellite to remain in stable orbit. Given actual satellite tracking data, the learner will be able to compare the orbital speed necessary for the satellite to maintain uniform circular motions at a given height with his own calculations based on the kinematics and dynamics for uniform circular motion.

SIMPLE HARMONIC MOTION

C16 - - - state the conditions necessary for a periodic motion to be classified as simple harmonic motion (SHN). Given time and opportunity to experiment with periodic motions, the conditions affecting or causing them, and viewing of miscellaneous selected visual aids and reference materials the learner will become familiar with those factors needed to initiate, maintain, and destroy S.H.M. (Note: The main condition to be met is that of a restoring force, proportional to a displacement from an initial equilibrium position).

C[illegible] - - to describe the relationship between SHM and uniform circular motion. Through study [illegible]servation of this relationship (by means of references, available visual aids, and teacher explanation) the learner will be able to furnish an accurate description in his own words.

P18 - - - identify on a graph of S.H.M. kinds of motion and conditions occurring at different points in time. Given a graph for S.H.M. the learner will be able to identify the points of maximum and minimum displacement, maximum and minimum velocity, and maximum and minimum acceleration. Also he will be able to describe the relative magnitudes and directions of the changing restoring forces.

#6 MOTION IN THE HEAVENS

M (Note: Throughout the learning of topics and concepts below, the learner will be lead along the way through continual touch with their historical development and significance as well as lead into acquaintances with the key personalities contributing to growth of the science)

C1 - - - describe daily and yearly motions of the sun, the moon, the stars, and the planets as observed from his location on the earth (fixed frame of reference). Through personal systematic observations of these bodies, involving determinations of positions relative to a fixed frame of reference and to regular intervals of time, the learner will be able to describe these motions as they are apparent to him from his vantage point.

C2 - - - explain phases of the moon. The learner will illustrate his understanding of what causes the apparent phases of the moon by sketching various correct relative earth, moon, and sun posit[illegible]

C3 - - - describe an earth-centered model that accounts for motions of celestial objects (including retrograde motion of planets). The learner will be able to illustrate of demonstrate with the aid of simple sketches or the use of three-dimensional models how a fixed earth frame of reference accounts for observed relative celestial motions.

C4 - - - describe a sun-centered model that accounts for apparent motions of celestial objects (including retrograde motion of planets). The learner will be able to illustrate or demonstrate with the aid of simple sketches or three dimensional models, how a fixed sun frame of reference accounts for observed relative celestial motions.

P5 - - - determine, from appropriate data, the height of a mountain on the moon. Given an enlarged photograph of a section of the moon's surface made near its third quarter phase, the learner will make measurements of the shadow of Piton (a mountain in the moon's Northern Hemisphere and approximately on the line separating the lighted portion from the darkened portion at third quarter phase) and be able to use simple geometry to calculate the height of Piton.

C6 - - - summarize the major differences between the Copernican theory of the universe and the Ptolemaic theory. Through directed reading assignments and discussion relating assumptions of both Ptolemy and Copernicus, the learner will be able to list at least three major differences in the theories of these two early astronomers.

M7 - - - state arguments used by Copernicus in favor of his system and arguments used by critics of his theory. Through directed reading assignments and subsequent discussion, the learner will be able to state two or more arguments used by each.

M8 - - - list the major contributions of Copernicus to modern planetary theory. Through directed reading assignments and subsequent discussion, the learner will be able to list at least two major contributions of Copernicus to modern planetary theory.

M9 - - - explain the description of Tycho as the "first experimental astronomer". Through reading and discussion directed at familiarizing the learner with the life and work of Tycho Brohe, the learner will be able to explain the meaning of "first experimental astronomer".

C10 - - - explain the relationship between Tycho's theory of the universe and that of Copernicus (Note: they were kinematically equivalent but choice of frame of reference provided differences) Through reading and discussion regarding Tycho's observations and his compromise system, the learner will be able to explain the major difference between Tycho's theory of the universe and t[illegible] Copernicus.

M11 - - - describe some of the major influences upon Kepler and how they were manifest in his work and accomplishments. Through directed reading and discussions regarding Kepler's life and times, his goals, his attitudes, and the results of his efforts, the learner will be able to list three or more major factors contributing ultimately to Kepler's three laws of planetary motion.

