On the premise that a knowledge of nuclear science is essential for intelligent decision-making regarding its uses, the Nuclear Science Curriculum Project was developed. Its objective is to provide a program that can be effectively used in science classes to provide an understanding of nuclear science and its impact on society. Though teacher institutes had been conducted to provide new materials and insights, a lack of an inclusive source of information on concepts and materials seemed to hinder implementation of instructional programs. This project was organized to develop a set of instructional objectives, expressed in behavioral terms, regarding nuclear science and its impact on society. These objectives were designed as modules that could be included within the framework of existing science and social science courses. "Need-to-know" items were determined for the average non-science oriented high school graduate, in order for him to perform as a responsible citizen. Two techniques employed to achieve project objectives were (1) the use of systems techniques for mission analysis and definitions, and (2) the use of behavioral terms for instructional objectives. The document is organized into sections as follows—(1) framework, identifying the higher order behaviors and providing an over-all matrix within which knowledge, attitudes, and skills can be ordered, (2) social issues relevant to nuclear technology, illustrating the way each terminal behavior from the framework could be developed, (3) modules of instruction, showing how science and social science content and decision-making processes can be structured into learning units, (4) behavioralized science data, giving a breakdown of the basic science data into behavioral terms—behavioral objectives, stimulus cues, and criterion test measures, and (5) background content, a compilation of the "need to know" content identified by the natural and social scientists as necessary to an understanding of the socio-scientific implications of technical discoveries. (DH)
NUCLEAR SCIENCE CURRICULUM PROJECT

PHASE I INSTRUCTIONAL SPECIFICATIONS

Prepared for submission to the
Board of Education
Culver City Unified School District
Culver City, California

Board of Education
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The basic premise upon which the Nuclear Science Curriculum Project was developed gave recognition to the fact that, with the advent of the control of nuclear energy and the resulting effects on our society, it has become imperative to formulate and disseminate knowledge of radiation and its effects, in order for an informed citizenry to make reasonable decisions concerning the social consequences of nuclear science in their everyday lives. E. J. Brunenkant, of the United States Atomic Energy Commission, recently stated:

"Nuclear energy is playing a vital role in the life of every man, woman, and child in the United States today. In the years ahead it will affect increasingly all the peoples of the earth. It is essential that all Americans gain an understanding of this vital force if they are to discharge thoughtfully their responsibilities as citizens and if they are to realize fully the myriad of benefits that nuclear energy offers them."

In a recent publication of the Atomic Energy Commission, Understanding the Atom, Lyman stated: "As citizens of a democracy, we are called upon to make decisions about the social implications of atomic energy. Few of us understand even the elementary principles underlying the release of atomic energy."

It has been estimated that technological knowledge has doubled in the last ten years, and is expected to redouble every three years henceforth. It is academic at this point, with the evidence at hand in our daily lives, to say that a need exists for the inclusion in the curriculum of nuclear science concepts and the resulting societal implications.

The Atomic Energy Commission has sponsored a number of summer institutes for presenting high school teachers with new materials and concepts in nuclear science. Though these institutes were quite successful, evidence from one study indicated that, due to a variety of problems such as the lack of an inclusive source of information on these concepts and materials, most teachers could not introduce a nuclear science curriculum to their students on a scale large enough to insure successful student interest and learning.
During the year 1965-1966, the Culver City Unified School District, with the cooperation of the California State Department of Education, formulated plans for the submission of a proposal to the United States Office of Education, Title III, Elementary and Secondary Education Act. The results of this study were then incorporated as part of the Nuclear Science Curriculum Project proposal.

**Purpose of the Project**

The primary objective of the Nuclear Science Curriculum Project was to develop a set of instructional objectives, expressed in behavioral terms, relating to nuclear science and its impact on society. The instructional objectives were developed for inclusion as modules within the framework of the existing courses in both the sciences and the social sciences. Derivation of the instructional objectives emphasized attitudes, knowledges, and skills based on real life requirements involving the socio-political and scientific implications of atomic energy. More specifically, the task was to determine the need-to-know items required of the average, non-science oriented high school graduate to perform as an informed citizen in the ever present and rapidly expanding nuclear society. To be an informed participant in our society today, and the society of tomorrow, requires the ability to understand the social, economic, political, and technological implications of the subject at hand. Stated with utmost simplicity, the end goal of this effort would be for the learner to possess the skills necessary to make rational and intelligent decisions based upon accurate knowledge and awareness, as opposed to decisions arrived at through fear emanating from ignorance.

**Innovative Techniques**

Recent developments in the state of the art in educational technology have demonstrated that it is not only feasible, but highly desirable, to design a course of instruction for the secondary program which embodies the simultaneous use of the latest techniques and principles leading to product development. During the past twenty years, there have been significant advances in many aspects of planning, development, and utilization of instructional materials and instructional strategies.
First, reliance on systems techniques provides a framework for the development of the educational mission and for the development of plans for its accomplishment. Second, reliance on task analysis techniques permits identification of objectives in terms of real-life performance needs leading to the specification of criteria for expressing course objectives in behavioral terms. Third, recognition that the changing needs of society and the rapid obsolescence of facts impose a consequent demand that objectives be phrased in terms of decision-making processes and behavioral competencies which should result from instruction. Fourth, recognition that decisions regarding instructional media must rest on identified course behavioral objectives. Fifth, reliance on a systematic procedure for product development which, through a cyclic process, enables decisions to be made on the basis of empirical data rather than on techniques which rely on intuitive judgments.

The nature of the requirements for the Nuclear Science Curriculum Project dictated the use and application of those techniques and principles of product development appropriate to the various stages in the product development cycle. These stages, as identified by James Popham of the Southwest Regional Laboratory, are project formulation, instructional specifications, prototype item tryout, and product development.

The outcomes for the planning phase of the Project are those relating to the instructional specifications and encompass the following elements.

1. A defensible list of need-to-know knowledge, attitudes, and skills pertaining to nuclear science as identified by experts from natural science, social science, and industry.

2. An analysis of existing course content in the sciences and social sciences to determine where in the existing curriculum concepts relative to nuclear science are, or could be, taught and where developed behavioral objectives could be incorporated.

3. An analysis of existing instructional aids to identify and specify those most appropriate to the implementation of the design learning paths.

4. A statement of terminal and interim objectives, expressed in behavioral terms, appropriate for a high school graduate who may never have additional formal training in the area, but who needs to be an informed, contributing member of our society.
5. A series of performance tests and criterion measures to determine learner achievement of the developed behavioral objectives.

6. A preliminary statement of the design requirements for preparing and implementing instructional systems to achieve the behavioral objectives. This will include the organization of the terminal and interim objectives and measurement criteria into a sequence of learning steps or requirements.

7. A statement of parameters influencing the implementation of the objectives.

The final product resulting from the planning grant should be a designed "blueprint" for the solution to a problem. The postulation of an ideal program for nuclear science education will necessarily be based on what may be called a priori determinates. It is anticipated that the demonstrated worth and utility of the Project will be confirmed by insightfully planned and evaluated pilot studies and field tests and by subsequent materials development. These should allow for development and refinement of the design requirements for completing a full instructional system for the secondary schools.

Methods of Procedure

Two techniques, which may be characterized as innovative in modern curriculum development insofar as general practice is concerned, were employed to achieve Project objectives: (1) the use of systems techniques for mission analysis and definition, and (2) the stating of instructional objectives in behavioral terms. The successes of systematic attack on problems, first widely used in the aerospace industries and now being applied in many other areas, have had their influence upon many forward-looking thinkers in education. The technique, variously described as an engineering or systems approach, was employed by the Project to develop a detailed description of terminal learner behaviors. This approach is based on the predefinition of: (1) what is to be learned; (2) the required levels of terminal performance to be achieved by the learner; and (3) the design of instructional paths by which learners progress through successive steps leading to the attainment of the prestated objectives.

The Systems Approach is an organized technique for solving complex problems. Beginning with the identification and definition of the end product, it is a goal-centered approach. The Systems Approach requires an analysis of the total mission to be performed, and specifies a logical progression of critical steps and an interfacing of methods, techniques, and resources required for the accomplishment of the final objective.
As applied to education, the Systems Approach is an effective integration of techniques, procedures, content, and processes with the objective of specifying efficient, reliable and measurable learning systems. At the onset of the Project, the systems analysis techniques were applied to the Nuclear Science Curriculum Project, as indicated in the planning report presented to the Culver City Board of Education in March 1967.

The procedures employed by the school district's Project staff in the development of instructional objectives relied on the involvement and interaction of academic scholars from both social science and natural science disciplines, of classroom teachers, and of lay persons from industry, commerce, economics, and politics. Reliance on an interdisciplinary approach served to insure the widest possible identification of need-to-know information from science, technology, and social science relevant to achieving a detailed statement of educational objectives for the study of nuclear energy and its social implications.

The methods employed called for an engineering or systems approach to curriculum development by which detailed learning objectives are specified. Expert consultants assisted in the specification of the instructional paths leading to the achievement of each terminal behavioral objective. Culver City Unified School District subcontracted with the Special Projects Department of Xerox Education Division, New York, and the Bio-Atomic Foundation, North Hollywood, California, for these services.

**Target Population**

In the Nuclear Science Curriculum Project the definition of the student population to be served refers to: (1) the student population of the Culver City Unified School District, characterized by the following test data of the eleventh-grade class in 1965 Lorge-Thorndike Verbal Mean I. Q. 114.1; Iowa Tests of Educational Development, composite score, 57 percentile, 65 percent of whom enroll in institutions of higher learning and (2) all non-science oriented graduating seniors, regardless of geographical location and intelligence level, entering society as an informed and participating citizen.
Basic Assumptions

1. Through the utilization of the "systems approach," a complex curriculum problem could be efficiently analyzed and resolved.

2. The state of the art relating to behavioral psychology and specification of behavioral objectives was sufficiently advanced to be utilized in dealing with the complexity of behaviors in the cognitive and affective domains.

3. The technical expertise of Xerox Corporation and Bio-Atomic Foundation, the two subcontractors to the Project, would be sufficient to furnish the Nuclear Science Curriculum Project staff with relevant technical assistance.

4. The academic consultant task groups in science and social science would provide valid data deemed necessary for inclusion as content in the proposed curriculum.

5. All behavioral objectives, suggested interim objectives and/or learning paths expressed in writing upon culmination of the Project represent postulated or hypothesized items which must be field tested and validated.

6. Learning standards recommended for performance are assumed to be 90% of the learning demonstrating measurably 90% of the objectives or criterion tests postulated.

7. The conditions under which such performance occurs are those found in the typical instructional setting of today's high school classroom profile.

Definition of Terms

The following definitions were extracted from various sources written by Professors Robert E. Corrigan and Roger O. Kaufman, Educational Technologies Department, Chapman College, Garden Grove, California.
1. **Systems Approach:**

   A system approach is an analytical method of problem solving. It essentially reduces a process for solutions of any specific problem into operational elements and details the performances of individuals, equipment, and facilities into a time sequence to achieve stated goals. The primary emphasis is upon what is to be achieved in defined performance terms. A process of iteration is used to integrate and interface all steps in the process.

   In simplest terms, a system approach asks where you are going, spells out what has to be done to get there, specifies how you know you are there, and gives an exact control over the separate elements of the process.

2. **System Iteration:**

   The analysis process whereby system analysts who are given mission objectives performance limits and constraints identify, classify, specify, check and (as necessary) reformulate system function and appropriate design criteria. The objective of system iteration techniques is system compatibility between system functions and engineering requirements in achieving stated system mission objectives.

3. **Instructional System:**

   The sum total of all components in a learning situation which are combined in such a manner as to contribute individually and together to accomplish given, definable terminal performances (mission objectives).

4. **Instructional System Approach:**

   The use of system methodology to design totally integrated, functional instructional systems. The instructional systems approach is a self-adjustive performance system. It is designed to achieve carefully established learning objectives for students who present the necessary
prerequisite skills for entrance into the instructional sequence. It is based specifically on the predefinition of (1) what is to be learned, (2) the required levels of terminal or final proficiency to be achieved by learners, (3) the most appropriately designed sequence of instructional steps for learners to insure their success on each successive step leading to the attainment of the prestated terminal performance objective.

The total emphasis is the designed, predictable achievement of prestated terminal or final performance specifications representing only the relevant concepts, principles and techniques required for "knowing" or "doing" skills.

5. Behavioral Objectives:

Behavioral objectives are the terminal performance specifications for education and training which identify and specify the exact skills and knowledges that are required of the learner upon completion of the program. They can be likened to the performance specifications that we might place on a typewriter or a furnace—what it must do, under what conditions, and how we will evaluate it. Behavioral objectives provide for the design of instructional materials into a need-to-know design level in order that learner oriented, learner performance materials can be developed. Properly expressed, behavioral objectives fix specific performance responsibilities, hold performers accountable for achievement within defined boundaries, and allow both management and the performer(s) to evaluate what has been done.

6. Terminal Performance Objectives:

Terminal objectives are specific unambiguous descriptions of the most complex behaviors expected of students upon completion of instruction.

7. Interim Performance Objectives:

Each terminal performance objective is analyzed to derive interim objectives which will lead to achievement of the terminal performance objective. Criterion measures or test questions are stated for each objective. These provide measurement not only of learner achievement, but also, of materials and methods.
8. **Learning Path:**

Interim or specific objectives are analyzed to determine all relevant knowledge and skills which must be acquired by the learner to achieve interim or specific objectives. The final analysis results in the specification of learning steps, which represent all the cognitive and/or manipulative skills that the learner must achieve to build the stated terminal performance.

9. **Criterion Tests:**

Criterion tests are the vehicles by which we validate the appropriateness and utility of the instructional materials and instructional elements. The criterion test items are derived from the behavioral objectives, and are the means by which the instructional materials are evaluated and validated. The criterion test is not a behavior sample like traditional tests, but rather is a complete assessment of all of the behaviors required and taught.

**Conclusions**

1. It is reasonable to conclude that, with the utilization of the "systems approach," this project was analyzed more efficiently within the time constraints imposed upon all concerned. The use of flow charts, buy-off milestones, and specified goals for the project expressed in functional flow terms contributed to efficient culmination of this initial phase. Without such guides, it is reasonable to assume that the project staff and all other consultant interface relationships would have been difficult to resolve. The evolving complexities of this project in curriculum analysis, communications, and logistics were dealt with efficiently. Since this project represented one of the few attempts in this country whereby large industrial educational technology personnel interfaced with local educators in a "co-partner" venture on a complex problem, it is rewarding to analyze this attempt and see the satisfactory resolution of the problems encountered.
2. Although it was recognized in the beginning of this project that the societal implications of scientific literacy relating to nuclear science were complex in nature, it is reasonable to conclude that this project has certainly clarified the problem in specific terms which will assist further researchers on the same topic. Educational theory, at present, in regard to "need-to-know" learning for graduating high school seniors is still vague except in terms of requirements for college entrance knowledge substantially in the cognitive areas of recall of facts and memorization of blocks of data. The NSCP staff, with the assistance of industrial expertise and academician input, exerted a concentrated effort to express the objectives of this project in terms of what the learner should be able to do or in performance behavioral terms. The generation of the data to support such objectives required many hundreds of man hours on the part of all personnel concerned. Out of this effort a few subconclusions can be reached as follows:

a. Present educational curriculum priorities are not sufficiently determined by criteria which allow such curriculum to be easily accepted as "need-to-know" for our societal purposes.

b. There is more general agreement in the area of nuclear science than in the general area of social science. For this reason, it is difficult, if not impossible at the present time, to index specifically designated important nuclear concepts within societal conceptual schemes of a general nature. The affective areas of societal values and psychological relationships regarding nuclear science are still yet not researched enough to translate such data into specific performance behavior on the part of learners. The baffling dilemma confronting personnel was that, although intuitively and verbally such attitudes and values could be somewhat described, these objectives were only measurable over long periods of the learner's life or in societal settings beyond the domain of the educator. In such cases, the data necessary to support objectives of this nature was not extensive to bridge the behavioral levels that would bring closure to specific learning paths.

c. It was recognized that the "state-of-the-art" in behavioral psychology regarding the specification of educational objectives in performance terms could furnish the engineering technology to this project necessary for the resolution of the problems identified in
curriculum confrontation between nuclear science and social science. After completion of this initial phase of this project, it is reasonable to conclude that this project has contributed to the "state-of-the-art" itself by identifying seeming discrepancies in present theory and technology on the subject. There are still unresolved discrepancies among several present schools of thought on behavioral objectives. Advocates of the schools of thought related to Gagne and Piaget, Mager, Ofiesh, etc., have similarities and differences between them. The NSCP personnel tried to blend such modes into this project. Some of the differences have yet to be resolved.

RECOMMENDATIONS

These recommendations were obtained from logical and reasonable conclusions by an analysis of all personnel input related to the Nuclear Science Curriculum project and within the professional experiences of the Xerox staff.

1. A field test period should be established for the implementation of selected modules into the existing curriculum.

2. During the field test period a series of control groups and approaches should be implemented to provide the most accurate data.

3. All materials should be reviewed and revised for relevancy following the field tests. This revision of material should be performed by the teaching personnel under the direction of personnel who are systems oriented.

4. An ongoing program should be established for the development of a total instructional program related to the "Societal Implications of Nuclear Science."

5. Consideration should be given to the inclusion of the recommended nuclear science materials into a nontraditional process oriented course offering to determine the effectiveness in achieving content (science and social science) while developing learning processes.
6. A series of inservice workshops should be conducted for the development of instructional materials and media applicable to establishing behavioral objectives.

7. An inservice training program should be instituted for all teaching and administrative personnel to assure accurate and effective development and implementation of behaviorally oriented materials and programs.

8. The Systems Approach to the development of modules of instruction should be applied to all disciplines within the Culver City Unified School District.
THE NUCLEAR SCIENCE CURRICULUM PROJECT OVERVIEW

This document describes a list of defensible learner objectives deemed important if citizens are to function as informed participants with respect to developments involving nuclear science and society. The basis for selecting objectives was their contribution to the development within the learner, competencies and skills for dealing with issues of a personal and social nature involving the application of nuclear science and technology. Real-world problems which the nonscience oriented learner can be expected to face may be listed under the following categories: Consumer, Socio-political, Personal, and Vocational.

A list of objectives was identified so that developed competency skills would transcend the particular subject content selected for their attainment. Specific competency measures were then elaborated for each identified objective for the difficult task of assessment. Objectives and measures are intended to describe what the individual "does" and from this what he would "need-to-know" to achieve the identified terminal objective. Each of the various sections then constitutes a higher degree of specification toward attainment of each terminal behavior. Successful utilization of this product demands an understanding of the rationale and sequence of each of the sections.

Section one is called the Framework which identifies the higher order behaviors. It was developed to provide an overall matrix within which the knowledges, attitudes, and skills identified as need-to-know by the Project staff and consultants can be ordered. It should be noted that there are two columns: "Instructional Objectives Hierarchy" and "Criterion Test Measures." The Instructional Objectives Hierarchy is a breakdown of the behaviors leading to the terminal objective identified in the framework. The Criterion Test Measures in the right-hand column are the performance measures which determine the learner's mastery of the behaviors suggested by the instructional objectives hierarchy with a corresponding criterion test measure.

Section two, Social Issues Relevant to Nuclear Technology, is an example of the way each terminal behavior from the framework could be developed within a decision-making matrix. Terminal behavior no. 4.0 was used as a vehicle for this exemplification since it most obviously
attends to broader social issues relevant to nuclear technology and weaponry than the other three. The goal is the mastery of rational decision-making processes within the context of relevant social problems and not primarily the inculcation of data. In this section, too, the attempt was to match a process in the left-hand column with a test measure in the right-hand column at every level of the hierarchy.