P12 - - - verify and state Kepler's law of areas. Given data to plot a planetary orbit, (or an already plotted planetary orbit) the learner will make actual determinations of areas swept over by a line from the sun's position to the moving planet for equal increments of travel time. The learner will verify that these areas are proportional to the time intervals.

P13 - - - The learner will also make his own determination of our Earth orbit by using a series of sun photographs taken by the U. S. Naval Observatory at approximately one month intervals. By measuring apparent size changes in the sun relative to the direction of the observer from the sun, and applying simple geometry Earth-Sun distances can be calculated and plotted as a functio of angular positions relative to the sun. The learner will be able to utilize this orbital plot also in verifying Kepler's law of equal areas.

M14 - - - gain some appreciation for this gigantic step in Kepler's (man's) thinking through stu of the historical development of this breakthrough.

C15 - - - show, as Kepler did, that the orbit of Mars is best described as an ellipse (and the other planets as well). Given an appropriate diagram for an ellipse, the learner will be able to define and locate the minor axis, the major axis, perihelion, and aphelion. Also, given sufficient date, the learner will be able to calculate or determine the value for the major and minor axis of an elliptical orbit, the mean distance to a planet, and the eccentricity of the ellipse. To show that the orbit of Mars is best described as an ellipse, the learner will compa the properties of his own plotted Mars orbit (from data obtained while carrying out an assigned laboratory exercise) with those of the given ellipse.

C16 - - - state Kepler's law of periods, both in words and formula form. The learner will becom familiar with this law and its discovery through study of the test and through application of it in conjunction with his own plotted Mar's orbit and/or tabulated time and position data of the various planets in the solar system. (Note: The value for R in the period law $\frac{T^2=K}{R^2}$ is the aver or mean distance between the sun and the planet. A requirement of the previous objective inclu the ability to determine this type of value).

M17 - - - describe in his own words the great controversy raised by Galileo's observations thro a telescope. The learner will become familiar with Galileo's findings and the reactions of his contemporaries regarding his interpretation of his findings through reading assignments and moti picture footage depicting this period in Galileo's life.

M18 - - - explain some of the effects of: the "arrogant" attitude of Galileo, the religious beliefs of Galileo's time, and the fact that Galileo wrote in Italian and not in Latin. The lear will be exposed to biographical writings and film footage re: the life of Galileo. Subsequent discussion will bring out the student's ability to explain the apparent effects.

#7 THE NEWTONIAN SYNTHESIS

M

(Note: The following objectives relate to the work of Newton "standing on the shoulders of gian as the climax of 17th century physics. The emphasis is on philosophical, historical, and scientific significance of Newton's Law of Universal Gravitation).

M1 - - - state reasons why the formation of scientific societies was important to the developme of science in the 17th century. Following adequate study time the learner will be able to list three reasons regarding above statement.

M2 - - - describe the mood or state of mind which led Newton to see the relationship between th of the planets and the fall of an object (apple) to the ground on earth. The learner, reading selected biographical material and commentary, will be sufficiently informed to describe in persepctive the characteristics referred to in the above statement.

M3 - - - discuss in his own words, the meaning of Newton's rules of reasoning (included in his Principia). After reading and thinking about these four rules the learner(s) will help his (their) colleagues in the grasp of the meaning of these statements through attempted meaningful class discussion.

C4 - - - appreciate the fact that Kepler's laws of motion can be explained by the dynamics of Newton. (Note: The instructor will help the student to follow the mathematical strategy involved in relating the role of the universe - square law, centrally directed force, the law of periods, and Newton's second law of motion. The P.S.S.C. film, "Elliptical Orbits" will be used in conjunction with this unit of instruction. The learner will be able to explain the meaning of all symbols used in the final expression of these relationships and will be able to solve problems using the derived formulas through direct substitution of values into them. He will expre his answers with the correct units.

C5 - - - accept the concept of gravitational force (as a phenomenon) operating as dependent on m and separation distance. (Note: to facilitate this acceptance the instructor will help the stud through the derivation of the general law of Universal Gravitation, what it means, and how to apply it).