Section three, Modules of Instruction, demonstrates how science and social science content and decision-making processes can be constructed into designed learning units from the universe of data as contained in section five of the product. The first module, designed for a science class, demonstrates the interrelationship and hierarchic structure of basic atomic information needed by learners to become involved in the later modules of instruction. It should be noted that the interrelatedness of the module includes all aspects—science data, behavioral objectives, test measures, degree of proficiency expected, and so forth. The intent was to develop a self-contained instructional unit with each element within the unit well integrated with all other elements. The second module, designed for a social studies class, exemplifies how decision-making processes may be developed in the context of a unit involving technology in society. Again, from the universe of social science data shown in the last section of the product, a selection was made regarding the impact of nuclear technology on American power needs. The structure of the unit, however, rests on the decision-making processes hierarchy, and the criterion test measures are primarily concerned with the mastery of the processes more than the factual content, although the content is not unimportant.

Section four, Behavioralized Science Data, is a more explicit breakdown of the basic science data into behavioral terms—behavioral objectives, stimulus cues, and criterion test measures. This section contains the basic repertoire of science data considered need-to-know by the Academic and Teacher Consultants. It is, in a sense, the universe of data to be utilized in the development of other learning hierarchies and sequences in science and social studies.

Section five, Background Content, is a compilation of the need-to-know content identified by the natural and social scientists as being relevant to the development of an understanding of the socio-scientific implications of technological innovation. The compilation of this data was derived as a result of analyzing the social implications of nuclear applications to such fields as medicine, agriculture, and industry, and the socio-political implications related to the application of technology to solutions of problems such as environmental control, conservation
of natural resources, and national security. Within the constraints of time, it was this body of content which formed the basis for the development of the experimental instructional modules included in the report and which would serve as resource material for the development of any further instructional modules.
RATIONALE FOR FRAMEWORK

As perceived by the Nuclear Science Curriculum Project staff, the ultimate goal of the project is to prepare the student to behave as a responsible citizen in relation to the growth and well-being of himself and his family and the advancement of society. These behaviors will manifest themselves in the following specific categories:

1. selecting and using products which have been treated or processed in some way by radiation when the selection and use of such products offer distinct benefits and advantages;

2. availing himself, when advisable, of radiation methods and processes for medical diagnosis and treatment;

3. seeking to prepare himself for a career in nuclear fields or related fields when such positions relate to his interests and hold promise for the achievement of his goals;

4. supporting actively, where evidence indicates the need and advisability, measures for the expansion, control, and use of nuclear technology in advancing the goals of society and national defense.

From these categories, four terminal behaviors were identified:

1.0 When deciding between the selection of products and/or services which involve nuclear radiation processes, the learner shall judge the products and services on individual merits, not allowing fear, bias, or misconception of radiation to enter into the judgment.

2.0 When faced with the possible need for exposure to radiation for diagnostic, therapeutic, or other purposes, the learner shall be able to understand the physician's preliminary evaluation for the risks and benefits involved.
When making vocational plans or selections, the learner shall consider nuclear science and associated fields on an equal basis, judging all occupations on the basis of their relationship to his interests, abilities and goals, not allowing bias, fear, or misconceptions about radiation to enter into the judgment.

The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

With the assistance of system analysts, each objective was broken down by the consultants into a hierarchical series of behaviors which are considered the most central manifestations of that objective. The hierarchically-arranged behaviors, instructional objectives, and criterion measures follow.
### Terminal Objective: 1.0

When deciding between the selection of products and/or services which involve nuclear radiation processes, the learner shall judge the products and services on individual merits, not allowing fear, bias, or misconceptions of radiation to enter into the judgment.

### Instructional Objectives Hierarchy

| 1.0 | When deciding between the selection of products and/or services which involve nuclear radiation processes, the learner shall judge the products and services on individual merits, not allowing fear, bias, or misconceptions of radiation to enter into the judgment. |

| 2.0 | Identify the situations below that you would avoid because of the danger involved. For those that you check, indicate why you would avoid them. |

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Wearing a wrist watch with a radium-dial</td>
</tr>
<tr>
<td>b.</td>
<td>Using a bowling ball that has been irradiated to give it added durability</td>
</tr>
<tr>
<td>c.</td>
<td>Eating a piece of meat that has been irradiated to make it possible to preserve it longer without refrigeration</td>
</tr>
<tr>
<td>d.</td>
<td>Using an X-ray machine in a shoe store to see if a pair of shoes fits you properly</td>
</tr>
<tr>
<td>e.</td>
<td>Eating fruit or grain that has been produced from seeds irradiated to improve a strain or to produce a new one</td>
</tr>
<tr>
<td>f.</td>
<td>Stirring your coffee with a plastic spoon that has been irradiated to give added strength</td>
</tr>
</tbody>
</table>
Terminal Objective: 2.0 When faced with the possible need for exposure to radiation for diagnostic, therapeutic, or other purposes, the learner shall be able to understand the physician's preliminary evaluation for the risks and benefits involved.

### Instructional Objectives Hierarchy

The learner shall:

| 2.1 | Identify some of the general types and uses of radiation techniques |

### Criterion Test Measures

Indicated by using the correct letter code whether or not the following situations can be (D) Diagnosed, (T) Treated, (B) Both, or (N) Not diagnosed or treated by radiation techniques.

- a. Broken bone
- b. Tuberculosis
- c. Thyroid condition
- d. Cancer of the lung
- e. Leukemia
- f. Diabetes

Match each of the following diagnoses and treatment techniques with the types of problems they can help solve.

- a. X-ray diagnosis
- b. Ingestion of a radioisotope
- c. External radiation from a radioisotope

| 1. Locating a spot on the lung |
| 2. Broken bones |
| 3. Thyroid condition |
| 4. Destruction of cancerous cells |
Indicate which of the following symptoms represent the danger signals of cancer:

1. a persistent, painless lump
2. a sore that doesn't heal normally
3. abnormal bleeding from any of the openings of the body
4. a change in color and/or size of a mole or wart
5. persistent indigestion
6. persistent hoarseness or cough
7. persistent change in the normal bowel habits
8. pain associated with an injury
9. persistent belching after a heavy meal
10. chronic sleeplessness
11. persistent twitching of a muscle
Instructional Objectives Hierarchy

<table>
<thead>
<tr>
<th>Objective</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td>Understand his physician's evaluation of his medical history to determine the number and type of prior exposure</td>
</tr>
</tbody>
</table>

Criterion Test Measures

Which statement best describes the need for your physician to know your medical history in regard to the amount of exposure to radiation you have experienced?

- **a.** Your doctor needs to know your history so that he can decide what setting to use on the X-ray machine to be able to get a "good picture." Different people, because of different densities of their tissue structure, require different degrees of X-ray penetration. Doctors keep records on these facts.

- **b.** The effects of radiation on body tissue may be cumulative. He needs to know your history of exposure in order to more accurately assess the relative need versus the risk involved.

- **c.** It is just good practice for a physician to know your medical history. There is no reason for him to be concerned about your particular history of exposure to radiation because if you need an X-ray you need it. He doesn't have much choice about whether or not to take it.

**True or False?**

- A chest X-ray is one of the best means for early detection of lung cancer, therefore, everyone should routinely receive a chest X-ray about once each month.
### Instructional Objectives Hierarchy

<table>
<thead>
<tr>
<th>Objective</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>Understand his physician's evaluation of the radiation processes for contributing to the solution of the problem</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Compare the uses of radiation techniques related to what needs to be done to determine the relative advantages of each</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Understand the dangers and benefits involved in the proposed techniques as identified by his physician and weigh them against the criticality of what needs to be done</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Discuss with his physician the need for consultation with specialists when the exposure constitutes a high level of hazard</td>
</tr>
</tbody>
</table>

### Criterion Test Measures

**What are the two basic factors you and your physician must consider in deciding between two courses of action, one involving radiation techniques, for diagnosing or treating a medical problem?**

- (the need, or the benefit to be gained)
- (the risks involved)

**If a radiation treatment or diagnosis proposed by your doctor represents a high degree of hazard to you:**

(Check the statement below that in your opinion best completes the statement above)

- a. I should accept his judgment unquestioningly since he is qualified to make such decisions.
- b. I should tell him I'll decide later and then go to another doctor to get a second evaluation.
- c. I should ask him about the advisability of consulting with another qualified physician to get an independent verification of his proposal.

**Are the following statements true or false?**

- a. The yellow pages of the telephone book is a good source of names of qualified physicians who can be relied upon.
- b. The government exerts sufficient control over radiation techniques that I don't have to worry about being treated by a quack or a registered physician who is not sufficiently skilled in the use of the techniques.
Terminal Objective: 3.0 When making vocational plans or selections, the learner shall consider nuclear science and associated fields on an equal basis, judging all occupations on the basis of their relationship to his interests, abilities and goals, not allowing bias, fear, or misconceptions about radiation to enter into the judgment.

<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>The learner shall:</td>
<td>True or False:</td>
</tr>
<tr>
<td>3.1 identify employment opportunities and trends within nuclear science fields and related occupations;</td>
<td>a. Job opportunities in nuclear science fields will increase rapidly over the next 10-20 years as new generating and desalinization plants, and the like, are built. They will then level out as enough plants are built and the occupations are saturated with workers.</td>
</tr>
<tr>
<td>3.2 Identify educational or training requirements within nuclear science fields and related occupations;</td>
<td>b. Occupations in the nuclear science fields are not limited to professional and semi-professional (technical) jobs. There will be places for skilled and semi-skilled workers as well.</td>
</tr>
<tr>
<td>3.3 evaluate occupational environment and job requirements and characteristics within nuclear science fields and related occupations;</td>
<td>c. Because of the highly technical nature of nuclear science occupations and the need for highly intelligent workers, jobs in these occupations will require a minimum of four years of college and a very critical screening of applicants.</td>
</tr>
<tr>
<td>3.4 match occupational requirements and characteristics with his own interests, abilities and goals.</td>
<td></td>
</tr>
</tbody>
</table>

Work in a nuclear power generating plant is less desirable than the same kind of work in a conventional plant because:

a. The working conditions would be dirtier

b. The physical dangers would be greater because of radiation
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicate which of the sources in Column II you would go to for the kind of information listed in Column I. List only the best sources.</td>
<td>Column II</td>
</tr>
<tr>
<td>Column I</td>
<td>1. Dictionary of Occupational Titles</td>
</tr>
<tr>
<td>a. Indications of the trends in occupational opportunities in nuclear science fields</td>
<td>2. Your local newspaper</td>
</tr>
<tr>
<td>b. Information on the specific kinds of jobs available in nuclear science in your area</td>
<td>3. State employment offices</td>
</tr>
<tr>
<td>c. Specific information about the amount of education and/or training required to qualify for a specific kind of job</td>
<td>4. Private employment agencies</td>
</tr>
<tr>
<td>d. Knowledge of the physical qualifications for a specific kind of job</td>
<td>5. The company employment office where the job is located</td>
</tr>
<tr>
<td>e. Knowledge about the working conditions under which a specific job is performed</td>
<td>6. Interview with someone in the field</td>
</tr>
<tr>
<td>f. Information about the safety measures employed to protect the worker</td>
<td>7. Government publications on the specific application of the technology</td>
</tr>
<tr>
<td>g. Information about the rate of pay for work in a nuclear science job as compared to the same kind of job in a non-nuclear occupation</td>
<td>8. Visit to the type of facility in which employment is contemplated</td>
</tr>
</tbody>
</table>
Instructional Objectives Hierarchy

Terminal Objective: 4.0

The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

Criterion Test Measures

The learner shall:

4.1
seek and evaluate materials pertinent to the particular issue, problem, or proposal;

4.1.1
locate sources of information from both producers and distributors.

Given (in Column I) the issue above, as well as two other issues (not related to the community) that the learner has given their support to the action group.

The problem is described below, along with the criteria established in the learning experiences.

Problem: A community organization called "Operation Poison Food" has been organized to prevent the use of foods which have been pasteurized by irradiation processes given free by the federal government in the public school lunch program. The group argues that the foods are dangerous because those who eat it could be irradiated, thus resulting in cancer, irritations, and other serious debilities. The group claims that the foods are dangerous because those who eat it could be irradiated, thus resulting in cancer, irritations, and other serious debilities.

The learner shall seek out authoritative, reliable, and relevant data on the basis of the criteria established in the community newspaper outlining the purported dangers.

When given the community problem described below, the learner shall seek out our sources of information.

Criterion Test Measures

Criterion: 2.1
Development and/or use of nuclear technology.

4.0
The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiatives of himself in regard to the development and/or use of nuclear technology. The learner shall seek out authoritative, reliable, and relevant data on the basis of the criteria established in the learning experiences.

Criterion: 2.1
Development and/or use of nuclear technology.

4.0
The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiatives of himself in regard to the development and/or use of nuclear technology. The learner shall seek out authoritative, reliable, and relevant data on the basis of the criteria established in the learning experiences.
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Column I</strong></td>
<td><strong>Column II</strong></td>
</tr>
<tr>
<td>b. Resumption of atmospheric testing of nuclear bombs</td>
<td>2. American Nuclear Society</td>
</tr>
<tr>
<td>c. Use of irradiated foods</td>
<td>3. Department of Agriculture</td>
</tr>
<tr>
<td></td>
<td>4. Department of Defense</td>
</tr>
<tr>
<td></td>
<td>5. Electric Energy Institute</td>
</tr>
<tr>
<td></td>
<td>6. University nuclear biologist</td>
</tr>
<tr>
<td></td>
<td>7. Local physician specializing in radiology</td>
</tr>
<tr>
<td></td>
<td>8. OPF newsletter</td>
</tr>
<tr>
<td></td>
<td>9. Local newspaper</td>
</tr>
</tbody>
</table>
The learner will then categorize each of the information sources in Column II into technical, nontechnical, public and private groupings. He will then select the three best sources (AEC, Dept. of Agriculture, and university nuclear biologists or radiologists).

The learner shall state from each source the degree of vested interest and therefore the influence of his opinion relative to the given issue and the reason they would do so. This will help him match the agency which would have the greatest interest in influencing him to the point of view. From the following list the learner shall match the agency which would have the greatest interest in influencing his opinion relative to the given issue and the reason they would do so.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.E.C.</td>
<td>Profits</td>
</tr>
<tr>
<td>E.E.I.</td>
<td>Patriotism</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
</tr>
<tr>
<td>Agancy</td>
<td>Profits</td>
</tr>
</tbody>
</table>

The criterion test measures for each type of information in Column I, from which the learner will indicate, for each type of information in Column II, the source(s) listed in Column II he would most likely find it. Variety of sources from a variety of governmental, corporate, private non-profit agencies, and publications.

Fluence his opinions?

- Chilling governmental organizations
- Chilling non-governmental organizations
- Influence several organizations
- Influence several groups

The learner will then determine each of the information sources from each type of information in Column II into which he would acquire the materials from a.

Institutional Objectives Hierarchy

Criterion Test Measures
## Instructional Objectives Hierarchy

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Facts about irradiated foods</td>
<td>1. Atomic Energy Commission</td>
</tr>
<tr>
<td>b. Fallacies about irradiated foods</td>
<td>2. Department of Agriculture</td>
</tr>
<tr>
<td>c. Arguments for the use of food in schools</td>
<td>3. Department of Defense</td>
</tr>
<tr>
<td>d. Arguments against the use of food in schools</td>
<td>4. Local newspapers</td>
</tr>
<tr>
<td>e. Facts about radiation hazards and controls</td>
<td>5. Newsletter of OPF</td>
</tr>
<tr>
<td></td>
<td>6. Available nuclear physicist</td>
</tr>
<tr>
<td></td>
<td>7. Textbook on radiation</td>
</tr>
<tr>
<td></td>
<td>8. School authorities who accepted government offer</td>
</tr>
<tr>
<td></td>
<td>9. Local librarian</td>
</tr>
</tbody>
</table>

List in order of the degree issues of authoritativness, given the indicated issue, of the following.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Authorities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>3.</td>
</tr>
</tbody>
</table>
Instructional Objectives Hierarchy

Criterion Test Measures

4.1.2.1 know where information from each source is located or how it is to be acquired;
4.1.2.2 know the procedures for acquiring the information;
4.1.3 judge the materials for authority, reliability and relevance to the issue under consideration;
4.1.3.1 evaluate the authoritative sources that:
   a. it varies with training and experience;
   b. it varies with personal and institutional goals and interests (i.e., vested interests);
4.1.3.2.1 evaluate the authoritative sources and/or spokesmen known:
   a. Written by those who stood to gain something by the acceptance or rejection of the proposal to use irradiated foods in the schools;
   b. Written by those who feel are truthful, honest, well-known, political, (labor, business, religious, etc.), leaders;
   c. Written by well-trained, experienced personnel;
4.1.3.2.2.1 isolate and list separately from the following list the characteristics of an authoritative source:
4.1.3.2.2.2.1 the learner will then list and apply the criteria for judging the reliability, authority, and relevance of acquired materials to the issue at hand;
4.1.3.2.2.2.2 though multiple techniques may be used, the learner will only be allowed to select one acquiring technique for each source, even:
   a. Library procedures;
   b. Letters writing;
   c. News articles;
4.1.3.2.2.2.3 the learner will then describe, by labeling each source, the means by which he would acquire the information from the following selections:
   a. Interview of pro, con, and neutral people;
   b. Letter writing;
   c. News articles;
4.1.3.2.2.2.4 source is located or how it is to be acquired;
   a. Written by well-trained, experienced personnel;
   b. It varies with personal and institutional goals and interests (i.e., vested interests);
4.1.3.2.2.2.5 the learner will then describe, by labeling each source, the means by which he would acquire the information from the following selections:
   a. Written by well-trained, experienced personnel;
   b. It varies with personal and institutional goals and interests (i.e., vested interests);
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. an authority in one field may not be an authority in another. In those cases where an authority is speaking or writing out of his field what he is commenting on must be analyzed closely to determine its accuracy for the subject or the degree of manipulation he intends by posing as an authority;</td>
<td>d. Written by those with nothing to gain by the acceptance of the proposal</td>
</tr>
<tr>
<td></td>
<td>e. Written by well-known experts in other fields not directly related to radiation science (scientists, business men, labor leaders, government officials, etc.), but who are vitally concerned with the issue</td>
</tr>
<tr>
<td></td>
<td>f. Written by a college professor expert in radiation science</td>
</tr>
<tr>
<td></td>
<td>g. Written by the local doctor who heads OPF</td>
</tr>
<tr>
<td></td>
<td>h. Written by a government expert on radiation.</td>
</tr>
<tr>
<td>He will then separate the sources into three categories determined by the degree of authoritativeness from the most disinterested (a, d, and b), somewhat interested (b and r) to those most interested (c, e, and g).</td>
<td></td>
</tr>
<tr>
<td>He will list the criteria for reliability, and discriminate between reliable and less reliable authoritative sources previously identified.</td>
<td></td>
</tr>
<tr>
<td>He will isolate and list separately from the following list the criteria for reliability a. Lacks factual evidence but is logical in argument</td>
<td></td>
</tr>
<tr>
<td>b. Feels as if it is the correct answer</td>
<td></td>
</tr>
<tr>
<td>c. Supports the position of the community leaders</td>
<td></td>
</tr>
<tr>
<td>d. Is technical and factual</td>
<td>e. Is written by a reputable scholar working for the government.</td>
</tr>
</tbody>
</table>
Given the three synopses of the articles below, with their sources identified, the learner will rate (A), (B), (C), those which are most to least relevant and needed.