Examples of applications the learner will be exposed to are:

(a) calculating the moon's acceleration relative to the earth (and comparing the result with that determined by an alternate method)
(b) describing the effects of tides
(c) describing comet orbitals
(d) calculating the ratio of the mass of a given planet to the mass of the sun
(e) describing the motion of other physical bodies in the universe

CM6 - - - accept "G" as a universal constant. (Note: the instructor will help the student realize why it appears in the law of gravitation and will attempt to help him realize that calculations based on this "assumption" have led to consistent results in a wide variety of astronomical data, including the behavior of a space ship orbiting and landing on the moon). The learner will be able to take the numerical value of "G" and calculate the actual masses of the earth, other planets, and the sun.

M7 - - - describe how Cavendish experimentally determined the value of "G". After study in the text and viewing the P.S.S.C. film "Forces", and subsequent discussion, the learner will be able to describe (with illustration) the strategy of the Cavendish experiment.

C8 - - - contrast accelerations due to gravity at different points relative to the center of the earth. By applying the law of universal gravitation to compare gravitational force differences at the equator, the poles, and various fixed distances above the surface (away from the center) of the earth, the learner will be able to compare corresponding accelerations.

NOTE: The following ___ objectives are to be achieved largely through combinations of study of texts, especially selected reference readings, audio visual media, classroom activities and are inherent in the essence of physics .

M9 - - - state in his own words what Newton meant when he said that he stood "on the shoulders of giants".

M10 - - - list the implications of the Law of Universal Gravitation.

M11 - - - list examples of the impact of Newton on man's knowledge outside of science.

CM12 - - - state the limitations of Newtonian mechanics.

#8 THE CONSERVATION LAWS

C... e learner will be able to illustrate that conservation of mass was an old accepted idea a... t Lavoisier provided sound experimental basis for this belief with his eighteenth century experiments. The learner will read some of the history regarding the development of this concept and become involved either directly or indirectly in the analysis of results of a Lavoisier type conservation of mass experiment (or demonstration). It will be acceptable if the learner concedes his understanding that the results are consistent with the stated conservations princip (Note: the importance of a closed system will be stressed).

PM2 - - - perceive how man's faith in an orderly universe results in him "thrashing around" using incomplete and vague concepts in his search to find order among the seemingly chaotic; a sort of private, pre-physics stage in which guesswork, hunch, and intuition are stirred in with experimental observation, good existing theory, and hope. The learner will study the case of the development of the concepts of conservation of momentum and conservation of kinetic energ The following objectives lead sequentially to acceptance of these conservation principles.

C3 - - - understood, through detailed observations of collisions, that the concept of motion car be quantized (the French philosopher Descartes had suggested that the proper measure of a body's quantity of motion was the product of its mass and its speed). The learner will perform experiments of carts colliding with one another along straight line paths and learn that total quantity mv for the closed system appears to be conserved only if Descarte's definition of quantity is modified to allow the term v to become velocity rather than speed. (Note: this is a good place to point out that the product of mass and velocity often plays an interesting role in mechanics, and therefore has been given a special name; instead of being called "quantity of motion", as in Newton's time, it is now called "momentum".

C4 - - - understand that the total momentum of a system remains constant during collisions (and "explosions"). The learner will be able to understand this concept as a result of studying the results of at least three lab experiments of collisions and "explosions" along a straight line (not all head on and not without varying the masses involved) and at least two collisions in tw dimensions (air pucks colliding at an angle). (Note: the learner will further demonstrate his grasp of previous learned concept by being able to apply them in his study - e.g. drawing and adding vectors, calculating velocities, etc.).

C5 - - - give evidence that the law of conservation of momentum universally applies. Through viewing of films, demonstrations, and related reading assignment, the learner will be able to list at least three examples outside his personal laboratory experience where this law applies.

C6 - - - show that the law of conservation of momentum is consistent with Newton's laws of motion. (Note: the law of Conservation of Momentum as derived so far is an "empirical" law, that is, it was arrived at as a summary of experimental results and was not derived from theory that is the way it actually was "invented"). With the aid of the textbook and the instructor, the learner will be lead through a derivation of the Conservation of Momentum from Newton's Laws. The learner will not be asked to repeat such a derivation on any examination but will be encouraged to apply his previously learned skills and understanding to follow through the strategy and to ask the instructor's assistance in determining whether or not he really understands (through voluntary discussion).

C7 - - - understand the necessity of an isolated system in determining conservation of momentum With reference to the application of Newton's laws of motion, the learner will be able to predi the effects of an "outside the system" force upon that system.

C8 - - - determine that if collisions are elastic, another kind of quantity is conserved (in addition to momentum) which is the arithmetic sum of the mv2's. The learner will examine very near elastic collisions in the laboratory (as well as film loops, etc.) and from mass and velocity date be able to compare the sum of the mv^2's before a collisions with the sum of the mv^2's after the collision. (An extension of this objective would be that of an analysis of these quantities for collisions in two dimensions of hard steel balls - where the magnitude only of the v's is used).

M9 - - - gain further insight into the role of intuition and faith in the growth of science. Through brief study of the Leibnitz-Descartes controversy regarding what it is about motion tha is conserved. (Note: Students will be encouraged to argue out the controversy by playing t[illegible]e of each of the different sides).

(Note: The following - objectives are to build a more refined and accurate concept of the nature of work and energy and to examine some of the reasons why you don't get"something for nothing" in exchange of energy).

C10 - The learner will be able to define work and energy and will understand them algebraically as they relate to each other. Using the correct formulas for work and kinetic energy, the learner will be able to show, dimensionally, that these formulas are equivalent. (Note: the significance of the concept of work is that it represents an amount of energy transformed from one form to another).

C11 - - - realize that doing work on an object can increase its kinetic energy, but work can be done on an object without increasing its kinetic energy. A simple demonstration of lifting and dropping a book dramatizes these ideas (also compressing a spring or moving two magnets near one another).

C12 - - - define potential energy and be able to determine mathematically the potential energy of a body. Given several demonstrated examples of changing the position of an object relative to the earth (complete with weight and distance data), the learner will be able to calculate correctly with 100% accuracy each new value of the potential energy relative to a defined origin of displacement.

C13 - - - evaluate the changing relationship between the kinetic and potential energies within a system at given instants in time. Through a variety of laboratory experiences (e.g. raising and dropping weights, oscillating springs, slow collisions) measurements of weights, forces, displacements, and velocities will be taken by the learner and utilized toward formulating conclusions about mechanical energy relationships during the observed transformations. (Note: it will be stressed that potential energy should be thought of as belonging to a system, rather than to an object - that potential energy is really shared by the whole system - e.g. electron + atom, book + earth).

C14 - - - recognize that the amount of energy in an isolated system does not change - - only its form changes. Through study of the test, viewing of film loops (e.g. "Speed of Rifle Bullet", "Conservation of Energy - Pole Vault", etc.) and performance of an experiment on the conservatio of mechanical energy the learner will be able to conclude that the total change in the sum of K.E. and P.E. gravitational of the system is zero.

C15 - - - recognize that work means a change in kinetic energy or potential energy and is the product of the component of the force in the direction of motion of the object and the distance through which the object moves while the force is being applied. The learner will demonstrate his understanding of this by responding correctly to four out of five problem examples representing situations where forces are not acting directly (or entirely) along the paths of the mot

M6 - - - realize that the idea of heat being a form of energy came to be accepted in the 19th century largely as a result of the practical application of steam engines. Through reading and discussion of selected reading assignments (case histories) the learner will be able to list in sequence at least three historical highlights contributing significantly to the evolution of theories about the phenomenon of heat.

M17 - - - explain how James Watt increased the efficiency of the steam engine. Through comparis of Watt's model of the steam engine with that of the earlier model of Newcomer's, and with the a of simplified drawings, the learner will be able to explain the effect of Watt's innovation.

M18 - - - define and use the term power. The learner will be able to express in both the M.K.S. metric and the English systems the meaning and significance of the units (derived) for power.

MC19 - - - appreciate and explain the contributions of J. P. Joule to the field of calorimentry. As a result of studying about the earlier "caloric theory" of heat and its overthrow, the studen will appreciate the significance of the experiments of Joule (mainly the mechanical equivalent o heat determination). Through experience performing selected calorimetry experiments, the learne will further comprehend the intricacies and values related to the science of calorimetry. The : will be able to work straightforward problems involving the equivalence of heat and ical energy with 70% accuracy.