<table>
<thead>
<tr>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>f. Letter to parents from the superintendent of schools</td>
</tr>
<tr>
<td>e. Newsletter from OPF</td>
</tr>
<tr>
<td>d. Booklet and technical papers prepared by special staff of the Department of Agriculture</td>
</tr>
<tr>
<td>c. Booklet prepared by the Atomic Energy Commission</td>
</tr>
<tr>
<td>b. Scientific American</td>
</tr>
<tr>
<td>a. Local newspaper article by the chairman of OPF</td>
</tr>
</tbody>
</table>

He labels (A) for Authoritative or (U) for Unauthoritative or suspect for the following:

- f. Is written by an unknown working for the Atomic Energy Commission
- i. Is written by a local minister (mayor, prince, etc.)
- h. Is written by a scholar working in the radiation science department
- g. Is an editorial
- f. Is written by an expert from the food company which will supply the food

In summary, the hierarchical structure of instructional objectives:

- Criterion Test Measures
- Instructional Objectives Hierarchy
Instructional Objectives Hierarchy

Criterion Test Measures

Article I: Scientific American, "Pasteurization and Sterilization of Food Items Through Irradiation"
This article explains the simple processes used to irradiate food, dosages required to pasteurize and sterilize; where irradiation is used in other industries; and the results of several experiments.

Article II: Atomic Energy Commission, "Nuclear Science and Life"
This article explains general uses of nuclear science and some of its applications for mankind's future.

Article III: Bulletin of Atomic Scientists, "Radiation Techniques"
This article explains the use of radiation in tracer technology; measuring; food and other consumer products improvement; and similar uses.

Given the three positions below regarding the issue, the learner will critique each in light of the evidence gathered from authoritative sources. He will identify by labeling each as (A) incomplete factually, (B) depends too heavily on biased or emotional material, or (C) ignores evidence for ideological reasons; and states the reason for his choice.

Position I: "If God meant man to have these new-fangled ways, he would have automatically provided us with them. This 'thing' they want to put in our schools is the work of the devil and is obviously one more attempt of the progressive educators to ruin our children."
Position II: "The use of irradiated food will cause cancer, cell mutations, and other horrible diseases too terrible to even mention. Our children must not be exposed to this danger. The Mayor, Reverend Jones, and Mr. Daily of our newspaper, and other leaders of OPF have clearly identified the danger. It is up to us to prevent it."

Position III: "I'm not sure whether I want the food used in school or not. I have heard that using the food could cause my son to have cancer and I certainly don't want that. I also know that at work they use some sort of radiation to find leaks in the oil pipes, but | will [Handwritten: I] want to support the use of irradiated food on the basis that the schools and government would not allow anything bad to happen."

Choice I: Support the use of irradiated food on the basis that the schools and government would not allow anything bad to happen.

Choice II: Oppose the use of irradiated food because of the dangers involved and the emotionality, tested interest, and preconceived assumptions.

The learner is required to change set. He will finally critique each position, including his own, on the basis of data sufficiency, emotionality, tested interest, and premise.

This is a role-playing situation in which the learner directly its own position. The learner will first support one, then the other, or both factual and emotional grounds. He will also outline the entire situation in which the issue is presented.

Given the three choices of action below regarding the issue, the learner will first support one, then the other, on both factual and emotional grounds. He will also outline the entire situation in which the issue is presented.
### Instructional Objectives Hierarchy

<table>
<thead>
<tr>
<th>4.1.4</th>
<th>form tentative conclusions on the basis of the data gathered regarding the issue, problem, or proposal;</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.4.1</td>
<td>resist external pressure—political psychological, propagandistic, etc.—which may preclude further investigation;</td>
</tr>
<tr>
<td>4.1.4.2</td>
<td>realize that limited data may have been collected which may not give a complete picture;</td>
</tr>
<tr>
<td>4.1.4.3</td>
<td>realize that all sides of the issue may not have been identified or explored;</td>
</tr>
</tbody>
</table>

### Criterion Test Measures

**Choice III:** Neither support nor oppose the proposal to use irradiated food because what is known about the horror of atomic weapons and radiation from them makes the OPF's evidence seem valid enough, but the school and government people supporting the idea couldn't really do anything to hurt the children. Let others decide.

**Choice IV:** The learner's own outline.

The learner will evaluate the conclusions of three community leaders below regarding the issue of irradiated food in the schools on the basis of their authoritativeness, reliability, and relevancy of their arguments regarding the issue. He will identify the weaknesses of each argument on the basis of their (A) not being able to resist external pressure from influential figures, (B) not including, ignoring or not knowing relevant data, and (C) not allowing for relevant arguments from the opposition. He will then state his own tentative conclusion regarding the issue.

**Conclusion I:** We must allow the schools to use irradiated foods and forget the fear-mongering argument of the OPF. I have personally talked to our superintendent, who said that he is not worried at all about the food—and he has a child of his own in school. I also heard that the government was involved, and I'm sure the President and my Congressman wouldn't let anything happen. Besides, those guys in OPF are crackpots who really don't care about the issue at all but just want their names in the paper.
Given the proposition below for solving the problem upon which he might potentially vote, the learner will compare the proposed advantages and disadvantages and determine the potential social dislocations which might result. The learner will recognize irrational arguments regarding the proposition by comparing fact and fallacy. He/she will then formulate a course of action.

4.2 
Given the proposition below for solving the problem upon which he might potentially vote, the learner will compare the proposed advantages and disadvantages and determine the potential social dislocations which might result. The learner will recognize irrational arguments regarding the proposition by comparing fact and fallacy. He/she will then formulate a course of action.

Conclusion II: I know for sure that this attempt to put irradiated food in our schools is a trick of anti-religious, communist-type people who are trying to influence our children's minds. OPF has issued a fact sheet which stated these factors: people in Japan are still dying from radiation let out by the atomic bomb; scientists working with reactors wear little badges that tell them when to get away before they set irradiated; genes in hamsters have been destroyed by radiation; and so on. The evidence is clear and can only make one come to this conclusion: Keep that dangerous food away from our children.

Conclusion III: There is no question that we are making great strides forward in science—look at the radio, the auto, the airplane, a computer—but all of these scientific gains were developed slowly, carefully, and with due consideration of people's lives and health. The scheme to give our kids irradiated food does not take these same things into consideration. So, I'm against progress, but neither do I want to be a guinea pig. I read in the newspaper that more radiation would be used on the food than on X-ray machines, and my doctor once warned Bruce about getting too many X-rays. These school people who told us about the food being absolutely safe and delicious possibly radiate our kids lensed front door X-rays. The school people who told us about the food being absolutely safe and delicious possibly radiate our kids lensed front door X-rays. I want to be a guinea pig. I read in the newspaper that more radiation would be used on the food than on X-ray machines, and my doctor once warned Bruce about getting too many X-rays. These school people who told us about the food being absolutely safe and delicious possibly radiate our kids lensed front door X-rays. I want to be a guinea pig. I read in the newspaper that more radiation would be used on the food than on X-ray machines, and my doctor once warned Bruce about getting too many X-rays. These school people who told us about the food being absolutely safe and delicious possibly radiate our kids lensed front door X-rays.

Conclusion III: I know for sure that this attempt to put irradiated food in our schools is a trick of anti-religious, communist-type people who are trying to influence our children's minds. OPF has issued a fact sheet which stated these factors: people in Japan are still dying from radiation let out by the atomic bomb; scientists working with reactors wear little badges that tell them when to get away before they set irradiated; genes in hamsters have been destroyed by radiation; and so on. The evidence is clear and can only make one come to this conclusion: Keep that dangerous food away from our children.
Proposition for Resolving the Poison Food Scheme for Our Schools.  
Public Vote Asked For.

The members and officials of Operation Poison Food which was organized to prevent the use of dangerous irradiated food in our schools, now ask for a decision from the people. We are sure when you read the facts below that you will support us. We oppose the use of irradiated foods for the following reasons:

a. Radiation is not well understood, and is dangerous to life and health. By allowing our children to eat such food we are exposing them to cancer, mutation, and other debilities.

b. It will bring more governmental control over local affairs from both the state and federal levels.

c. Economically, no benefit can come from using foods or products which have been irradiated; as a matter of fact, it may actually hurt economic development.

d. Finally, we feel that the way we want to live and the things we want our children to know should not be dictated by outsiders, or the so-called "professional educator"; or schools should do what we want them to.
4.2.1 determine the potential dangers or benefits to life and property.

4.2.1.1 categorize the stated dangers of the issue, problem, or proposal and match them against the data collected.

Given the following list of notions regarding the utilization of irradiated foods and products, the learner will (A) separate out those factors which demonstrate the utility of radiation techniques in improving quality and quantity of food and products; (B) separate out the fallacies connected with the use of radiation to process food and products, and match them with the factual evidence which demonstrates their fallaciousness; and (C) compare the safety factor of radiation techniques with other technological advances.

Facts and Fallacies (Regarding Agricultural and Industrial Uses of Radiation)

- Radiated products continue to be radioactive and can irradiate people eating or using them.
- Radiated food can have some discoloring.
- Radiation can only be used to harm or kill, and not for socially productive ends.
- Radiated food can have some discoloring.
- Radiation of certain seeds and vegetables can improve their quality and quantity through controlled mutations.
- Radiation of foods can kill entirely or reduce significantly the disease-causing germs in them.
- Radiation of some products increases their strength.
- Radiation can only be used to harm or kill, and not for socially productive ends.
- Radiation of irradiated foods and products continues to be radioactive and can irradiate people eating them.
- Radiation can be used to control weeds and insects harmful to agriculture.
- Radiation can be used to control weeds and insects harmful to agriculture.
- Radiation can be used to control weeds and insects harmful to agriculture.
- Radiation of certain seeds and vegetables can improve their quality and quantity through controlled mutations.
- Radiation of foods can kill entirely or reduce significantly the disease-causing germs in them.
- Radiation of some products increases their strength.
- Radiation can only be used to harm or kill, and not for socially productive ends.
- Radiated food can have some discoloring.
- Radiation of irradiated foods and products continues to be radioactive and can irradiate people eating them.
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- Radiation of foods can kill entirely or reduce significantly the disease-causing germs in them.
- Radiation of some products increases their strength.
- Radiation can only be used to harm or kill, and not for socially productive ends.
- Radiated food can have some discoloring.
Instructional Objectives Hierarchy

| 4.2.1.2 categorize the stated benefits and match them against the data collected; |

Criterion Test Measures

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>i.</td>
<td>Radiation techniques can be employed by industry to measure thickness of products and wear spots.</td>
</tr>
<tr>
<td>j.</td>
<td>Eating or using foods or products processed by radiation techniques will cause harmful mutations.</td>
</tr>
<tr>
<td>k.</td>
<td>Radiation is never dangerous.</td>
</tr>
</tbody>
</table>

**Fallacies**

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Radiated Products continue to be radioactive.</td>
</tr>
<tr>
<td>2.</td>
<td>Radiation is only used to harm and kill.</td>
</tr>
<tr>
<td>3.</td>
<td>Use of radiation to process food and products is the same as an X-ray.</td>
</tr>
<tr>
<td>4.</td>
<td>Eating or using foods or products processed by radiation will cause mutations.</td>
</tr>
<tr>
<td>5.</td>
<td>Radiation is never dangerous.</td>
</tr>
</tbody>
</table>

**Truth**

<p>| | |</p>
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>1 (1)</td>
<td>Food and products never become radioactive due to the techniques employed.</td>
</tr>
<tr>
<td>2 (2)</td>
<td>Radiation cures disease, has tracer and isotopic uses, and accomplishes many socially useful purposes.</td>
</tr>
<tr>
<td>3 (3)</td>
<td>Different types of radiation sources are used to process food and products.</td>
</tr>
<tr>
<td>4 (4)</td>
<td>Since the foods and products are not radioactive, they cannot cause mutations.</td>
</tr>
<tr>
<td>5 (5)</td>
<td>Continued exposure to radiation sources, not irradiated foods or products, can cause severe damage and even death.</td>
</tr>
</tbody>
</table>
determine the potential costs social, economic, political of the issue, problem, or proposal in comparison with current practices, and make a decision to act; the learner will state in writing how the utilization of radiation techniques will affect social, political, and economic life in his community, and compare this with traditional ways, which will include at least the following points:

a. Political effects: Government control and regulation of safety factors in processing plants tends to grant more decision-making prerogatives to state and federal governments at the expense of local businesses, but this intrusion of government can be accepted, when balanced against the need to protect life and property.

b. Economic effects: Industrial and agricultural uses of radiation techniques are varied and great: tracers, ionizing processes, gauging, weed and insect control, new plant species evolved, and similar examples demonstrate that not only are there diverse uses for radiation techniques, but that the techniques improve the quality and quantity of the food and products we use.

c. Social effects: The use of radiation techniques by industry and agriculture produce goods that will be found in every household in America. Plastic goods that have been hardened through radiation are now found in supermarkets. Gasoline, which has minute amounts of radioactive isotopes in it, is found in gasoline stations. Irradiated foods will last, in sealed packages, for long periods of time, and need no refrigeration. Irradiated foods are not found in large quantities in markets, but the government is sponsoring huge experiments. Irradiated foods will be found in every household in America. Plastic products are being used extensively in industry and agriculture.

in the issue, problem, or proposal—social, economic, political—of 4.2.2 determine the potential costs—
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.2.1 compare the relative cost of change with the established pattern and or procedure;</td>
<td>Other products so processed are also in use. What is happening to society as a result of this is largely unrecognized by them, but it has already produced foods and products of better quality, in more quantity, and quickly. Cost will come down. Health will improve. Insects will be controlled.</td>
</tr>
<tr>
<td>4.2.3 know the comparative statistics between other technological inventions or innovations now generally accepted as both necessary and worthwhile (e.g., the auto) and nuclear science developments;</td>
<td>The learner will compare the advantages of irradiated food with traditionally preserved food being used in his school presently, including the following advantages: longer lasting, germ free, greater variety. Then he will compare the cost of change, and conclude that the use of irradiated foods and products decreases the costs of production.</td>
</tr>
<tr>
<td></td>
<td>The learner will be given statistical evidence of deaths from autos, trains, and planes in the last twenty years, along with the same statistics for employment of radiation, including experimental use. He will construct a graph to show statistical comparisons and: (A) State in writing why the statistical information is unfair; (B) Identify how governmental controls and regulations in all categories have improved their safety; and (C) Draw the conclusion that controlled radiation techniques, utilized food and product processing, are just as safe, if not safer, than other now-accepted technological innovations.</td>
</tr>
<tr>
<td></td>
<td>The learner will describe in writing the typical techniques used in industry and agriculture, and give at least one example of their applications; included must be information about radioisotopes, gauging, radiography, and tracers.</td>
</tr>
</tbody>
</table>
4.2.3.1 The learner will evaluate the impact of the issue, problem, or proposal on the social aspects of our culture (how will it affect people and institutions) and the degree to which the change will interface with other elements of the society.

The learner will select from the following list those kinds of industries, now or potentially utilizing radiation techniques as part of their processing procedures:

- Food storage industry
- Fishing industry
- Oil industry
- Plastics industry
- Farming industry
- Pipe industry
- Fishing industry

The learner will select and categorize from the following list those applications of radioisotopes under the headings: Tracers, Radiation Affects Materials, Materials Affect Radiation, and Radiation Has Energy:

- Flow measure
- Catalysis
- Fiber modification
- Power source
- Density gauges
- Radioisotopes

Institutional Objectives Hierarchy

Criterion Test Measures
4.3 compare the proposed with appropriate historical analogies relative to technological innovation and their impact as well as present trends in social, political, and economic areas as they are affected by technological change;

4.3.1 decide a course of action by determining the answers to the following questions:

a. How serious is the situation (what is the need)?
b. What alternatives are open?
c. What authorities support or oppose the issue, problem, or proposal?
d. What position does the evidence support?

The learner will analyze emotional and irrational responses to technological innovations by comparing the attitudes, misconceptions, and emotionalism of OPF with the reaction to the introduction of textile machinery in England in the early 19th century (i.e., the Luddite reaction).

The learner will collect and label all positive and negative statements and facts regarding the use of irradiated foods in the school, compare them with the empirical evidence, and then answer the questions below:

a. Why change the present system?
b. What happens if just refrigerators are used?
c. What objective authorities support or oppose the change?
d. What do the objective facts demonstrate regarding the supporting and opposing arguments?

The learner will then make a written summary of his position which demonstrates: (A) Disassociation from fallacies; (B) Dependency on facts; (C) Willingness to withhold judgement; (D) Recognition of emotions and propagandistic appeals; and (E) A decision as to his own personal involvement to effect a decision.
After the learner has completed the instructional sequence presented above, he will then be presented with an entirely different social issue involving technological innovation (nuclear or non-nuclear). He will be required to follow the same processes he mastered in investigating the issue in the learning design. Criteria for judging learner performance are the same as those identified in the materials above. (In this segment the instructor is given greater options and decision making.)
SOCIAL ISSUES RELEVANT TO NUCLEAR TECHNOLOGY
ELECTRIC POWER AND NUCLEAR ENERGY
Terminal Objective: 4.0 The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

Instructional Objectives Hierarchy

The learner shall:

4. seek and evaluate materials pertinent to the particular issue, problem, or proposal;

Criterion Test Measures

When given the two proposals below, regarding an issue on nuclear technology (the building of a nuclear reactor in his community and the reintroduction of nuclear bomb testing, in this example), the learner shall seek out authoritative, reliable, and relevant data on the basis of the criteria established in the learning experiences.

Nuclear Power Plant

Proposal 1. Nuclear power plants are dangerous and unnecessary. They are dangerous because they could explode like an atomic bomb and kill millions of people. They could emit radiation throughout the community and all would die unknowingly. They are unnecessary because, since the old ways have worked for us up to now, they will continue to work. Therefore, do not allow one to be built.

Proposal 2. Nuclear power plants are both necessary and not dangerous. Federal and state controls make reactor plants safer than other power generating plants. There have been no major accidents involving the atomic aspects of power production. Additionally, traditional fuels are running out while our need for power expands. Nuclear power will supply limitless power for all time. Therefore, build the power plant.
### Instructional Objectives Hierarchy

<table>
<thead>
<tr>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candidate for a Peace Policy</td>
</tr>
<tr>
<td>3. Resumption of Atmospheric Test Measures</td>
</tr>
<tr>
<td>2. American Nuclear Society</td>
</tr>
<tr>
<td>4. Committee for a Sane Nuclear Policy</td>
</tr>
</tbody>
</table>

### Criterion Test Measures

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Construction of a nuclear reactor in the community</td>
<td>1. Atomic Energy Commission</td>
</tr>
<tr>
<td>b. Resumption of atmospheric testing</td>
<td>2. American Nuclear Society</td>
</tr>
<tr>
<td></td>
<td>3. Committee for a Sane Nuclear Policy</td>
</tr>
</tbody>
</table>

#### Proposal 1

The enemy is secretly testing weapons in the air (probably outer space) and is building up his arsenal with super atomic weapons.

If the USA is to continue and deter the enemy, it is necessary for us to start testing. We can get a clean bomb and thereby reduce air pollution, at the same time we build super weapons for our self-defense.

Thus, proposal 1. Atmospheric testing will produce fewer casualties and thereby reduce air pollution, at the same time we build super weapons for our self-defense.

Proposal 2

Atmospheric testing will produce evolutionary damage to human, animal, and plant life, which will not only cause death, disease, and mutation to future generations as well. There is not scientific evidence that the enemy has already started testing—our equipment would tell us. The dangers involved in testing are therefore greater than in not testing.

Thus, proposal 2. Don’t start testing again.