C20 - - - relate physics to the energy transformations involved in biological processes. Through selected assigned reading and subsequent discussion the learner will be able to explain at least four examples of energy transformations involved in biological processes. (Note: another connection to physics is provided by the problem of inadequate world food supply here, too, many physicists, with others, are presently trying to provide solutions through work using their special competence.

C21 - - - state the law of conservation of energy in its precise form called the <u>first Law of</u> Thermodynamics: $\triangle E = \triangle H$; the change in total energy of a system and the net heat input to the system. The learner will be able to explain the meaning of this statement through examples based on his study of physics so far. (Note: discussion of this idea is to show off the coherence of physics. Of course, it relates as well to concepts not studied yet in the course).

MC22 - - - appreciate the historical significance of faith in every conservation (it predicts new observations). The learner will be able to list at least two currently accepted ideas that were first predicted by the conservation of energy principle.

#9 KINETIC THEORY OF GASES

Note: The purpose of this section is to present the development and consequences of a simple theoretical model and to develop the relationship between kinetic theory and the principle of the dissipation of energy.

C1 - - - understand that the basis of what is called the Kinetic-molecular theory of heat is that: since heat can produce mechanical energy and mechanical energy can produce heat, the"heat energy" of a substance is simply the kinetic energy of its atoms and molecules (to a large exten After study of this unit the learner will be able to list three lines of evidence that support this assumption.

CM2 - - - understand that kinetic theory based on Newtonian mechanics ran into difficulty. The learner will be able to relate at least one type of discrepancy between experiment and kinetic theory based on Newtonian mechanics. (Note: Realization of the two above objectives are best enhanced by first hand knowledge of the behavior of gases through laboratory investigation with the observed results being checked against theoretical accountability. It is intended that the learner will learn in this course that all models are oversimplifications, and one is prepared t find that simple assumptions of a model have to be modified from time to time in order to get a theory that agrees well with experimental data).

C3 - - - describe a model which explains the observable behavior of a gas. He will be able to summarize at least five characteristics of the model. (Note: see parenthetic comments in #2 above).

M4 - - - identify some of the historical milestones in the formulation of kinetic molecular theo Through reading selected reference material involving the contributions of Boyle, Bervoulli, Herapath, Joule, Clausius, Maxwell, Boltzmann, Stern and others, the learner will be able to discuss, at least qualitatively, the significance of the contributions towards development of kinetic molecular theory by at least three of these scientists.

P5 - - - experimentally verify Boyle's law. As a result of formal zing pressure-volume data (at constant temperature) from their own experimentation/or a classroom demonstration the learne will be able to demonstrate that the date illustrate Boyle's law. (Note: the instructor might lead some students through the theoretical derivation that predicts the same pressure-volume relationship).

C6 - - - describe how the diameters of particles of a gas effect the rate of diffusion of the ga Through assigned reading regarding Clausius accounting of diffusion and mixing of gases and through first hand laboratory investigation (hydrogen sulfide meets chlorine in long glass tube at predicted locations) the learner will be able to explain what modification of kinetic-molecul theory was necessary to update it so it could account for these observations

C - state the mathematical relationship (developed by Clausius) between the mean free path c article and its diameter. The learner will be able to obtain some feeling for this concep through a paper and pencil experiment (game) in which a hypothetical particle moves somewhat randomly across graph paper (subject to game rules). This is a two dimensional experience yielding quantitative results consistent with theory and not far removed from the three-dimensional concept.

* See note after objective #13

C8 - - - define entropy in terms of disorder of a system. The learner will do this on the basis of text study, reference to phenomenological experience and subsequent directed discussion

C9 - - - describe the second law of thermodynamics in terms of entropy (through reference study and discussion aimed at interpretation).

C10 - - - describe the "heat death" as conceived by Lord Kelvin (through reference study and interpretation in class).

C11 - - - describe the statistical nature of the second law of thermodynamics (via reference stu and follow through interpretive class discussion).

C12 - - - describe how Maxwell's Demon could reverse the natural entrophy charge in a system. (V reference study and follow through interpretive class discussion).