#### Column Sources of Information from both producers and distributors of information

- 4.1.1 locate sources of information
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.1.1</td>
<td>Column I</td>
</tr>
<tr>
<td>realize that information is pro-</td>
<td>4. Woman's Strike for Peace</td>
</tr>
<tr>
<td>duced which is technical or non-</td>
<td>5. Defense Department</td>
</tr>
<tr>
<td>technical, and that several or-</td>
<td>6. John Birch Society</td>
</tr>
<tr>
<td>ganizations, including govern-</td>
<td>7. Local Power Company</td>
</tr>
<tr>
<td>mental organizations, may be</td>
<td>8. Department of Agriculture</td>
</tr>
<tr>
<td>attempting to influence his</td>
<td>9. International Atomic Energy Agency</td>
</tr>
<tr>
<td>opinions;</td>
<td></td>
</tr>
</tbody>
</table>

The learner will then categorize each of the information sources in Column II into technical, non-technical, public and private groupings. He will then select four sources, which he prejudges will be most useful, from each category.
### Instructional Objectives Hierarchy

**Criterion Test Measures**

| 4.1.1.2 | know the major sources of information from governmental, private non-profit agencies, private profit agencies, and publications; |
| 4.1.2.1 | know where information from each source is located, or how it is to be acquired; |
| 4.1.2.2 | know the procedures for acquiring the information; |

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Need for reactor testing</td>
<td>1. Newspaper</td>
</tr>
<tr>
<td>b. No need for reactor testing</td>
<td>2. AEC</td>
</tr>
<tr>
<td>c. Need for atmospheric testing</td>
<td>3. Department of Defense</td>
</tr>
<tr>
<td>d. No need for atmospheric testing</td>
<td>4. Department of Agriculture</td>
</tr>
</tbody>
</table>

The learner indicates, for each type of information listed in the first column, where he would most likely acquire it.
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3 judge the materials for authority, reliability and relevance to the issue under consideration;</td>
<td>The learner will then describe, for each potential source, the way he would acquire it from the following selection: interviews, letter writing, news articles, library procedures. He will only be allowed to select one technique for each source, even though many techniques may be used.</td>
</tr>
<tr>
<td>4.1.3.1 evaluate the authoritativeness of the sources and/or spokesmen; know that</td>
<td>The learner will list and apply criteria for judging the reliability, authority, and relevance of the acquired materials to the issues at hand.</td>
</tr>
<tr>
<td>a. it varies with training and experience;</td>
<td>He will isolate and order, from the following list, those characteristics of authoritative sources:</td>
</tr>
<tr>
<td>b. it varies with personal and institutional goals and interests (i.e., vested interests);</td>
<td>a. Written by well-trained, experienced personnel</td>
</tr>
<tr>
<td>c. an authority in one field may not be an authority in another, and that in such cases where an authority is speaking or writing out of his</td>
<td>b. Written by those he feels are truthful, honest, known, political (business, labor, religious, etc.) leaders</td>
</tr>
<tr>
<td></td>
<td>c. Written by those who stand to gain something by the acceptance or rejection of their position by the public</td>
</tr>
<tr>
<td></td>
<td>d. Written by the most disinterested</td>
</tr>
<tr>
<td></td>
<td>e. Written by experts in related fields who are scientists (businessmen, politicians, labor leaders, etc.), but are not, directly, expert in the field</td>
</tr>
<tr>
<td></td>
<td>f. Written by college professors expert in technical field</td>
</tr>
<tr>
<td></td>
<td>g. Others to be added</td>
</tr>
</tbody>
</table>
a.
identify fallacies and

look for adequate detail
and specificity;

d.

c.

look for bias and vested
interest;

popularizations and/or
argumentative sources;

distinguish between technical information and

emotionalism;

b.

to

sources and/or spokesmen; know

evaluates the reliability of the

authority;

curacy for the subject or the
degree of manipulation he
intends by posing as an

field, that what he is commenting on must be analyzed
closely to determine its ac-

Instructional Objectives Hierarchy

4.1.3.2

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Criterion Test Measures

He will separate the sources into three categories, determined by the degree of
authoritativeness.

d.

c.

b.

a.

Is written by a reputable scholar working for the government;

Is technical and factual;

Supports America's position;

Feels as if it is the correct answer;

Lacks factual basis but is logical in argument;

He will isolate and order, from the following list, the criteria for reliability:

e.

Is written by expert from power company as an editorial;

Others to be added.

Is written by a technical scholar working for a university;

f.
9h.

He will list the criteria for reliability and will be able to discriminate between
the reliable and less reliable authoritative sources listed in Column II for each
of the issues in Column I.


4.1.3.3 evaluate the relevancy of the information, sources or spokesmen
   a. determine that the information is really pertinent to the issue, problem or proposal;
   b. avoid making premature or incorrect generalizations;
   c. change set to identify his own biases;

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Community reactor</td>
<td>1. Local newspaper</td>
</tr>
<tr>
<td>b. Nuclear testing</td>
<td>2. Scientific American</td>
</tr>
<tr>
<td></td>
<td>3. Bulletin of Atomic Scientists</td>
</tr>
<tr>
<td></td>
<td>4. Newsletter from those opposing the issue</td>
</tr>
<tr>
<td></td>
<td>5. Newsletter from those supporting the issue</td>
</tr>
<tr>
<td></td>
<td>6. Others to be added</td>
</tr>
</tbody>
</table>

Given four synopses of articles, with their sources identified, the learner will select those which have the most relevancy, in terms of the given issues, for his decision-making responsibilities. The synopses should be: one on general science, one on the technical aspects of a nuclear reactor, one on the pros and cons of nuclear reactors, and one overtly propagandistic (or any other set of synopses that will allow contrast between those with too little, too much or too biased information).

Nuclear Power Plants

Synopsis 1 - *In Life*, "Science and Man"

Describes the effect of science on man's life and institutions and makes a few comments on atomic energy and weapons.
<table>
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<tbody>
<tr>
<td>Describes uses of the atom in industry and agriculture. Begins with one paragraph.</td>
<td>Describes community opposition to prevent its being built.</td>
</tr>
</tbody>
</table>

### Health

**Synopsis 4 - Daily Gazette (community newspaper), "Let's Keep Our Community Healthy"**

- Describes the disadvantages of nuclear power plants, and includes most of the proposed dangers:
  - They can explode like bombs (a) (they can explode like bombs (b) cause
  - Describes the development of reactors, uses of reactors, safety factors, and development.

**Synopsis 2 - In Scientific American, "Nuclear Power"**

- Describes the development of reactors, uses of reactors, safety factors, and development.

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<table>
<thead>
<tr>
<th>Instructional Objectives</th>
<th>Test Measures</th>
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</tbody>
</table>
Synopsis 2 - *Scientific American*, "Half-life and Atmospheric Testing of Nuclear Weapons"

Describes types and amount of contamination, effects on life, and predicts what would happen if testing started again.

Synopsis 3 - *Bulletin of Atomic Scientists*, "The Teller-Pauling Debate"

Describes the position of two scientists regarding the testing of atomic weapons.

Synopsis 4 - *Reader's Digest*, "The Russians Are Testing Again"

Describes evidence which purports to prove the case, discounts the danger of testing, describes the need for testing, and demands that the government act to save freedom and security.

Given three general positions regarding the issues, the learner will critique each in light of the evidence gathered thus far to demonstrate that they are (1) incomplete factually, (2) depend too heavily on biased or emotional materials, or (3) ignore evidence for ideological reasons.

**Nuclear Power Plants**

Position 1. "We should not build nuclear power plants. We probably need the new source of power, but they are so dangerous it's not worth the risk."
Position 2. "I don't want to be irradiated. They are proposing to build that plant only a mile from me. See that smoke coming from the oil plant? The smoke from a nuclear plant will bring radioactivity all over this town."

Position 3. "The communists are planting agitprop in us. They want to take over the world. All this business about benefited and radioactivity contamination is a bunch of lies put out by the communists to make us grow weak. Don't be afraid."

Position 3. "The communists are plotting agitprop us, they want to take over the world. All this business about benefited and radioactivity contamination is a bunch of lies put out by the communists to make us grow weak. Don't be afraid."

Atmospheric Testing

Position 1. "Atmospheric testing should start again. The air contamination now may help us protect the country from our enemies in the future."

Position 2. "Atmospheric testing should never be started again. I don't want my baby mutilated. I read that 10,000 people will die as a result of past testing."

Position 3. "Atmospheric testing should never be started again. I don't want the contamination now may help us protect the country from our enemies in the future."

Criterion Test Measures

Position 1. "There are none of all! So let's build it! I live in the community and you who argue that there may be some disadvantages live for the power company doesn't mean I support a nuclear power plant."

Position 2. "Look, this town needs more power if it is to grow. Just because a nuclear plant will bring radioactivity all over this town, only a mile from me, see that smoke coming from the oil plant?"

Position 3. "I don't want to be irradiated. They are proposing to build that plant and the town will need more power. Но I live in the community and you who argue that there may be some disadvantages live for the power company doesn't mean I support a nuclear power plant."

Instructional Objectives Hierarchy
Given three choices to make regarding each issue, the learner will first support one, then the others, on both factual and emotional grounds. One of the choices must be his own personal predilection. (This is a role-playing situation in which the learner is challenged to change set.) He is then to critique each choice on the basis of data sufficiency, emotionalism, and premature assumptions.

**Nuclear Power Plants**

Choice 1. Build a power plant, since it has no dangers at all and is needed by the country, the AEC and the President have said so, and I believe them.

Choice 2. Don't build the power plant, because it may explode or give us all radiation.

Choice 3. Build a non-nuclear power plant. That way we know we are safe and will continue to meet our power needs.

**Atmospheric Testing**

Choice 1. Start testing again: The enemy has, and the dangers are not real.

Choice 2. Don't test again. If we do, the Russians will. The dangers of irradiation are too great.

Choice 3. Find some way to test underground. That way we don't have contaminations, and do have testing to protect ourselves.
Instructional Objectives Hierarchy

Criterion Test Measures

4.1.4.3 Realize that limited data may have been collected which may not give a complete picture of the issue.

4.1.4.4.1 Resist external pressures—political, psychological, propagandistic, etc., which may preclude further investigation.

4.1.4.4.2 Realize that all sides of the issue may not have been presented.

4.1.4.4.3 Realize that all sides of the issue may not have been identified or explored.

4.1.4.4.4 From tentative conclusions on the basis of the data gathered regarding the issue, problem, or proposal, the learner will evaluate the conclusions of three pseudogroups or individuals, and identify the weakness of each argument on the basis of their:

(1) not being able to resist external pressures or influence by figures (e.g., President, Congress, the Mayor, etc.)

(2) not including, ignoring relevant or not knowing relevant data; or

(3) not allowing for relevant arguments from the opposition.

The Learner will then state his own tentative conclusions regarding the issues.

The conclusions are:

Conclusion 1. A nuclear power plant would be a bad thing for our community.

I don't know too much about it, but the Mayor and the best newspaper editor in town have come out against it, and that's good enough for me.

Conclusion 2. Building a nuclear power plant is a bad thing.

I can remember a few years ago, at Bodega Bay, the government did not care at all where they put the nuclear plant. They wanted to build it over the biggest earthquake fault in North America! If they were that unconcerned with our safety, why should we trust them now?

Conclusion 2. Building a nuclear power plant is a bad thing.

I can remember a few years ago, at Bodega Bay, the government did not care at all where they put the nuclear plant. They wanted to build it over the biggest earthquake fault in North America! If they were that unconcerned with our safety, why should we trust them now?
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conclusion 3. I don’t want the nuclear plant. I’ve heard all about it from the Mayor and the Editor. They explode, and that’s all I need to know. Why should I go to a community meeting? The only people there are those guys from the power company and the government, and you know what they will tell you!</td>
<td></td>
</tr>
</tbody>
</table>

**Atmospheric Testing**

Conclusion 1. The President, my Congressman, and my boss all agree that we must test again. Maybe there is some danger, but I’m sure these leaders would not let us get hurt. We better test again.

Conclusion 2. Here are the facts: The Russians are testing; we need bigger and better bombs; we must defend ourselves. It’s clear, isn’t it, that we must test!

Conclusion 3. Don’t tell me that! There are no reasons for starting to test. You right-wingers always see Communists under the bed. Look, I don’t want to hear your arguments, my mind is made up. No more bomb testing!

The learner will then make a preliminary assessment of his own conclusion on the same basis as his critique of the three above conclusions.
Instructional Objectives Hierarchy

4.2 evaluate the issue, problem, or proposal on the basis of relevant data, to determine the potential advantages or disadvantages and then formulate a course of action.

4.2.1 determine the potential dangers or benefits to life and property due to the production of electricity.

Criterion Test Measures

Given the following list of facts regarding the utilization of nuclear reactors for the production of electricity, the learner will (1) separate out the factors that demonstrate the superiority of nuclear power generation over traditional means; (2) separate out the factors connected with nuclear power; (3) list the limitations of traditional fuel sources; and finally, (4) identify disadvantages of fossil fuels used to generate electricity, and finally, defend this decision to support or reject the proposal on the basis of the facts.

Proposal: Since the nation's need for power is increasing at an ever-expanding rate, and since fossil fuels will soon be exhausted, it has become absolutely necessary to develop nuclear power. The so-called dangers of nuclear power are not real, and since fossil fuels will soon be exhausted, it has become absolutely necessary to develop nuclear power.

Cite the following list of facts regarding the utilization of nuclear reactors for the production of electricity, the learner will (1) separate out the factors that demonstrate the superiority of nuclear power generation over traditional means; (2) separate out the factors connected with nuclear power; (3) list the limitations of traditional fuel sources; and finally, (4) identify disadvantages of fossil fuels used to generate electricity, and contrast, for each, how nuclear generation could result in a more efficient use of energy.

Given the following proposal for the solution on the issue for the building of a nuclear reactor power generating plant in his community (see separate sheet for discussion of atomic bomb testing), the learner will (1) separate out the factors that demonstrate the superiority of nuclear power generation over traditional means; (2) separate out the factors connected with nuclear power; (3) list the limitations of traditional fuel sources; and finally, (4) identify disadvantages of fossil fuels used to generate electricity, and contrast, for each, how nuclear generation could result in a more efficient use of energy.
<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Nuclear production is cheaper.</td>
<td></td>
</tr>
<tr>
<td>b. Nuclear power more dangerous because of radiation.</td>
<td></td>
</tr>
<tr>
<td>c. Nuclear plants could explode as a nuclear bomb does.</td>
<td></td>
</tr>
<tr>
<td>d. Nuclear power production allows significantly less contaminants to escape into the atmosphere, thus reducing smog and other air pollutants.</td>
<td></td>
</tr>
<tr>
<td>e. Nuclear fuel lasts longer and has a greater potential supply.</td>
<td></td>
</tr>
<tr>
<td>f. Fossil fuels produce contaminants which cause lung diseases and destroy paint, rubber and other materials.</td>
<td></td>
</tr>
<tr>
<td>g. Others to be added.</td>
<td></td>
</tr>
</tbody>
</table>

**Fallacies**

| a. Nuclear power plants can explode | b. Nuclear plants produce radiation | c. Others to be added |

**Truth**

<p>| a. Knowledge of physical laws has led to barriers which prevent leakage | b. Others to be added |</p>
<table>
<thead>
<tr>
<th>Objective 1.1 Limitation of Fossil Fuels</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Others to be added</td>
<td></td>
</tr>
<tr>
<td>b. Cannot be designed</td>
<td></td>
</tr>
<tr>
<td>a. Cannot explode</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objective 1.2 Correction by Nuclear Power</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Others to be added</td>
<td></td>
</tr>
<tr>
<td>b. Spreads radiation</td>
<td></td>
</tr>
<tr>
<td>a. Cannot explode</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Truth</th>
<th>Fallacies</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cannot explode</td>
<td></td>
</tr>
<tr>
<td>b. Spreads radiation</td>
<td></td>
</tr>
<tr>
<td>c. Others to be added</td>
<td></td>
</tr>
</tbody>
</table>

For each statement of a list of fallacies connected with the use of nuclear power generation, the learner will match the factual replies to those of the fallacies. Given a list of fallacies connected with the use of nuclear power generation, the learner will match the factual replies to those of the fallacies.
4.2.2 determine the potential costs—social, economic, political—of the issue, problem or proposal in comparison with current practices, and make decision to act

<table>
<thead>
<tr>
<th>Instructional Objectives Hierarchy</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given the list of the purported benefits of a nuclear power generating plant, the learner will identify those that answer the specific social problems listed in a second column.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cheaper</td>
<td>a. Smog control</td>
</tr>
<tr>
<td>b. Less contaminants</td>
<td>b. Limited resources</td>
</tr>
<tr>
<td>c. Allows greater dispersal</td>
<td>c. Urban conglomeration</td>
</tr>
<tr>
<td>d. Longer lasting fuel supply</td>
<td>d. Rising costs of traditional fuels</td>
</tr>
<tr>
<td>e. Others to be added</td>
<td>e. Others to be added</td>
</tr>
</tbody>
</table>

The learner will state in writing how the wide-scale introduction of nuclear power generation will affect social, political, and economic life in his community, including at least the following points:

a. Political effects: Federal and state control of reactor safety will introduce this kind of control into local communities. Decision to build the reactor will oppose federal and local persons and organizations. Safety measures will depend basically on federal and state agencies.
4.2.2.1 compare the relative costs of change with the established pattern or procedure;

4.2.3 compare the proposal with appropriate historical analogies relative to technological innovations and their impact, as well as present trends in social, political, and economic areas as they are affected by technological change.

The learner shall construct a graph which shows the relationship between fossil fuel supplies and nuclear fuel supplies from 1945 to 1977, and extrapolate to 2000 to draw the necessary conclusion regarding the reserve potential and cost of fossil fuels vs. nuclear fuels. The graph should be an example of the consequences of the introduction of the cotton gin (or other example) with its economic, social, and political effects.

The learner will analyze emotional and irrational responses to technological innovations by comparing the introduction of the cotton gin (or other example) with those of nuclear power. Included in the analysis should be an outline of the consequences of the introduction of the cotton gin (or other example) with its economic, social, and political effects.

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</thead>
<tbody>
<tr>
<td>4.2.3.1 know the comparative statistics between other technological inventions or innovations which are now generally accepted as both necessary and worthwhile (e.g., the automobile), and nuclear science developments;</td>
<td>Given a graph comparing statistical evidence of deaths caused over the last 20 years by automobiles, trains, and airplanes (all acceptable and demanded technological innovations) and by nuclear accidents, the learner will (1) state in writing why the statistical comparison is unfair, (2) identify and compare how governmental controls on safety (from trains, to autos, to airplanes, to nuclear plants) have increased the safety factors in all categories, and (3) draw the conclusion that nuclear power plants under rigid control of state and federal governmental agencies are safe.</td>
</tr>
<tr>
<td>4.2.3.2 evaluate the impact of the issue, problem, or proposal on the social aspects of our culture (How will it affect people and institutions?) and the degree to which the change will interface with other elements of the society;</td>
<td>The learner will identify, in writing, how nuclear power production will ameliorate, or not affect, the two following social problems: population explosion and air pollution, including at least the following points:</td>
</tr>
<tr>
<td></td>
<td>a. Nuclear energy does not need a continuous supply of bulky fossil fuels as a power source. Fossil fuels also need a large amount of air forced through the burning areas to maintain heat; nuclear fuels do not. Thus fossil fuels, through the exhaust system, add unburned (unoxidized) contaminants to the air while nuclear fuels do not.</td>
</tr>
<tr>
<td></td>
<td>b. Because nuclear power production does not depend on bulky raw materials, but on small amounts of materials, industry and population are relieved from having to consider power and water needs when selecting site locations; they can use other factors (days of sunshine, transportation facilities, etc.).</td>
</tr>
</tbody>
</table>
Given a list of possible changes in the internal political structure which may result from introduction of nuclear power generation, the learner will check those that are least likely to happen. The issue, problem, or proposal to influence decision-making by rank (i.e., most important in decision-making first):

<table>
<thead>
<tr>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear reactor plant</td>
</tr>
<tr>
<td>Atomic bomb testing</td>
</tr>
<tr>
<td>Atomic bomb treaty</td>
</tr>
<tr>
<td>President and Cabinet</td>
</tr>
<tr>
<td>U.S. Senate</td>
</tr>
</tbody>
</table>

Criterion Test Measures

4.2.3.3 Evaluate the probable effects of the issue, problem, or proposal on the internal political structure, and foreign policy.

4.3 Decide course of action and take appropriate action based upon his investigation and analysis of the issue, problem, or proposal to influence decision-making.

4.3.1 Identify the principles involved in the decision-making, or having influence on the decision-makers, and their involvement in the decision-making process.

72 Given a list of possible changes in the internal political structure which may result from introduction of nuclear power generation, the learner will check those that are least likely to happen.

<table>
<thead>
<tr>
<th>Agency</th>
</tr>
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<tbody>
<tr>
<td>AEC</td>
</tr>
<tr>
<td>U.S. Congress</td>
</tr>
<tr>
<td>President and Cabinet</td>
</tr>
<tr>
<td>U.S. Senate</td>
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</tbody>
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Criterion Test Measures

4.3 Identify the principles involved in the decision-making, or having influence on the decision-makers, and their involvement in the decision-making process.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Instructional Objectives Hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.</td>
<td>Use of atomic weapons in limited wars</td>
</tr>
<tr>
<td>f.</td>
<td>Irradiation of food in food supply</td>
</tr>
<tr>
<td>g.</td>
<td>Irradiation in industry (local electric company)</td>
</tr>
<tr>
<td>h.</td>
<td>Occupations in nuclear field (Joint Chiefs of Staff)</td>
</tr>
<tr>
<td>i.</td>
<td>Underdeveloped world and atomic power (University physicists)</td>
</tr>
<tr>
<td>j.</td>
<td>Atomic power and foreign policy (Joint Committee on Atomic Energy)</td>
</tr>
<tr>
<td></td>
<td>C.</td>
</tr>
<tr>
<td></td>
<td>B.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agency</th>
<th>Criterion Test Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>Pentagon (Joint Chiefs)</td>
</tr>
<tr>
<td>6.</td>
<td>Food and Drug Administration</td>
</tr>
<tr>
<td>7.</td>
<td>Local electric company</td>
</tr>
<tr>
<td>8.</td>
<td>University physicists</td>
</tr>
<tr>
<td>9.</td>
<td>Joint Committee on Atomic Energy</td>
</tr>
<tr>
<td>10.</td>
<td>Dept. of Agriculture</td>
</tr>
<tr>
<td>11.</td>
<td>Bureau of Standards</td>
</tr>
<tr>
<td>12.</td>
<td>International Atomic Energy</td>
</tr>
</tbody>
</table>

| A.  | Nuclear Reactor Plant |
| B.  | Atomic bomb testing |
4.3.1.1 Know the specialized governmental and private agencies related to the issue, problem, or proposal, and their function.

Having completed the identification listing, the learner will start that agency of the three listed for each issue, which has the most vested interest in convincing him of the correctness of the issue.

Define the role of the following governmental and private agencies, and give two examples of the kinds of involvement they would have with the development of nuclear technology, including weapon development.

- D. Department of Agriculture
- C. Department of Health, Education, and Welfare
- B. Joint Committee
- A. AEC

D. Political and economic power of AEC

1. 3.
2. 2.
3. 1.

C. Food and product irradiation

1. 1.
2. 2.
3. 3.

E. Population problem and atomic energy

1. 3.
2. 2.
3. 1.
### Instructional Objectives Hierarchy

**4.3.1.2** know other agencies or groups interested in the issue, problem, or proposal, or publications which attempt to exert influence on the decision-makers.

### Criterion Test Measures

| e. Bureau of Standards                                  | 1. Opposed to weapons development and use |
| f. Power Companies                                       | 2. Opposed to nuclear reactors           |
| g. American Nuclear Society                              | 3. In favor of total use of weaponry     |
| h. Atomic Industrial Forum                               | 4. In favor of expansion and support of nuclear technology for business reasons, etc. |
| i. International Atomic Energy Agency                    |                                           |

Define the role of the following pressure groups, and identify their particular points of view by matching them with those listed.

| a. SANE                                                  |                                           |
| b. W.S.P.                                                |                                           |
| c. Power companies                                       |                                           |
| d. Atomic Industrial Forum                               |                                           |
| e. John Birch Society                                    |                                           |
| f. Various Private Organizations composed of retired military men, etc. |                                           |
4.3.1.3 decide on a course of action by determining the answers to the following questions:

a. How serious is the situation (what is the need);

b. What alternatives are open;

c. Which authorities support or oppose the issue, problem, or proposal;

d. What position does the evidence support.

The learner will then make a written summary of his position, which demonstrates:

a. Evidence support - what position does the learner take or propose;

b. Which authorities support or oppose the building of the plant;

c. What alternatives are open;

d. What is the need for the plant;

e. What happens if the plant is not built and the old methods are continued?

The learner will collect and label all positive and negative facts regarding the utilization of nuclear generating plants, and utilize the data gathered to answer the following questions:

4.3.1.3.1 determine the answers to the

Institutional Objectives Hierarchy

Criterion Test Measures
Given the following issues, the learner will select the possible courses of action to be taken to influence the decision-making process, and which technique is most appropriate for each issue, by a check.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Course of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Nuclear reactor</td>
<td>1. Organizing the community to support and approve</td>
</tr>
<tr>
<td>b. Nuclear weapons</td>
<td>2. Writing letters</td>
</tr>
<tr>
<td>c. Test ban treaty</td>
<td>3. Talking directly to officials</td>
</tr>
<tr>
<td>d. Introduction of irradiated foods and products</td>
<td>4. Picketing</td>
</tr>
<tr>
<td>e. More to be added</td>
<td></td>
</tr>
</tbody>
</table>

The learner will match "community action" or "personal action", with the issues listed below in terms of which is more appropriate as a first approach to the problem.

| a. Using irradiated products | |
| b. Atomic weapons testing | |
| c. Atomic reactor | |
| d. Building of reactor | |
| e. Getting radiation treatment | |
| f. More to be added | |
Instructional Objectives Hierarchy

4.3.2.2 Know the possible means of communicating his desires

4.3.2.3 Realize that others in his community, state, or nation may also be concerned with the issue, problem, or proposal, and attempt to contact them to gain support for his position through cooperative action.

The learner will arrange in order the techniques of communications in terms of personal to collective (community, state, national) action validating at least the following:

a. Join organization supporting or opposing
b. Picketing Congressmen and other official agencies
c. Letter writing to officials working for candidates
d. Visiting reactor sites
e. Working for candidates
f. Letter writing to officials
g. Join organization supporting or opposing

Identity from a list those organizations made up of private citizens, possibly found in his area, which would be concerned with these issues.

a. SANE, PTA, WSP, etc.
b. Democratic - Republican Parties
c. Labor Unions
d. Power companies
e. University academics
f. More to be added

Identification of others in his community, state, or nation may also be concerned with the issue, problem, or proposal, and attempt to contact them to gain support for his position through cooperative action.
After the learner has completed the instructional sequence presented above, he will then be presented an entirely different social issue involving technological innovation (nuclear or non-nuclear). He will be required to follow the same processes he mastered in investigating the issue in the learning design. Criteria for judging learner performance are the same as those identified in the materials above.

(In this segment the instructor is given greater options and decision making.)
Terminal Objective: 4.0 The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

Instructional Objectives Hierarchy

The learner shall:

4.2 evaluate the issue, problem, or proposal on the basis of relevant data to determine the potential advantages or disadvantages, and then formulate a course of action;

4.2.1 determine the potential dangers or benefits to life and property;

Criterion Test Measures

Given the pronouncement by the President that it is necessary for the United States to unilaterally break the atmospheric nuclear test ban treaty to improve its weapons system, the learner will compare the advantages and disadvantages of testing in terms of national defense, foreign policy, and health aspects of atmospheric testing by determining through a study of the relevant data the potential dangers and benefits; potential social, political, and economic costs; and arrive at a decision to support or oppose the government's decision.

The learner will summarize the potential dangers and benefits to life and property (broadly defined to mean national life and property, in this case) of atmospheric bomb testing in a short 2-4 page report which includes at least the following points:

Dangers

1. Nuclear weapons are so powerful that in the event of war no victor could emerge; civilization would be destroyed.
2. Spread of nuclear weapons will allow lesser powers to practice nuclear coercion.
3. Nuclear weapons do not deter war, but lead to new forms of war (e.g. limited war, insurrections).
4. Accidental war could come about through escalation.
5. Nuclear weapons tend to maintain attitudes of fear and mistrust of intentions, which would lead to a misinterpretation of acts which, in turn, could lead to nuclear war.
6. Russians, Chinese, French, and British will begin testing, negating potential advantage of tests.

7. Biological damages that will result (details).

8. Advantages of adding greater nuclear capability.

Criteria Test Measures

Criteria: Objectives Hierarchy
From the following list of arguments relative to nuclear bomb testing, the learner will: (A) separate those in favor of testing from those which oppose; and then, (B) separate the apparently emotional arguments from those which are apparently factual, and list them.

1. Weapons so destructive no hope for victory.
2. Nuclear weapons deter enemies.
3. Maintenance of weapons superiority allows the United States more strategic freedom of action.
4. Nuclear weapons do not deter war but lead to new forms of war.
5. Babies will be born deformed from irradiation.
6. Nuclear weapons are needed to maintain superiority over manpower potential of enemies.
7. New arms race will start.
8. Accidental nuclear war could result from escalation.
9. Nuclear weapons will contaminate the air, but danger of attack makes risks worth it.

The learner will match the pro and con arguments for weapons testing to determine areas of agreement and conflict. He will then match the areas of disagreement with testimony presented below, to identify possible solutions to the disagreements from a radiation biologist; members of Joint Chiefs; Soviet Embassy; statistical summary of contamination from previous testing by two politically oriented physicists; and one nonpolitical nuclear physicist.
Testimony 1: Biological Effects

Any radiation exposure is potentially harmful to animals and plants. Radiation can cause cancer, mutation, and a host of other effects resulting in destruction of life. Any radiation exposure is potentially harmful to animals and plants. Radiation can cause cancer, mutation, and a host of other effects resulting in destruction of life.

Testimony 2: Military Needs

It is quite clear that the major reason for the reluctance of the USSR to get involved in military conflict with the USA has been the USA’s ability to completely destroy our bombs and objects below the bomb. We can only find this out by atmospheric testing. The only way to maintain the superiority we now have, however, is to see what actually happens to our bombs and objects below the bomb. We can only find this out by atmospheric testing. The only way to maintain the superiority we now have, however, is to see what actually happens to our bombs and objects below the bomb.

Testimony 3: Reaction of Potential Enemies

We cannot allow capitalistic imperialism to destroy socialism! We cannot allow capitalistic imperialism to destroy socialism!

The Honorable Ambassador from the United States: It has come to our attention that the present Government of the United States intends to break the treaty regarding atmospheric testing of nuclear devices. We wish to inform your Government that in this situation, we also will begin to test to defend our socialist Fatherland and protect our socialist Fatherland. We wish to inform your Government that in this situation, we also will begin to test to defend our socialist Fatherland and protect it.

The President of the Soviet Union: The treaty regarding atmospheric testing of nuclear devices is only a means by which the USA can continue to develop weapons of superiority vis-a-vis the Soviets. Militarily, we need to continue to develop weapons of superiority vis-a-vis the Soviets. Militarily, we need to continue to develop weapons of superiority vis-a-vis the Soviets.

The Honorable Ambassador from the United States: It has come to our attention that the present Government of the United States intends to break the treaty regarding atmospheric testing of nuclear devices. We wish to inform your Government that in this situation, we also will begin to test to defend our socialist Fatherland and protect it.

We cannot allow capitalistic imperialism to destroy socialism!
In addition, your decision to test will cause the destruction or mutilation of millions of innocent people of Africa and Asia as well as Europe and North and South America. Consider that in your final decision.

Testimony 4: Statistics Regarding Half-Lives of Major Contaminants Resulting from Atom Bomb Explosions

- Strontium - 90: 25 years
- Ruthenium - 103: 39.8 days
- Rhodium - 106: 30 seconds
- Iodine - 131: 8 days
- Barium - 140: 12.8 days
- Cerium - 144: 590 days
- Praseodymium - 144: 17 minutes

Testimony 5:

Pro-Testing. As a scientist who once lived under a totalitarian regime, I know the evils of such systems. We cannot allow that to happen in America. My former homeland is now controlled by Communists. Of course, I will admit that there is some danger in testing, but it is a necessary risk—freedom is much more important.
After reading the testimonials, the learner should identify those which contain biases or vested interests in the position they maintain, emotional or other irrational argument, oversimplifications, and flaws in fact.

Testimony 6: Non-political Physicist

The fission or fusion explosion creates particles which have lifetimes of various lengths. These particles combine with skin, plants, soil, and so forth, and retain their potential for irradiating other things when brought into contact with them. Strontium 90, for example, which has a half-life of 25 years, is very similar to other particles produced by atmospheric testing. These particles combine with skin, plants, soil, and so forth, and retain their potential for irradiating other things when brought into contact with them. Strontium 90 is created by an atmospheric test in Nevada. The winds blow the strontium 90 across the U.S. It finally settles to the ground, where it contacts the grass eaten by cows, is converted to milk, and is finally drunk by children. When strontium 90 is created by an atmospheric test in Nevada, the winds blow the strontium 90, for example, which has a half-life of 25 years, is very similar to other particles produced by atmospheric testing. These particles combine with skin, plants, soil, and so forth, and retain their potential for irradiating other things when brought into contact with them.

The learner should identify those which contain biases or vested interests in the position they maintain, emotional or other irrational argument, oversimplifications and flaws in fact.
### Instructional Objectives Hierarchy

4.2.2 determine the potential costs—social, economic, political—of the issue, problem, or proposal in comparison with current practices and make a decision to act;

### Criterion Test Measures

The learner will construct a graph from given statistics regarding the arms race of World Wars I and II, and the current arms race with the Soviet Union, and derive a tentative hypothesis regarding the effectiveness of arms as a deterrent to war.

Given a series of potential outcomes regarding the social, economic, and political costs, (based on expert testimony from both sides) if nuclear testing is or is not reintroduced, the learner will write his position statement by countering each argument opposed to his position in each of these areas.

The learner will check each of the following items in the social, economic, and political areas which may result if atmospheric testing is reintroduced.

<table>
<thead>
<tr>
<th>Social</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radioactive contamination of soil, food, humans</td>
<td></td>
</tr>
<tr>
<td>2. Potential increase in mutations</td>
<td></td>
</tr>
<tr>
<td>3. Increased irrationalism regarding use of nuclear energy</td>
<td></td>
</tr>
<tr>
<td>4. Fatalism regarding war</td>
<td></td>
</tr>
<tr>
<td>5. More to be added</td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>Political</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>1. Increased defense spending</td>
<td>1. More to be added</td>
</tr>
<tr>
<td>2. Decrease in GNP</td>
<td>2. World tensions rise</td>
</tr>
<tr>
<td>3. Decrease in jobs</td>
<td>3. Decrease in influence of the military on political decision-making</td>
</tr>
<tr>
<td>4. Increase in government-business competition</td>
<td>4. More to be added</td>
</tr>
<tr>
<td>5. Decrease in jobs</td>
<td>5. Decrease in private sector</td>
</tr>
<tr>
<td>6. Decrease in GNP</td>
<td>6. Increase in government-business competition</td>
</tr>
<tr>
<td>7. Decrease in dependence on military spending for economic stability</td>
<td>7. More to be added</td>
</tr>
</tbody>
</table>

He will then compare, in a one-page statement, the social, economic, and political changes with the potential of not changing as announced by the President, and conclude whether or not he thinks the change is worth it.
4.2.3 compare the proposal with appropriate historical analogies relative to technological innovation and their impact, as well as present trends in social, political, economic areas as they are affected by technological change.

The learner will summarize the pro and con data, and then decide a course of action by answering the following questions:

1. What is the need for resuming testing as stated by the decision-maker?
2. What alternatives are open to answer the need if testing is not started again? Are they as satisfactory as testing?
3. Which objective authorities support or oppose the position; which non-objective authorities do?
4. What position does the evidence suggest as the best possible solution?

The learner will report on the decision to use or not use gas in World War I, and the consequences of the use, including facts about: The race to produce gas, the race to produce counter-measures, the use and effectiveness of gas war (in World War I); the growth of value questions regarding "humane" and "inhumane" weapons of war, conventions regarding weapons use. The learner will also report on the role of military expediency in the development of nuclear engineering science, and its impact on peaceful nuclear applications after World War II.

After the learner has completed the instructional sequence above, he will then be presented an entirely different social issue involving technological innovation (nuclear or non-nuclear). He will be required to follow the same processes he mastered in investigating the issue in the learning design. Criteria for judging learner performance are the same as those identified in the material above.

(In this segment the instructor is given greater options and decision making.)
The Economic Impact of Nuclear Power Reactors

United States History, Secondary Level
Underdeveloped Area Studies, Secondary

This unit assumes that the learner has been exposed to:

a. Basic nuclear science concepts;
b. Substantive knowledge of the operation of nuclear reactors.

The learner will be able to:

a. Identify, compare, and evaluate traditional and nuclear power production;
b. State the needs and advantages of nuclear power over traditional methods by relating these to typical problem situations;
c. Master the techniques of rational inquiry.

This unit introduces two factors to the learner, both of which are essential elements of the curriculum design:
a. The decision making processes;
b. Relevant data regarding the impact of technology on economic institutions and practices using nuclear technology as a vehicle.
PROFICIENCY TEST FOR SOCIAL SCIENCE MODULE

The learner will select from the choices offered those items which indicate:

- a. A capacity to identify factual evidence regarding nuclear power production to ensure safety and reasonable development of nuclear power.

- b. Big government will take control of power production to ensure safety and reasonable development through nuclear desalination.

- c. Fresh water supplies will increase and desert areas can be irrigated with water supplied by nuclear desalination.

- d. Undeveloped nations without ready supplies of traditional fuel sources will be able to build a power based upon nuclear resources.

- e. Nuclear power production has a fuel base which guarantees unlimited power for the future, and the production of fresh water.

- f. Nuclear power generation makes it possible to provide less expensive power to the consumer.

- g. Air contamination will lessen.

- h. Nuclear power generation makes it possible to provide less expensive power to the consumer, note a community.

1. Indicate by placing a check before the item the common fallacies regarding the use of nuclear power.

- a. Nuclear reactors may explode such as atomic bombs do.

- b. Working in a nuclear plant is dangerous because of radiation coming from the reactor.

- c. Nuclear reactors may explode such as atomic bombs do.

- d. Nuclear reactor core contains deadly raditation through their exhaust systems which could contaminate the environment.

- e. Nuclear power production has a fuel base which guarantees unlimited power for the future.

- f. Nuclear power generation makes it possible to provide less expensive power to the consumer.

2. Indicate the present or potential socio-economic implications of nuclear power generation by placing a check before the statements which are true regarding the use of nuclear power.

- a. Air contamination will lessen.

- b. Fossil fuel prices will decrease.

- c. Population and industry will be able to disperse into presently unused lands due to nuclear power.

- d. Underdeveloped nations without ready supplies of traditional fuel sources will be able to build a power based upon nuclear power.

- e. Nuclear power generation makes it possible to provide less expensive power to the consumer.

- f. Nuclear reactors may explode such as atomic bombs do.

THIS IS BOTH A PRE AND POST TEST

- c. An awareness of the processes of rational inquiry.

- b. An understanding of the socio-economic implications of nuclear power.

- a. A capacity to identify factual evidence regarding nuclear power production.

- q. A capacity to identify factual evidence regarding nuclear power production.

The learner will select from the choices offered those items which indicate:

PROFICIENCY TEST FOR SOCIAL SCIENCE MODULE
3. Label the following statements (A) for authoritative, (B) for biases or containing vested interest, and (NF) for nonfactual or fallacious. The statements are concerning the need and dangers of having a community nuclear power plant built.
   a. "Tampering with the atom is the work of the devil," said the clergyman, "and if we allow this further tampering by building a nuclear power plant, we will surely be destroyed."
   b. "Modern nuclear power plants are constructed in a much different way than is an atomic bomb," said a representative for the Atomic Energy Commission, "thus, they cannot possibly explode like one."
   c. "As city planner for this community, I can say that if we are going to provide for the present and future needs of our population and industry, we must build a nuclear power generator."
   d. "I say that to build a nuclear power plant is bad," said the owner of the local coal company, "since they are dangerous. The old way is best."