Note: Objectives 8 through 13 do no t lend themselves well to "behavioral" form but nevertheles open doors to much stimulating discussion and speculation. To leave out of a course glimpses in strange and mysterious consequences of accepted theory would be a disservice to the learner.

APPENDIX 1

NSTA CONCEPTUAL SCHEMES

I All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

II Matter exists in the form of units which can be classified into hierarchies of organizational levels.

III The behavior of matter in the universe can be described on a statistical basis.

IV Units of matter interact The bases of all ordinary interactions are electromagnetic, gravitational and nuclear forces.

V All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

VI One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid and gaseous.

VII All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

APPENDIX 2

MAJOR ITEMS IN THE PROCESS OF SCIENCE

I Science proceeds on assumption, based on centuries of experience, that the universe is not capricious.

II Scientific knowledge is based on observations of samples of matter that are accessible to public investigation in contrast to purely private inspection.

III Science proceeds in a piecemeal manner, even though it also aims at achieving a systematic and comprehensive understanding of various sectors or aspects of nature.

IV Science is not, and will probably never be, a finished enterprise, and there remains very much more to be descovered about how things in the universe behave and how they are interrelated.

V Measurement is an important feature of most branches of modern science because the formulation as well as the establishment of laws are facilitated through the development of quantitative distinctions.

APPENDIX 3

REPORT OF 1972 CONFERENCE OF SCIENCE CHAIRMEN

A CURRICULUM FORMAT FOR SCIENCE IN HIGH SCHOOL DISTRICT 214

INTRODUCTION

The following statements represent some initial thinking about the science curric ulum in District 214. They attempt to summarize a conference of the science chairmen held in June, 1972. In their present form they represent the commitment of the chair- men to a philosophy and direction of our science curriculum. It is intended that thes thoughts will be expanded by subsequent workshop groups and ultimately by the behavio of students who learn within the format. While a final form will never exist it is hoped that the work of summer groups will be sufficient to allow evaluation during th 1972-73 school year.

The conference began with a "brainstorming" session. The resulting thoughts are included in order to convey some of the initial and broader thinking of the science chairmen. These statements are not conclusions or necessarily a consenus of thinking

1. What are the specific concepts which should be required of all students in the biological, physical and earth sciences?

2. The amount of science required of all students should be limited to one year provided that adequate coverage of the concepts can occur.

3. There should be a District policy on establishing courses in any school.

4. There should be a reduction in fact memorization.

5. There should be no required courses, rather proficiency in the concepts and meaning of science.

6. What should be the relative emphasis on specialization and generalization? By proliferating courses are we forcing students to specialize early?

7. The number of course offerings should be increased as feasible.

8. Textbook adoption should be more realistic and given more serious attention by committees. There is difficulty in adopting textbooks at a new school when students come from one building and staff from another with a different philosophy.

9. Instruction in reading should be integrated into the freshmen science program.

10. Regarding student placement procedures - can a curriculum format accommodate placement by course selection rather than by ability measures? How can we present students from selecting incorrect levels or the path of least resistance? How can we encourage students to set realistic goals?

11. The format should accommodate and encourage individualized instruction and programming.

12. How do we insure correct counseling of students into the appropriate science program.

13. The format should reflect a curriculum which would have a basis in major concepts, process skills, and the meaning of science. The meaning of science should include aspects of relevance, value systems, significance for life, the "Paul Hurd View".

The chairmen concluded that the activities of the conference should center around the following objectives:

1. Establish the basic curriculum format.

2. Determine the operational mechanisms as they are perceived at this point in the development of the program.

3. Provide direction for the subject area workshop groups in developing the details of the format.

THE FORMAT

The science curriculum in District 214 will encourage learning and feeling in three areas:

1. The conceptual schemes common to science.

2. The process skills necessary to competently investigate reality.

3. The meaning of science to individuals living in a world of experience and technology.

The emphasis of the initial activities of those developing the format will be upon the area of conceptual schemes. This is not to indicate any conclusion about the relative importance of the three areas but rather our estimate of the area of most immediate payoff in terms of providing a curriculum change. It is the area of our greatest understanding and preparation. The frustration of trying to define the "meaning of science" is perhaps indicative of our level of understanding of this area. It was the conclusion of the chairmen to start with the concepts in science but the greater future activity should be given to the areas of process and meaning.