4. Identify the agencies which will have information regarding the building of a nuclear power plant by checking them in the following list. Then label each in the following manner to show which method of contacting them and acquiring information from them (one label per identified item): (L) for Letter, (I) for Interview.
   a. Atomic Energy Commission
   b. Joint Committee on Atomic Energy
   c. Local Power Company
   d. Department of Defense
   e. Department of Agriculture
   f. Local University Physicist

5. Assuming that your congressman refuses to hold a hearing regarding the siting of a proposed nuclear power plant and you and others in your community oppose the site selected, number the following courses of action from 1 to 4 in terms of the sequence of rational procedures to influence the congressman's point of view.
   a. Picketing
   b. Letter writing campaign
   c. Committee formed to contact representative face to face
   d. Newspaper ads and meetings
A. Need for Nuclear Power:

1. A high standard of living depends upon the power that is available to a country. Little power means an underdeveloped economic system and a low standard of living.

2. Nuclear power needs growth will continue as long as energy consumption in the United States doubles every ten years. Current reserves of fossil fuels will be exhausted in 200 years. The most easily mined are gone in 100 years. Then, becomes necessary that the United States develop alternative sources of power.

3. Accelerated industrial expansion. This last decade and with our population growth of an average rate of 4% per year over the past decade, and with our population growth expected to double every ten years from 1960-1990, it is also expected that the United States will have a population of over 320,000,000 by the year 2000.

4. America's need for power has been growing at an average rate of 17% per year. America's need for power has been growing at an average rate of 4% over the last decade and with our population growth expected to double every ten years. Then, becomes necessary that the United States develop alternative sources of power.

5. Power needs growth will continue at a faster rate.
Content and Processes Involved in the Investigation of the Implication of Nuclear Power Generation

B. Advantages of nuclear power generation in comparison with fossil fuels:
   1. Overall costs of generation of electricity are equal to and potentially cheaper than electricity generated by fossil fuels.
   2. Raw materials for nuclear fuel will last at least 1700 years and will be limitless when breeder reactors have been perfected.
   3. Use of nuclear power as an energy source in industrial areas will help lessen air pollution since pollutants from reactors are insignificant.
   4. Utilization of nuclear power will allow for industrial and population dispersal since new areas can be opened and/or industry will no longer be constrained by power needs.
   5. Fossil fuel prices will go down as nuclear power gains wider usage.

C. Socio-economic implication of nuclear power production:
   1. Increased involvement of the government in economic decision making;
   2. Less cost for power and fossil fuels which will be used for other purposes;
   3. Greater economic regional planning to make the system more rational;
   4. Greater dispersal of population and industry;

Objectives to Be Obtained

2. Identify and compare the advantages and disadvantages of nuclear power with the disadvantages of traditional techniques.

3. Identify the relationship between socio-economic problems and the use of nuclear power.
Content and Processes Involved in the Investigation of the Implication of Nuclear Power Generation

5. Amelioration of such social problems as air pollution, water supplies, urban congestion;

6. Introduction of new occupational fields;

7. More sophistication in the use of computers and other automatic processes.

Objectives to Be Obtained

4. Utilize established criteria for rational decision making to arrive at a decision regarding the given social issue involving nuclear power.

D. Processes of Rational Inquiry to Be Introduced:

1. Identify sources of information relative to the selected issue;

2. Analyze the authority, objectivity, reliability of the sources;

3. Analyze the costs/benefits factors necessary and relevance of the sources;

4. Analyze and determine individual courses of action.

J
<table>
<thead>
<tr>
<th>Instructional Objectives</th>
<th>Learning Steps/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.0</strong> The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose actions or initiate actions himself in regard to the development and/or use of nuclear technology;</td>
<td>Introducing the Unit: The teacher presents the problem which has arisen from the suggestion that a nuclear power plant be built in a community (see presentation of issue in Social Issue 1). Dialogue with the learners to gain their initial impression regarding the issue which leads to the listing of a number of procedural questions: (1) Are the statements made, accurate? (2) How do we determine their accuracy? (3) Where do we get information? (4) How do we judge the accuracy of the information? and (5) What actions would we take if we had to decide?</td>
</tr>
<tr>
<td><strong>4.1</strong> seek and evaluate materials pertinent to the particular issue, problem or proposal;</td>
<td>Gaining Information: The students are directed to identify the key words in the statement (nuclear power, atomic bomb, etc.) and are asked to list the possible sources for finding further information based on the key words (card catalog, Reader's Guide, encyclopedias, etc.). The teacher then suggests that there may be other more specialized sources of information that may be identified by a preliminary scanning of the preliminary sources. The teacher directs the learners to list all the agencies and other potential sources of information mentioned in the library sources (AEC, Joint Committee, international agencies, and others can be found). The class makes a preliminary check of the relevancy of the information so gathered by comparing the information with the key words previously identified.</td>
</tr>
<tr>
<td><strong>4.1.1</strong> locate sources of information from both producers and distributors of information;</td>
<td></td>
</tr>
</tbody>
</table>

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Instructional Objectives

4.1.2 acquire the materials from a variety of sources;

4.1.3 judge the materials for authority, reliability and relevance to the issue under consideration;

The teacher then directs the class to compare the technical information found in the encyclopedia with those of selected magazine articles (technical and nontechnical) and asks the learners to categorize the sources into technical and nontechnical groupings. From this activity a set of criteria for judging authoritative, objective, scientifically accurate, non-argumentative, lack of vested interest (define) should be developed for future use. Including at least the following:

- Technical, and nontechnical sources
- Articles (technical and nontechnical)
- Authority, reliability, and relevance to the issue under consideration
- Technical and nontechnical groupings

The learners devise a system for acquiring materials from a variety of sources by analyzing how much time and distance is involved. The teacher presents to the learners three very obvious articles written from the standpoint of technical information, emotional, and vested interests written by authorities and nonauthorities.

The learners are directed to categorize as best they can the articles in terms of which one appears to be most authoritative, objective data, and which appears to be argumentative, persuasive, or emotional, and which appears to contain vested interest (define). From this activity the learners are directed to develop a set of criteria for judging authoritative, objective, scientifically accurate, non-argumentative, lack of vested interest (define) which appears to be objective, data, and which appears to contain vested interest (define). The learners break down the categories into three parts: library research, letters of request, and interviews. The materials and information are then acquired by the most efficacious means.

The teacher presents to the learners three very obvious articles written from the standpoint of technical information, emotional, and vested interests written by authorities and nonauthorities. The learners are directed to categorize as best they can the articles in terms of which one appears to be most authoritative (define), which appears to be objective data and which appears to be argumentative, persuasive, or emotional, and which appears to contain vested interest (define). From this activity the learners are directed to develop a set of criteria for judging authoritative, objective, scientifically accurate, non-argumentative, lack of vested interest (define). The sets of criteria are then applied to the acquired materials and from this screening the learners are asked to isolate the factual evidence regarding nuclear power generation from the unfactual or irrational.
<table>
<thead>
<tr>
<th>Instructional Objectives</th>
<th>Learning Steps/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.1.4</strong> form tentative conclusions on the basis of the data gathered regarding the issue, problem or proposal;</td>
<td>The teacher directs the learners to compare the factual, authoritative information with the opinion stated in the case study presented at the beginning of the unit and form a tentative conclusion regarding its intent and accuracy. The learner is then given a set of three conclusions which point out: (1) a conclusion based on the effect of external pressure, (2) one based on limited data; and, (3) one based on information representing only one side of the issue. All conclusions should come from apparently authoritative sources which are identified in an appendix to each conclusion. The class is then directed to match known information to each conclusion to gauge the reasons for the inadequacies of each conclusion including at least the following. (See points made under 4.1.4.) The teacher then has the learners apply the criteria to their own conclusions and make any modifications that become apparent.</td>
</tr>
</tbody>
</table>

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Learning Steps/Activities

4.2.1 Analyzing the Issue: At some point during the investigation of the issue, when enough is known about the proponents and opponents of the nuclear power plant, the teacher should develop a role playing situation with learners involved in opposing groups, with the elements of bias, vested interest, disinterest, and so forth, built into the role playing situation. Most likely a mock community could be established with each viewpoint or pressure group identified.

When the learners have been given these challenges, the teacher directs them to isolate each fact and fallacy and to also identify the needs for technological innovation from the information already acquired or derived from further research.

The opposite conclusion on the basis of the needs of society for nuclear power.

Each viewpoint or pressure group identifies its position, its dangers, and its benefits to life and property. These positions are expressed in a mock community could be established with each viewpoint or pressure group identified.

When learners are involved in opposing groups, with the elements of bias, vested interest, disinterest, and so forth, built into the role playing situation, the teacher directs the learners to analyze the proposal for the solution of the issue posed by the opposition group by matching the factual evidence against the fallacious charges made by the opposition group by issue passed by the nuclear group. The opposition should present the factual evidence against the opposition group by issue passed by the nuclear group.

The learner is directed to analyze the proposal for the solution of the issue posed by the opposition group by issue passed by the nuclear group. The opposition should present the factual evidence against the opposition group by issue passed by the nuclear group.

From further research, it is evident that the opposition group has failed to present the factual evidence against the fallacious charges made by the opposition group. The opposition should present the factual evidence against the opposition group by issue passed by the nuclear group.

The teacher asks: "Are there dangers involved in the development of a nuclear power plant?" He then challenges each response with whatever arguments are necessary to motivate the learner to a stronger defense of his position, e.g.: Learner: No dangers involved. Teacher: "These are dangerous involved in the development of nuclear power..."
### Instructional Objectives

| 4.2.2 | determine the potential costs—social, economic, political—of the issue, problem or proposal in comparison with current practices and make decision to act; |

### Learning Steps/Activities

The teacher will direct the class to report on the relationship of social and economic problems and how these might be ameliorated through the use of nuclear power generation. Included should be the following points: (See points made under Criterion Test Measure column, point 4.2.2.)

The learner is then directed to summarize all known factors including: (1) technical information regarding nuclear reactors and power generation, (2) social and economic problems or issues or dislocations, (3) analysis of unfactual, emotional, biased appeals and the potential dislocation which could result from them. From this summary the learner is asked to answer the following questions (these questions involve value judgments and therefore are open to class discussion). The teacher and learners evaluate each judgment on the basis of previously derived criteria and information (i.e., the degree of authoritative support, technicality, lack of emotional bias, vested interest, etc.): (See questions listed under point three in the "Instructional Objectives" column.)
Learning Steps/Activities

3.2.1 The teacher directs the learners to list potential sources of irrationalities in the arguments of those opposed to the building of the nuclear power plant.

3.2.2 The learners are to report on the following historical studies:

- The development of the mechanized textile industry where the Luddites reacted to change.
- The development of the manufacture of graphic materials (1) and its consequences as an example of a conscious awareness of the negative impact of technological innovation which could be used in today's situation.

To test these generalizations, the teacher directs the learners to:

- Investigate and report on the following historical studies:
  - The development of the mechanized textile industry where the Luddites reacted to change.
- The development of the manufacture of graphic materials (1) and its consequences as an example of a conscious awareness of the negative impact of technological innovation which could be used in today's situation.

In the decision to be made more rationally:

- To become a better decision maker in a democratic society by allowing
  (consciousness of change, etc.) and (2) consciousness of change helps one
  (unconsciousness of change leaves one with a feeling of helplessness)

Essentially, the hypothesis should contain elements which suggest:

1. The hypothesis should be tested to form a hypothesis regarding
   change. The learner should be asked to form a hypothesis regarding
   change, the hypothesis should be tested to form a hypothesis regarding
   change. The learner should be asked to form a hypothesis regarding
   change.

2. From this contrast of the unconscious and conscious factors
   of innovation, the learner should be asked to form a hypothesis regarding
   change.

3. To test these generalizations, the learner should be directed to
   list potential sources of irrationalities in the arguments of those opposed to the building of the nuclear power plant.

Instructional Objectives

4.2.3 Compare the proposal with appropriate historical analogies relative to technological innovation and their impact as well as present trends in social, political and economic areas as they are affected by technological change;
### Instructional Objectives

<table>
<thead>
<tr>
<th>4.3</th>
<th>decide a course of action and take appropriate action based upon his investigation and analysis of the issue, problem or proposal to influence decision making;</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.1</td>
<td>identify the principals involved in decision making or having influence on the decision makers and their involvement in the decision making process;</td>
</tr>
</tbody>
</table>

### Learning Steps/Activities

During the course of the historical investigation of the Luddite reaction, the teacher develops a role playing situation for the learner to have him first take the role of an employer and then of the unemployed handicraft worker.

By this point in the unit a consensus should have been formed regarding the proposal and the issue: those opposing the nuclear power plant are wrong factually and are using arguments based upon irrational feelings or vested interest. The learners are asked to identify what can be done to prevent the opposition from succeeding in its goal. From this discussion the learners should isolate a number of potential courses of action.

The teacher asks the learners: In this case (i.e., the issue at hand), which agencies previously identified are most susceptible to influence? (AEC, Congress, power companies, etc.) Why? The class is led to discriminate between those in favor of the project on the bases of (1) their own vested interest in seeing it completed, (2) their obligations to other agencies or directives, and (3) their responsibility to the community and nation in terms of the long-range needs. The class then analyzes each of the agencies identified to discover their motivation for supporting the power plant construction to identify further the type of influence it might respond to.
Instructional Objectives

Learning Steps/Activities

Determine the method of communication or action that will reach and influence the principal. Proceed with a number of role playing situations which will involve the learners in attempts to influence decision making in the face of indifference, opposition and other constraints. The roles should involve the learner becoming aware that in some situations individual action is enough, while in others collective action is needed.
References and Resources

(Resources followed by an asterisk will have to be prepared by the teacher.)

United States Atomic Energy Commission Publications

1. "Atomic Energy in Use"
2. "Atomic Power Safety"
3. "Atoms in Agriculture"
4. "Careers in Atomic Energy"
6. "Food Preservation by Irradiation"
7. "Our Atomic World"
8. "Radioisotopes in Industry"
9. "Research Reactors"

Other Useful Publications

1. Edison Electric Institute, Atomic Power Progress
2. Esso Research and Engineering Company, 101 Atomic Terms and What They Mean
4. Smith, C. B., Nuclear Energy Laboratory, UCLA, Nuclear Power
5. American Nuclear Society, Nuclear Power Reactor Siting

Motion Pictures

1. Atomics International, Atomic Furnaces
2. AEC, Atomic Power and the United States
3. AEC, Harvest of An Atomic Age
4. AEC, The Atom Comes to Town
References and Resources

1. Statistical Comparison of Atomic and Fossil Fuel Potential
2. Statistical Comparison of Safety in Nuclear, Auto, Airplane and Train Fields
3. Decision-Making Model in a Democracy
4. Professional Aids

2. Schmuck, Chester and Lippitt, Problem Solving to Improve Classroom Learning, SRA
3. Oliver and Shaver, Teaching Public Issues in the High School, Houghton Mifflin
NUCLEAR SCIENCE CURRICULUM MODULE OF INSTRUCTION

UNIT: Basic Atomic Structure

COURSE INDEX: This unit should be taught in an eighth grade general science course of study.

THRESHOLD KNOWLEDGE: There is no prerequisite for this unit. It is the first of the series and provides the foundation knowledge for succeeding units.

TERMINAL PERFORMANCE OBJECTIVE: Using a periodic table, the learner will be able to identify and state the atomic number of a given element; the number of protons in the nucleus of a given element; an estimate of the number of neutrons in a given element; and the number of orbital electrons in a given element.

The units provide the technical knowledge required to understand the effects of radiation on matter and thus the ramifications of these effects for the use of irradiated products, using radiation methods for medical diagnosis and treatment, and working with radioactive materials.
**Sequenced Learning Path**

**Instructional Objectives**

**TERMINAL OBJECTIVE.** Shown a Periodic Table, state: the atomic number of a given element; the atomic weight of a given element; the number of protons in the nucleus of a given element; and the number of orbital electrons in a given element.

**b. Orbital electrons**

1. State the symbol and charge for neutron, electron, proton.
2. State mass relationships between neutrons, protons and electrons.
3. Identify the definition of a nuclide.
4. Identify the definition of an isotope.
5. Identify the definition of a nucleon.
6. Distinguish between atomic weight and atomic mass.
7. Given an element with its mass number as a superscript and its atomic number as a subscript, distinguish one from the other.
8. Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom.

**C. Terms and Symbols**

1. Mass number
2. Atomic number
3. Symbol
4. Energy levels, binding energy, ionization potential
5. Ionization
6. Isotope
7. Nucleus

**d. Periodicity of the Elements**

1. Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom.
2. Other.
3. Identify the definition of a nucleon.
4. Identify the definition of a nuclide.
5. Identify the definition of a nucleon.
6. Distinguish between atomic weight and atomic mass.
7. Given an element with its mass number as a superscript and its atomic number as a subscript, distinguish one from the other.
8. Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom.

**2. Atomic number**

A (subscript) Z

**3. Mass number**

A (superscript) n

**4. Symbol**

Symbol

**5. Energy levels, binding energy, ionization potential**

b. Orbital electrons

1. State the symbol and charge for neutron, electron, proton.
2. State mass relationships between neutrons, protons and electrons.
3. Identify the definition of a nuclide.
4. Identify the definition of an isotope.
5. Identify the definition of a nucleon.
6. Distinguish between atomic weight and atomic mass.
7. Given an element with its mass number as a superscript and its atomic number as a subscript, distinguish one from the other.
8. Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom.

**c. Present Concepts of Atomic Structure**

- Nucleus composed of...
- Atomic number Z
- Mass number A
- Symbol
- Protons +
- Neutrons n
- Charge

- Periodic Table, Atomic Weight
- Atomic Number
- Protons
- Neutrons
- Electrons

- Bohr's Postulate of an Atom
<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The atomic number of tin is</td>
<td>1. (50)</td>
</tr>
<tr>
<td>2. The atomic weight of oxygen is</td>
<td>2. (16)</td>
</tr>
<tr>
<td>3. How many protons are in the nucleus of carbon?</td>
<td>3. (6)</td>
</tr>
<tr>
<td>4. How many neutrons would you estimate to be in the nucleus of carbon?</td>
<td>4. (6)</td>
</tr>
<tr>
<td>5. How many electrons would you estimate aluminum contains?</td>
<td>5. (13)</td>
</tr>
</tbody>
</table>

This test may be used as a pre-test and a post-test to measure learner performance. Any one of the elements on the Periodic Table may be substituted in the above test to eliminate pre-post test carry-over.
1. Given the terms neutron, electron, and proton, the learner will be able to prepare a chart indicating the symbol and electrical charge for each particle.

2. Given a list of atomic particles, the learner can prepare a list identifying mass relationships between neutrons, protons, and electrons.
Complete the following chart by indicating the symbol and electrical charge for each of the particles:

<table>
<thead>
<tr>
<th>Particle</th>
<th>Symbol</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron</td>
<td>(n)</td>
<td>(o)</td>
</tr>
<tr>
<td>Electron</td>
<td>(e)</td>
<td>(-)</td>
</tr>
<tr>
<td>Proton</td>
<td>(p)</td>
<td>(+)</td>
</tr>
</tbody>
</table>

**References and Resources**

- *8th Grade Text*
  - The Atom and the Earth
  - Chap. 4, Sec. II B

- Transp. - Relative size of Atom to learner's environment
- Film - How Big is an Atom?
- Single Concept 8 mm loops
  - 1 (Size Relationships of Atoms)
  - 2 (Space Relationships within an Atom)

Selected Readings of the contribution of specific scientists to our knowledge of atomic structure and their experimental approach.