I. The Conceptual Schemes Common To Science

(see the attached copy of the NSTA report titled "Theory Into Action, . . . In Science Curriculum Development, NSTA, 1964, pages 16-29)

These statements were considered and adopted by the chairmen as providing the basis for the conceptual portion of the science curriculum in District 214. After further investigation and evaluation these statements may be revised. However, it is intended that they will provide the basis for beginning operation of the format. Experience may provide the need for revision but changes on the basis of philosophy will be avoided until evidence is available to direct such changes. Our present commitment is to developing and experiencing the NSTA statements.

II. The Process Skills Necessary to Competently Investigate Reality

(See the attached copy of the NSTA report titled Theory Into Action, . . . In Science Curriculum Development, NSTA, 1964, pages 29-31)

The NSTA statements on process are included for purposes of definition. The chairmen did not adopt these statements or commit our program to their evaluation. They are provided as a sample set of statements. It is expected that major changes will be necessary before the final statements are adopted. Future efforts will be given to formulating definitive process statements.

III. The Meaning of Science

This goal of science teaching is only minimally understood. The most definitive statement about "meaning" (even the term may be inaccurate is the attached article by Paul DeHart Hurd. We desire to provide the rational for investigating science and direction for communicating science on a human level. The statement of "meaning" is an attempt to provide what Hurd calls the ability to cope with ones environment with diginity. The area of "meaning" has within it elements of relevance, values, decision making in a social context, solving of human problems, technology and career education.

Our limited understanding of this goal should not diminish its importance or the amount of future effort given to it. We will probably need to contact Hurd and Robert Samples from the Environmental Studies Project to increase our competence to write a curriculum which reflects these concerns. It is important that at this point, enough thought is given to relating the "meaning" of science to avoid writing concepts and processes which prevent or obstruct the goal of communicating the significance of science to people.

OPERATIONAL AND IMPLEMENTATION MECHANICS

1. The Science Curriculum Format will be submitted to the Curriculum Council, Administrative Council, and Board of Education for approval as the basis for the science curriculum in all District 214 schools.

2. During the 1st year of operation (1972-73) and before final approval of the above groups, the Format will be evaluated by the experience of our present curriculum. The evidence accumulated from the evaluation will be used to refine the basic format and to direct the development of the areas not completed during the summer of 1972.

3. After the Format is approved all courses will be presented to the Science Chairmen for review relative to meeting the adoption criteria. Upon approval by the majority of the Science Chairmen the courses will be submitted to the Curriculum Council. Administrative Council and Board of Education for their decision as to the implementation into the District 214 Curriculum. Courses submitted for approval as experimental will be evaluated by the Science Chairmen on the same basis used in the adoption procedures. Experimental courses receiving approval of the chairmen will be submitted to the curriculum council.

4. Criteria for meeting the Science Curriculum Format. Each course will be judged in terms of:

a) Its contribution to teaching the basic concepts identified in the format.
b) Its contribution to teaching the basic process skills identified in the format.
c) Its contribution to illustrating the meaning of science to our students.
d) Its avoidance of non-meaningful duplication or redundancy of other courses.
e) Its effects on previously adopted courses regarding the availablity laboratory equipment and supplies.
f) The availability of resources, including staff to effectively implement the course.
g) The existence of course objectives, how they relate to the format and their educational worth.
h) The feasibility of evaluating the attainment of the course objectives.
i) The topics covered and their sequence.
j) The predominant teaching method to be used in presenting the course to the students.
k) The extent to which the cognitive and affective skills of students will be developed: i.e.,

Cognitive skills (C.F. Bloom)
1. knowledge
2. comprehension
3. application
4. analysis
5. synthesis
6. evaluation

Affective skills (Kratwohl)
1. receiving
2. responding
3. valuing
4. organization
5. characterization by a value or value complex

5. It is the goal of the science curriculum and staff that all students will demonstrate competence in all basic conceptual schemes at least at the level of comprehension (C.F. Bloom). However, we recognize that for some individuals the goals of education are satisfied by a student showing progress in non-cognitive areas. Hence, for these individuals satisfactory progress towards comprehension level performance may be acceptable.

6. Course required of all students will be those which are necessary to provide the student with experience in all of the basic concepts and processes sufficient to develop a comprehension level of competence.

7. In an attempt to create a workable program of student grouping based on selection of courses rather than ability or achievement measures the following grouping structure is proposed.

IMPLEMENTATION MECHANICS

The primary distinction between courses will be determined by the nature of their purpose and the needs of the student they intend to accommodate. Each course will be identified by its primary intention of being exploratory, preparatory, or investigative at an advanced or independent level. These are identified by the following level description.

A. Exploratory

1. emphasis on relevance (application)
2. activity oriented - laboratory and field work
3. broad inclusion of concept topics at a general level of sophisticatio
4. emphasis on process skills
5. career orientation
6. low mathematical emphasis

B. Preparatory

1. course is designed as part of a sequence of courses (sequence may include high school, college, or vocational school programs)
2. concept development at a relatively advanced level
3. mathematical emphasis when appropriate
4. process skills mainly used to illustrate concepts
5. laboratory is phenomenologically oriented

Note: A basic difference between preparatory and non-preparatory courses will be the amount of time spent on providing evidence which leads to the conclusion derived.

C. Advanced Investigation

1. orientation investigation
2. laboratory is research oriented
3. students capable of independent investigation
4. concepts developed at a relatively high level of sophistication
   a) when appropriate preparation will be at a level of first year college instruction (advanced placement)
5. seminar, independent study, and special topics courses at an advanced level

DIRECTIONS TO SUMMER WORKSHOP GROUPS

The primary purpose of each workshop group will be to expand the basic conceptual statements in the format to a level where they will be directly meaningful to the classroom. This means that if one were to teach chemistry this fall he could offer his students the set of concepts they would be introduced to in the course. Thus, the statement should be in a form which is understandable by students.

In addition to preparing these conceptual statements, the groups should consid the following:

1. Preparation of course objectives in behavioral terms.

2. Identification of the level of the conceptual statements, i.e. Exploratory, Preparatory, or Advanced Investigation.

3. Investigate new course sequences appropriate to the area, e.g., should Non-terminal Physical Science, Chemistry, and Physics become Chemistry I, II, III and Physics I, II, III...

4. Identification of the concept statements at the level at which they should be required of all students.

5. Develop implementation procedures specific to the area of the group. These procedures to be discussed at the August 22-24 meeting.

6. Investigate the expansion of resources available to science instruction.

7. Expand the statements on process and meaning.

While it may be logical that the work of the subject groups may replicate or justify our present curriculum, this should bot be the intention of the groups. We should begin from the position of the kind of curriculum we would like based on the adopted format. Workshop participants are encouraged to be as innovative in their thinking about expanding the format as they would enjoy.

Finally, these statements should be accepted only as a rough draft of the final form of the Format. It is anticipated that a great many changes will be made before we are ready to commit ourselves to a final position.

APPENDIX 4

ORIGINAL WORKSHOP PARTICIPANTS

The following format has been formed from the thinking and efforts of a large number of science teachers and chairmen. Those specifically contributing through their role as chairman and/or participating in a summer workshop were the following:

Science Chairmen

Arlington - Hugh Jones

Prospect - Robert Kemman

Forest View - Roy Meiller

Wheeling - John Ashenfelter

Elk Grove - Merrill Froney

John Hersey - Donald Hruby

Rolling Meadows - Darwin Miller

Workshop Participants

Arlington - Saul Ploplys, John Strack

Prospect - Paul Gates

Forest View - Dave Buchheit, Dennis Jason

Wheeling - JoAnne Bibergall, Louis Nettelhorst

Elk Grove - Virginia Gray

John Hersey - Ron Mills, Tom Reed

A number of additional District 214 science teachers were involved in reviewing materials and providing insights to those more directly involved.

The format is presented in a 1st draft form. It is intended that it will be revised. It is submitted to the science teaching staff for their consideration and trial use. It is hoped that the format will be sufficiently developed to justify an experimental program during the 1973-74 school year.

Donald G. Ring
District Coordinator of
Mathematics and Science

DGR:sn