- Rutherford
- Planck
- Bohr
- Dalton
- Thomson
Learning Steps/Activities

3. Identify the definition of a nucleon.

Instructional Objectives

- Discuss and define a nucleon.
- How electrons are attracted and "held" by the nucleus.
- The discovery of protons and the relative mass and charge of protons and neutrons.
- The necessity of neutrons to account for the mass of the atom (No charge; mass = proton).
- Given a definition of a nucleon, the learner will be able to identify that protons and neutrons are referred to as nucleons.
Protons and neutrons are both called

<table>
<thead>
<tr>
<th>A. Particles</th>
<th>B. Nucleons</th>
<th>(X) Both</th>
<th>Neither</th>
</tr>
</thead>
</table>
4. Identify the definition of a nuclide.

Given a description of the term "nuclide," the learner will be able to determine if the given element is a nuclide. When the learner is doing helium, show how the number of neutrons can vary within the atoms of a given element. Explain to the learners that the difference between atoms of different elements is in the number of the particles of which they are composed. Specifically, the atoms of each element have different numbers of protons and, therefore, also electrons. Show some models of simple atom structure and have the learners diagram these models on the board. Identify the structural parts of hydrogen and helium. When the learners diagram these models on the board, identifying numbers of protons and, therefore, also electrons, Which they are composed.

Discuss the value of a 3-dimensional model as opposed to a drawing.

Learning Steps/Activities

Instructional Objectives
The term "Nuclide" is used to describe

A. both protons and neutrons
(X) B. an atomic species characterized by the number of protons and neutrons it contains

Both
Neither

References and Resources

8th Grade Test
The Molecule and the Biosphere
Chap. 10, Sec. III A

Transp. Atomic Structure
(Series of overlays)

Film - A is for Atom
(5.4.4)

Film Strip - Exploring the Atom

Models - Models of simple atoms that can be taken apart.
5. Identify the definition of atomic weight.

6. Distinguish between atomic weight and atomic mass.

Account for the fact that individual isotopes of an element have an atomic mass that is a whole number, while the atomic weight of an element is usually shown as a decimal.

Using the Periodic Table, show how to distinguish one from the other.
The atomic weight of an element

A. is the weighted mean of the masses of the neutral atoms of the isotopes that constitute the element

B. can differ slightly from the atomic mass number because of the presence of isotopes

(X) Both

Neither

8th Grade Text
The Atom and the Earth
Chap. 4, Sec. IV

Table: Periodic Table
Transparency: Periodic Table of Elements
Film Strip: Atomic and Molecular Weights
7. Given an element with its mass number as a superscript and its atomic number as a subscript, distinguish one from the other. Demonstrate on the board how a specific nuclide is designated with the atomic mass number as a superscript and the atomic number as a subscript.

Explain how to determine the number of neutrons in a nuclide by subtracting the atomic number from the atomic mass number. Continue with the diagrams of successively heavier elements, introducing the concept of energy levels as a background for other, later objectives, e.g., ionization and chemical bonding. Should expect learners to be able to diagram electron configuration for elements 1-20.

Instructional Objectives

Given the designation of a specific isotope of an element including the mass number and atomic number as sub and superscripts, the learner will be able to identify the proper subscript which designates the atomic number and mass.

Concept of energy levels could be introduced here as background for other, later objectives, e.g., ionization and chemical bonding. Should expect learners to be able to diagram electron configuration for elements 1-20.

Diagram each.

From the class the number and location of particles compos-

By indicating a specific isotope of the element and listing

Continue with the diagrams of successively heavier elements.

number from the atomic mass.

number of neutrons in a nuclide by subtracting the atomic

number of a nuclide as a subscript. Explain how to determine the

neutrons with the atomic mass number as a superscript. The

Describe on the board how a specific nuclide is designated.

Other.

Given an element with its mass number as a superscript and

Learning Steps/Activities
In the expression $^{235}_{92}\text{U}$:

A. the superscript (235) is the atomic number
B. the subscript (92) is the atomic mass
Both
Neither

(X)

References and Resources

8th Grade Text
The Atom and The Earth
Chap. 4, Sec. IV, A, 2

Transparencies of atomic structure previously used.

Model of atoms used prior activity.

8th Grade Text
The Molecule and the Biosphere
Chap. 10, Sec. III A.
Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom.

Instructional Objectives

8. Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom.

Select specific nucleons from elements 1-20 and ask learners to draw diagrams, showing number of protons, showing number of electrons in the various energy levels. In the nucleus of a given element, the number of protons in the nucleus of a given element; the atomic weight of a given element; and the number of orbital electrons in a given element.

Terminal Performance Objective

Show a Periodic Table, state: The atomic number of an atom.
A carbon atom contains 6 protons, 6 neutrons and 6 electrons. Draw a diagram of this atom according to Bohr's postulate of an atom.
**Instructional Objectives Hierarchy**

**1. A. Background Concepts of Nuclear Energy**

1. **Given a brief description of the Rutherford experiment in 1911 involving the scattering of alpha particles, the learner will be able to state (1) the essential elements in the experiment and (2) the significant conclusion postulated by Rutherford.**

   - **STIMULUS**
     - In 1911, after a series of experiments conducted in a small volume, Rutherford concluded that the atom consists of a central nucleus containing a charge distributed over a small volume.

   - **RESPONSE**
     - Later (1912), the atom was called the Rutherford atom, by which he studied the scattering of alpha particles.

2. **Given a series of statements about the release of electromagnetic energy from the orbital electrons of an atom, the learner will identify that the energy is released in discrete packets or quanta.**

   - **STIMULUS**
     - When waves of electromagnetic energy are released from the orbital electrons of an atom:

   - **RESPONSE**
     - (X) A. The energy is released in discrete packets or quanta.
     - B. The energy released is composed of all the wavelengths of the visible spectrum.
     - C. The energy released is composed of all the wavelengths of the visible spectrum.
     - D. Neither.

   - **C. Given a series of statements about the release of electromagnetic energy from the orbital electrons of an atom:**
     - By Rutherford, significant conclusion postulated in the experiment and (2) the two essential elements to state (1) the essential elements. The learner will be able to identify the scattering of alpha particles, the scattering of alpha particles, the scattering of alpha particles, the scattering of alpha particles.

   - **1. A. 1. Background Concepts of Nuclear Energy**
<table>
<thead>
<tr>
<th>Curriculum Index</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Recommended Achievement</th>
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<td>80/100</td>
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<td>V8,D,1,2</td>
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<tr>
<td>UNIT X SEC 3</td>
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</tbody>
</table>
1. Given the components of a carbon atom, the learner can construct a diagram according to Bohr’s postulate of an atom.

   STIMULUS
   A carbon atom contains 6 protons, 6 neutrons and 6 electrons. Draw a diagram of this atom according to Bohr’s postulate of an atom.

   RESPONSE
   
   

2. Given the terms neutron, electron and proton, the learner will be able to prepare a chart indicating the symbol and electrical charge for each particle.

   STIMULUS
   Complete the following chart by indicating the symbol and electrical charge for each of the particles:

<table>
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<tr>
<th>Particle</th>
<th>Symbol</th>
<th>Charge</th>
</tr>
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<tbody>
<tr>
<td>Neutron</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td>Electron</td>
<td>e</td>
<td>-</td>
</tr>
<tr>
<td>Proton</td>
<td>p</td>
<td>+</td>
</tr>
</tbody>
</table>

   RESPONSE
   
   (n)   (e)   (p)
   (-)   (+)   (+)
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
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<th>Curriculum Index</th>
</tr>
</thead>
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<td>1, II, III, IV</td>
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<td>SEC II B</td>
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</table>
### Instructional Objectives Hierarchy

#### Criterion Test Measures

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Given a list of atomic particles, the learner can prepare a list identifying mass relationships between neutrons, protons, and electrons.</td>
<td></td>
</tr>
<tr>
<td>4. Given a series of statements relative to the structure of an atom, the learner will be able to identify the factors which the structure of an atom determine.</td>
<td></td>
</tr>
<tr>
<td>5. Given a definition of ionization energy, the learner will be able to identify it as such.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The energy required to separate an electron from the remainder of the atom is called the</td>
<td>(ionization)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The structure of an atom determines</td>
<td></td>
</tr>
<tr>
<td>A. to which element it belongs</td>
<td></td>
</tr>
<tr>
<td>B. the chemical properties of the element</td>
<td></td>
</tr>
<tr>
<td>4. Given a series of statements relative to the structure of an atom, the learner will be able to identify the factors which determine</td>
<td></td>
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</tbody>
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<td></td>
</tr>
</tbody>
</table>

### Relational Table

<table>
<thead>
<tr>
<th>Atomic Particle</th>
<th>Relative Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron</td>
<td>Approximately 1/2000 of an electron</td>
</tr>
<tr>
<td>Proton</td>
<td>Approximately 2000 times an electron</td>
</tr>
<tr>
<td>Electron</td>
<td>Approximately some mass</td>
</tr>
<tr>
<td>Neutron</td>
<td>Approximately same mass</td>
</tr>
<tr>
<td>Proton</td>
<td>Approximately 2000 times an electron</td>
</tr>
<tr>
<td>Electron</td>
<td>Approximately some mass</td>
</tr>
<tr>
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<td>Framework Index</td>
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<tr>
<td>90/100</td>
<td>1,III</td>
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<tr>
<td>90/100</td>
<td>1,II,III,IV</td>
</tr>
</tbody>
</table>
Instructional Objectives Hierarchy

Criterion Test Measures

6. Given a statement relative to binding energy, the learner will be able to identify that it holds the particles of the nucleus of the atom together.

7. Given the designation of a specific isotope of an element including the mass number and atomic number as sub and superscript, the learner will be able to identify the proper script which Designates the atomic number and mass.

8. Given a series of statements relative to atomic weight and atomic mass, the learner can identify the characteristics of each.

MO

Binding energy is the term given to the force which

A. holds the protons and neutrons together in the nucleus

B. holds the electrons in specific orbits

Both

Neither

In the expression: $^{235}_{92}U$

- A. the superscript (92) is the atomic number
- B. the subscript (235) is the atomic mass
- Both
- Neither

The atomic weight of an element

A. is the weighted mean of the masses of the neutral atoms of the isotopes that constitute the element

B. can differ slightly from the atomic mass number because of the presence of isotopes

Both

Neither

The learner can identify the characteristic to atomic weight and atomic mass.

7. Given the designation of a specific isotope of an element including the mass number and atomic number as sub and superscript, the learner will be able to identify the proper script which Designates the atomic number and mass.

8. Given a series of statements relative to atomic weight and atomic mass, the learner can identify the characteristics of each.

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Binding energy is the term given to the force which

A. holds the protons and neutrons together in the nucleus

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Neither

In the expression: $^{235}_{92}U$

- A. the superscript (92) is the atomic number
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- Both
- Neither

The atomic weight of an element

A. is the weighted mean of the masses of the neutral atoms of the isotopes that constitute the element

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Both

Neither

The learner can identify the characteristic to atomic weight and atomic mass.

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<tr>
<th>Recommended Achievement</th>
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<th>Curriculum Index</th>
<th>Media-Resource</th>
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<tr>
<td>Instructional Objectives Hierarchy</td>
<td>Criterion Test Measures</td>
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<tr>
<td>-----------------------------------</td>
<td>-------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given a series of four choices, the learner can determine which choice determines the chemical properties of an atom.</td>
<td>9. Given a series of four choices, the chemical properties of an atom are determined by:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given a description of the term “nuclide”, the learner will be able to identify it as an atomic species characterized by the number of protons and neutrons it contains.</td>
<td>10. The term “nuclide” is used to describe:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given a definition of a nucleon, the learner will be able to identify that protons and neutrons are referred to as particles.</td>
<td>11. Given a description of a nucleon, the learner will be able to identify that protons and neutrons are referred to as:</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>Framework Index</td>
<td>Curriculum Index</td>
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<td>-----------------</td>
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<td>UNIT V</td>
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<td></td>
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<td>SEC III</td>
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</tr>
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<td>Science-Chemistry</td>
<td>UNIT XI</td>
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<td>SEC IV</td>
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<td>UNIT X</td>
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<td></td>
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<td>SEC I</td>
<td></td>
</tr>
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<td></td>
<td>Science-Chemistry</td>
<td>UNIT V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SEC III</td>
<td></td>
</tr>
</tbody>
</table>

Media-Resource
12. Given two statements about atoms which differ only in their number of neutrons, identify that they will have a different mass and that they are called isotopes of the same element.

13. Given a series of statements describing isotopes, the learner will identify that different isotopes of an element (1) possess same number of protons but have the same number of neutrons, and (2) have varying numbers of neutrons and are also considered as different nuclides, the learner will identify different isotopes of an element. Two or more types of atoms which differ only in their number of neutrons are called isotopes of the same element. Different isotopes (X) are nuclides. Given two statements about atoms, the learner will identify that they have a different mass and that they are called isotopes of the same element.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
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<td>TEXT B</td>
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<td></td>
<td>TEXT B</td>
<td>CHAP 4</td>
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</tbody>
</table>
14. Given a diagram of an ion, the learner will be able to identify the particle as an ion and determine the net positive or negative electrical charge.

15. Given a description of the process whereby an electron is knocked away from an orbit, the learner will be able to state that this process is called ionization.

The atom shown would have a net (positive/negative) electrical charge. An atom (or molecule) with a net electrical charge is called a(n) _____________. The process whereby an electron is knocked away is called (ionization).
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<td>UNIT 6 SEC IV C</td>
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</tr>
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</table>
16. Given two statements about what produces similar behavior in elements, state that they have the same number of electrons in the outer shell.

17. Given six element symbols with superscripts, state that the superscript is called the mass number and that it represents the mass of the isotope to the nearest whole number.

The similar behavior among elements having similar chemical characteristics is attributed to the fact that:

(A) they have the same number of outer electrons, 
(B) they have the same number of outer shells, 
(C) they have the same number of nuclei, or 
(D) they have the same number of nuclei.

The similar behavior among elements having similar characteristics is attributed to the fact that:

(A) they have the same number of outer electrons, 
(B) they have the same number of outer shells, 
(C) they have the same number of nuclei, or 
(D) they have the same number of nuclei.
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</table>
18. Given a diagram of an atom, state the atomic mass number and the atomic number.

19. Given an example of the process of ionization, name the process as an ionization process and identify the resulting particle as an ion.
<table>
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<tr>
<td>SEC I</td>
<td></td>
<td>19</td>
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</tr>
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</table>
Given a description of periodicity, name it as such.

Given the Periodic Table, state:
- the atomic number of a given element;
- the atomic weight of a given element;
- the number of protons in the nucleus of a given element, an estimate of the number of neutrons;
- the number of orbital electrons in a neutral atom of the element.

The Periodic Table of Elements

5. How many electrons would a neutral atom of aluminum (Al) have?

6. How many neutrons would you estimate to be in the nucleus of carbon (C)?

7. How many protons are in the nucleus of carbon (C)?

2. The atomic weight of tin is 118.70

1. The atomic number of tin is 50

The Periodic Table of Elements

21. Given a description of periodicity, name it as such.

20. Given the Periodic Table, state:
- the number of protons in the nucleus of a given element;
- the number of neutrons and the atomic weight of a given element;
- the number of orbital electrons in a neutral atom of the element.

Instructional Objectives Hierarchy

Criterion Test Measures
<table>
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<td>SEC II</td>
</tr>
</tbody>
</table>
Given two statements concerning the vertical arrangement of elements on the periodic chart, identify (1) the significance of the groupings and (2) the proper nomenclature.

A graphic display, showing the various forms of energy classified according to electromagnetic energy levels, is called an electromagnetic spectrum.

The learner can identify the display as a representation of the electromagnetic spectrum as various forms of energy classified as electromagnetic energy levels are shown.

(a) Both
(b) Neither
(c) X

Given a graphic display, showing the various forms of energy classified according to electromagnetic energy levels, the learner can identify the display as a representation of the electromagnetic spectrum.

22. Given two statements concerning the vertical arrangement of elements on the periodic chart:

- A. are called "groups"
- B. contain elements with analogous properties

Select the correct response:

- (X) Both
- Neither

23. A graphic display, showing the various forms of energy classified according to electromagnetic energy levels, is called an electromagnetic spectrum.
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### Instructional Objectives

<table>
<thead>
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<tbody>
<tr>
<td><strong>Hierarchy</strong></td>
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24. Given three explanatory statements about observed properties of matter, state that all observed properties of matter can be explained if you assume a wave-particle characteristic of matter.

25. Given two statements describing when a photon has mass, the learner can identify the relationship of movement to mass. A photon has mass when it is moving.

<table>
<thead>
<tr>
<th>STIMULUS</th>
<th>RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither</td>
<td>(b)</td>
</tr>
<tr>
<td>Both</td>
<td>(d)</td>
</tr>
<tr>
<td>A. When it is moving</td>
<td>(X)</td>
</tr>
</tbody>
</table>

- **STIMULUS**
  - Ali observed properties of matter can be explained by:
    - (a) assuming a wave-particle characteristic of matter
    - (b) assuming that all matter exists in the form of waves
    - (c) assuming that all matter exists in the form of particles
    - (d) none of the above

- **RESPONSE**
  - A photon has mass when it is moving.
<table>
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<th>Media-Resource</th>
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<td>SEC 5 B, 6, C</td>
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</table>
### Instructional Objectives Hierarchy

#### Criterion Test Measures

26. Given a series of statements relative to mass and charge of various atomic particles, the learner will identify and classify each.

27. Given a statement concerning the relationship between the kinetic energy and mass of a photon, the learner will be able to state that they are equivalent.

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
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</thead>
<tbody>
<tr>
<td>Match B-column terms to A-column terms</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A-column</th>
<th>B-column</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. has mass of 1 amu</td>
<td>1. proton</td>
</tr>
<tr>
<td>B. has no rest mass</td>
<td>2. electron</td>
</tr>
<tr>
<td>C. has negative electrical charge</td>
<td>3. neutron</td>
</tr>
<tr>
<td>D. has negative electrical charge</td>
<td>(A, C)</td>
</tr>
<tr>
<td>E. has positive electrical charge</td>
<td>(A, F)</td>
</tr>
</tbody>
</table>

A photon is said to have mass because its kinetic energy is equivalent to mass.

Equivalent energy is the mass of a photon, the learner will be able to state that they are equivalent.
<table>
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<tr>
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<th>Objectives Measured</th>
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<th>Curriculum Index</th>
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<td>SEC II E</td>
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</tbody>
</table>
28. Given a series of statements, the learner will be able to identify the statements relevant to the law of conservation.

29. Given a statement about the type of energy that is produced by the changing of energy levels of orbital electrons within an atom, state that this type of energy is called electromagnetic energy.

30. Given two correct statements concerning the reasons atoms may emit electromagnetic energy, state that both statements are correct.

STIMULUS
The law of conservation of energy states that energy can be created but not destroyed, can be transformed into equivalent states, can neither be created nor destroyed.

RESPONSE
(a) Neither
(b) Both
(x) Both

STIMULUS
The type of energy that is produced by the changing of energy levels of orbital electrons within an atom is called electromagnetic energy.

RESPONSE
(d) Both b and c

STIMULUS
Atoms may emit electromagnetic energy because

RESPONSE
A. They are radioactive
B. They have absorbed a surplus of energy from some external source
C. They are radioactive
D. They have absorbed a surplus of energy from some external source

xe

Both

Neither

0

1
<table>
<thead>
<tr>
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<th>Curriculum Index</th>
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Instructional Objectives Hierarchy

Criterion Test Measures

I.B.1 Nuclear Radiation

1. Given two forms of radiation, state that these are the forms of radiation radioactive elements give off.

2. Given two statements about the forms of radiation, state that Beta particles are given off by radioactive elements.

3. Given two correct statements describing when an element is radioactive, state that both of them are correct.

4. In what form do radioactive elements give off radiation?
   - A. Alpha particles
   - B. Gamma Rays
   - Neither
   - Both

5. In what form do radioactive elements give off radiation?
   - A. Beta particles
   - B. Infrared rays
   - Neither
   - Both

6. An element is radioactive
   - A. it spontaneously disintegrates and gives off particles and/or electromagnetic energy.
   - B. it randomly disintegrates and gives off particles and/or electromagnetic energy.
   - Neither
   - Both

7. In what form do radioactive elements give off radiation?
   - A. Alpha particles
   - B. Gamma rays
   - Neither
   - Both

Institutional Objectives Hierarchy

Criterion Test Measures

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<table>
<thead>
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</table>
1. The learner will be able to associate the fact that knowing the characteristics of a form of nuclear radiation or a nuclear particle, aids in predicting its effects on matter.

2. Given a series of statements about particles or rays, the learner will identify that different particles or rays will more easily penetrate matter because they have different abilities to ionize the atoms of which the matter is composed.

3. Given a problem regarding the determination of an unknown isotope, the learner will be able to state that you must know the type of radiation emitted by a radioactive isotope, you need only determine its half-life in order to identify the isotope. If you know the type of radiation emitted by a radioactive isotope, you will know the emitting element.

Criterion Test Measures

Criterion: Properties

1. B. 2 Kinds of Nuclear Radiation

Instructional Objectives Hierarchy

Criterion: Properties

1. B. 2 Kinds of Nuclear Radiation
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</table>
4. Given the definition of transmutation, the learner will be able to name it as such.

5. Given the three types of radiation—Alpha particle, Beta particle, and Gamma ray, state their symbols and their compositions.

<table>
<thead>
<tr>
<th>Type of Radiation</th>
<th>Symbol</th>
<th>Symbol Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha particle</td>
<td>( \alpha )</td>
<td>( 2 \text{ protons} + 2 \text{ neutrons} )</td>
</tr>
<tr>
<td>Beta particle</td>
<td>( \beta )</td>
<td>( 1 \text{ electron} )</td>
</tr>
<tr>
<td>Gamma ray</td>
<td>( \gamma )</td>
<td>( \text{emitted from nucleus} )</td>
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</table>

Gamma ray, Beta particle, and Alpha particle are collectively known as radioactive particles. The changing of a nucleus from one element to another by the emission of radioactive particles is called transmutation.
<table>
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</tr>
</tbody>
</table>
6. Given a series of statements about the emission of gamma rays from the nucleus of a radioactive isotope, the learner will be able to identify that normally, before the nucleus will emit a gamma ray, it must emit an Alpha or Beta particle.

7. Given that Alpha, Beta and Gamma rays are kinds of nuclear radiation, identify that protons and neutrons as types of radiation may also be emitted from the nucleus of radioactive atoms. In addition to Alpha, Beta and Gamma rays, the nuclei of radioactive atoms may sometimes emit:

A. Protons
B. Neutrons
C. Light Red
D. Ultra Violet
E. Both A and B
F. Both C and D

RESPONSE

A. It must emit an Alpha or Beta particle.
B. It must absorb energy from some outside source.
C. Neither.
D. Both.

STIMULUS
<table>
<thead>
<tr>
<th>Curriculum Index</th>
<th>Science-Physics</th>
<th>Science-Chemistry</th>
<th>TEXT B CHAP. 7 SEC. III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework Index</td>
<td>I, III</td>
<td>I, II, III, IV</td>
<td></td>
</tr>
<tr>
<td>Objectives Measured</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Recommended Achievement</td>
<td>$\frac{90}{100}$</td>
<td>$\frac{90}{100}$</td>
<td></td>
</tr>
</tbody>
</table>
8. Given a statement about the approximate number of nuclear fragments discovered thus far, identify that almost 50 nuclear fragments have been discovered.

9. Given two terms—neutrino and meson—state that they are examples of particles identified from fragmentation of nuclei of an atom. An example of a particle identified from fragmentation of nuclei is

- A. neutrino
- B. meson
- Both
- Neither

STIMULUS

Scientists have discovered (almost 50) nuclear fragments in their experimentation thus far. Thus far, they have identified 50 nuclear fragments in their experimentation thus far. Almost 50 nuclear fragments discovered. Scientists have discovered in their experimentation thus far a number of nuclear fragments almost 50.

RESPONSE

Almost 50 nuclear fragments discovered. Scientists have discovered a number of nuclear fragments almost 50.
<table>
<thead>
<tr>
<th>Curriculum Index</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Recommended Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science-Physics UNIT X SEC. 1</td>
<td>I, II, III, IV</td>
<td>8</td>
<td>90/100</td>
</tr>
<tr>
<td>Science-Physics UNIT X SEC. 1</td>
<td>I, II, III, IV</td>
<td>9</td>
<td>90/100</td>
</tr>
<tr>
<td>Stimulus</td>
<td>Response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The rate at which an isotope emits radiation increases as the amount of isotope present increases.</td>
<td>(x) B. Neither</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. **Instructional Objectives Hierarchy**

**I.B.3. Characteristics of Radioactive Decay**

2. **Criterion Test Measures**

Given two statements, identify that the laws of probability enable you to determine when the sample of an isotope contains a great number of atoms and when an isotope emits radiation.

- A. enable you to predict when a single atom will emit radiation
- B. enable you to determine the decay constant of an isotope when the sample of the isotope contains a great number of atoms

**STIMULUS**

The rate at which an isotope emits radiation (decreases/increases) as the amount of isotope present increases.

**RESPONSE**

(x) B. Neither

**The laws of probability**

A. enable you to predict when a single atom will emit radiation

B. enable you to determine the decay constant of an isotope when the sample of the isotope contains a great number of atoms.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>CHAP. 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SEC. III</td>
</tr>
</tbody>
</table>
3. Given instructions to write the definition of half-life, state that the half-life is the time required for a radioactive substance to lose half its radioactivity.

(1) Given the half-life of a specific radioactive isotope, the learner will be able to state how long it would take for the amount of that isotope to be reduced by 1/4.

(2) Given a graph of the rate of decay of a radioactive isotope, the learner will be able to state the half-life.

(3) Given instructions to write the definition of half-life, write a definition of half-life.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<td>CHAP. 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SEC. III B</td>
<td></td>
</tr>
<tr>
<td>90/100</td>
<td>4</td>
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<td></td>
<td>SEC. III B</td>
<td></td>
</tr>
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<td>Science-Chemistry</td>
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<td>I C 2</td>
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<td>Science-Physics</td>
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<td></td>
<td>SEC. I</td>
<td></td>
</tr>
</tbody>
</table>

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### Instructional Objectives Hierarchy

**Criterion Test Measures**

1. **1.8.4 Interaction of Radiation with Matter**
   - **1.** Given a series of statements about the absorption of radiation by different materials of varying thickness, the learner will identify which materials are appropriate for shielding from the different types of radiation.

<table>
<thead>
<tr>
<th>Type of Radiation</th>
<th>Required Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alpha Particles</strong></td>
<td>Neither</td>
</tr>
<tr>
<td><strong>Beta Particles</strong></td>
<td>Both</td>
</tr>
<tr>
<td><strong>Gamma Rays</strong></td>
<td>Both</td>
</tr>
</tbody>
</table>

Experiments show that a sheet of paper is an example of the minimum amount of shielding required to absorb

- Neither
- Both

A few inches of wood or aluminum is sufficient to absorb

- Neither
- Both

A fairly great thickness of lead will absorb

- Neither
- Both

1. **1.8.4 Interaction of Radiation with Matter**

- Experiments show that a sheet of paper is an example of the minimum amount of shielding required to absorb

- Alpha Particles
- Beta Particles

- A fairly great thickness of lead will absorb

<table>
<thead>
<tr>
<th>Alpha Particles</th>
<th>Neither</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta Particles</td>
<td>Neither</td>
</tr>
<tr>
<td>Gamma Rays</td>
<td>Neither</td>
</tr>
</tbody>
</table>

- Experiments show that a sheet of paper is an example of the minimum amount of shielding required to absorb

1. Given a series of statements about the different types of radiation, which materials are appropriate for shielding from the different types of radiation by different materials.
<table>
<thead>
<tr>
<th>Media-Resource</th>
<th>Curriculum Index</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Recommended Achievement</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>90/100</td>
</tr>
<tr>
<td>Type of Radiation</td>
<td>Ability to Penetrate Matter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha-particles</td>
<td>1. Penetrate least amount</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta-particles</td>
<td>2. Penetrate in between least and most</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gamma rays</td>
<td>3. Penetrate farthest</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Match the following:**

**STIMULUS**

3. Given three types of radiation and three levels of penetration of matter, state that Alpha particles penetrate the least amount, Beta particles penetrate in between least and most, and Gamma rays penetrate the farthest.

**RESPONSE**

- A. Alpha-particles
- B. Beta-particles
- C. Gamma rays
<table>
<thead>
<tr>
<th>Media-Resource</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Framework Index</td>
<td>2</td>
<td>90/100</td>
</tr>
<tr>
<td></td>
<td>Science-8 TEXT B</td>
<td>CHAP 7 SEC III I, II, III, IV</td>
<td></td>
</tr>
</tbody>
</table>
3. Given three types of radiation, state that the Alpha particle is most effective in producing ions per unit path of material, that the Beta particles are in the middle in effectiveness in producing ions per unit path of material, and that Gamma rays are the least effective in producing ions per unit path of material.

4. Given a statement which asks what effect of radiation on matter is of primary concern from a health standpoint, state that it is the ionizing effect.

**Match the following:**

<table>
<thead>
<tr>
<th>Type of Radiation</th>
<th>Effortiveness in Producing Ions per Unit Path of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma rays</td>
<td>3. Most effective</td>
</tr>
<tr>
<td>Beta particles</td>
<td>2. Middle effectiveness</td>
</tr>
<tr>
<td>Alpha particles</td>
<td>1. Least effective</td>
</tr>
<tr>
<td>Curriculum Index</td>
<td>Science-Physics UNIT X SEC I - III</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Framework Index</td>
<td>I, II, III, IV</td>
</tr>
<tr>
<td>Objectives Measured</td>
<td>3</td>
</tr>
<tr>
<td>Recommended Achievement</td>
<td>90/100</td>
</tr>
</tbody>
</table>
Instructional Objectives Hierarchy

Criterion Test Measures

5. Given a statement about the ionizing effect of radiation on matter, (1) state that the atoms of the material absorb the energy of the radiation. (2) Identify that orbital electrons are ejected from the atom; a positively charged ion remains. (3) State that what remains is a positively-charged ion.

STIMULUS

In the ionizing effect of radiation on matter, the atoms of the material absorb the energy of the radiation. (2) Identify that orbital electrons are ejected from the atom; a positively charged ion remains. (3) Given a statement about the ionizing effect of radiation on matter, (1) state that the atoms of the material absorb the energy of the radiation. (2) Identify that orbital electrons are ejected from the atom; a positively charged ion remains.

RESPONSE

(energy) (Orbital) (ion) (Nuclear) electrons are ejected from the atom; a positively-charged ion remains.

Criterion Test Measures
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>ObjectivesMeasured</th>
<th>FrameworkIndex</th>
<th>CurriculumIndex</th>
<th>Media-Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>90/100</td>
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<td>I,II,III,IV</td>
<td>Science-Chemistry UNIT XI SEC 2 UNIT XI-4E 1, 2 Science-Physics</td>
<td></td>
</tr>
</tbody>
</table>
Instructional Objectives Hierarchy

I.C. 1

Units of Measurement of Radioactivity
and Radiation Dosimetry

1. Given four units for measuring radiation and radioactivity and four descriptions of these units, match the descriptions with their proper units.

Match the units on the left with their descriptions on the right.

**Criterion Test Measures**

**RESPONSE**

1. Rutherford
   - amount of radioactive material
   - amount of radiation at a specified point
   - amount of radiation at a particular point
   - amount of radiation from a source

2. Roentgen
   - amount of radiation at a specified distance
   - amount of radiation absorbed per gram of material
   - amount of radiation absorbed per unit mass
   - Roentgen equivalent

3. Rem
   - amount of radiation absorbed per gram of material
   - amount of radiation absorbed per unit mass
   - amount of radiation absorbed per unit mass
   - amount of radiation absorbed per unit mass

4. Rad
   - amount of radiation at a particular point
   - amount of radiation absorbed per unit mass
   - amount of radiation absorbed per unit mass
   - amount of radiation absorbed per unit mass

5. Curie
   - amount of radiation absorbed per unit mass
   - amount of radiation absorbed per unit mass
   - amount of radiation absorbed per unit mass
   - amount of radiation absorbed per unit mass

With their proper units.

Criterion Objectives Hierarchy
<table>
<thead>
<tr>
<th>Media-Resource</th>
<th>Curriculum Index</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Recommended Achievement</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Science-8 TEXT B</td>
<td>1, II, III, IV</td>
<td>1</td>
<td>$\frac{90}{100}$</td>
</tr>
</tbody>
</table>
2. Given instruction to write the symbol for a Curie and a Roentgen, write that "Ci" is the symbol for a Curie and that "r" is the symbol for a Roentgen.

3. Identify that it is sometimes useful to consider a Roentgen, a rad, and a rem to be practically equivalent, although a Roentgen and a rad are not always equivalent.

Which of the following statements may usually be considered as facts?

A. Sometimes it is useful to consider a roentgen, a rad, and a rem to be practically equivalent.
B. A roentgen and a rad are not always equivalent.

( ) Neither
( ) Both
( ) A
( ) B

Write the symbol for a Curie.

( ) Write the symbol for a Roentgen.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<td></td>
<td>CHAP &amp;</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td>SEC II B2</td>
<td></td>
</tr>
</tbody>
</table>
Instructional Objectives Hierarchy

Criterion Test Measures

1. Given six prefixes—kilo, mega, micro, milli, nano, and pico—write the symbol for each of the following prefixes.

2. Given six prefixes—kilo, mega, micro, milli, nano, and pico, order them from the largest to the smallest.

1. C.2 Prefixes and Symbols

Criterion Test Measures

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pico</td>
<td>pico</td>
</tr>
<tr>
<td>Nano</td>
<td>nano</td>
</tr>
<tr>
<td>Milli</td>
<td>milli</td>
</tr>
<tr>
<td>Micro</td>
<td>micro</td>
</tr>
<tr>
<td>Mega</td>
<td>mega</td>
</tr>
<tr>
<td>Kilo</td>
<td>kilo</td>
</tr>
</tbody>
</table>

RESPONSE

STIMULUS

ORDER THE FOLLOWING PREFIXES ACCORDING TO DECREASING SIZE: KILO, MEGA, MICRO, MILLI, NANO, PICO.

RESPONSE

STIMULUS

WRITE THE SYMBOL FOR EACH OF THE FOLLOWING PREFIXES:

- Pico
- Nano
- Milli
- Micro
- Mega
- Kilo
3. Given eight units—curie, microcurie, picocurie,.

STIMULUS

Criterion Test Measures

Instructional Objectives Hierarchy

3. Given eight units—curie, microcurie, picocurie,.

RESPONSE

A. Most appropriate unit to measure the amount of 90 Sr found in milk.

B. Most appropriate unit to measure the amount of background radiation.

C. Most appropriate unit to measure the amount of radiation from a chest X-ray.

8. Milliquivango

7. Milliroentgen

6. Kilojoule

5. Measured

4. Millirontgen

3. Picocurie

2. Microcurie

1. Curie
<table>
<thead>
<tr>
<th>Curriculum Index</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Recommended Achievement</th>
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<td>UNIT VI</td>
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</tr>
<tr>
<td>SEC III C</td>
<td></td>
<td></td>
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</tbody>
</table>
Given a statement about radioactive material and its ease of detection in comparison to an equal amount of chemical substance, state that a small amount of radioactive material is easier to detect than an equal amount of chemical substance.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
</tr>
</thead>
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<td>CHAP 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SEC III</td>
</tr>
</tbody>
</table>
1. Given two correct statements about standards for measuring radioactivity, state that both are correct.

A. are established and maintained by the National Standards for measuring radioactivity
B. are similar to the standards for measuring length, mass, and time
C. are established and maintained by the National Bureau of Standards

2. Given a list of several instruments, identify those used to detect radiation. Here is a list of instruments. Place a check before those used to detect radiation.

- Accelerator
- Reactor
- Cloud chamber
- Geiger tube
- Photographic film
- Cathode-ray tube
- Electroscope

RESPONSE

Neither

Both

(X)
<table>
<thead>
<tr>
<th>Media-Resource</th>
<th>Social Science-8</th>
<th>Science-8</th>
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</thead>
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</tbody>
</table>
### Instructional Objectives Hierarchy

#### I.D. Methods of Detection and Measurement of Radioactivity

<table>
<thead>
<tr>
<th>STIMULUS</th>
<th>RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>To find out whether or not a radiation detection instrument is operating accurately, you compare its reading with the radiation of a (known source or standard)</td>
<td>Most radiation detection devices measure the ionizing effect of radiation on matter.</td>
</tr>
<tr>
<td><em>(X)</em></td>
<td>B. the degree of penetration of matter by radiation</td>
</tr>
<tr>
<td></td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Neither</td>
</tr>
</tbody>
</table>

1. State what is used to determine whether or not a radiation detection instrument is operating correctly.

2. Identify what most radiation detection devices measure.
<table>
<thead>
<tr>
<th>Media-Resource</th>
<th>Curriculum Index</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Recommended Achievement</th>
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<tbody>
<tr>
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</table>
Instructional Objectives Hierarchy

3. Given two correct responses about the function of mechanical and electrical devices used in radiation detectors; state that they are correct.

4. Given a statement about film being used to detect radiation, state what is the observable effect of radiation on photographic film and what process causes this effect.

Radiation detectors are associated with mechanical and electrical devices. The function of these mechanical and electrical devices is

A. to amplify, convert, and record the signal from the detector
B. to supply high voltage to the detector when needed

Film can be used to detect radiation.

STIMULUS

A. (ionization)
B. (dark areas)

RESPONSE

Neither
Both (x)

The observable effect of radiation on photographic film causes changes that will show up as

in the film emulsion, resulting in chemically caused by

When the film is developed, what is the observable effect of radiation on photographic film?
Instructional Objectives Hierarchy

Criterion Test Measures

I.E.1 Sources of Radiation - Natural Sources

1. Given instruction to state the source of cosmic radiation, state that its source is outer space.
2. Given a statement about cosmic rays bombarding the earth, identify that the cosmic rays have always bombarded the earth since about 1900.
3. Given the statement concerning the three natural sources of background radiation, name the three natural sources of radiation.

Additionally:

- Cosmic radiation comes from outer space.
- The cosmic rays have always bombarded the earth.
- The three natural sources of background radiation are:
  1. Cosmic rays
  2. Radioactive isotopes in building materials
  3. Radioactive isotopes in radioactive isotopes
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### Instructional Objectives Hierarchy

#### Criterion Test Measures

4. Given four numbers, identify the appropriate amount of radiation we receive in a year from our natural background.

5. Given three sources of background radiation, identify the approximate amount of radiation contributed by each source.

#### Stimulus

**Given three sources of background radiation, identify the approximate amount of radiation contributed by each source.**

Place the appropriate letter in the second column of the box below.

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<thead>
<tr>
<th>Source</th>
<th>Amount of Radiation Received in a Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmic radiation</td>
<td>F, 125 rad/year</td>
</tr>
<tr>
<td>Radiation from earth and building materials</td>
<td>E, 25 rad/year</td>
</tr>
<tr>
<td>Internal radiation</td>
<td>D, 5 rad/year</td>
</tr>
<tr>
<td>Radiation from source</td>
<td>C, 125 mrad/year</td>
</tr>
<tr>
<td>In a year from source</td>
<td>B, 25 mrad/year</td>
</tr>
<tr>
<td>Radiation received</td>
<td>A, 5 mrad/year</td>
</tr>
</tbody>
</table>

#### Response

Circle the number which most closely represents the amount of radiation received in a year from natural background.

- 3 mrad
- 30 mrad
- 300 mrad
- 3,000 mrad

**Response**

- 3 mrad
- 30 mrad
- 300 mrad
- 3,000 mrad

Circle the number which most closely represents the amount of radiation received in a year from natural background.

**Response**

- 3 mrad
- 30 mrad
- 300 mrad
- 3,000 mrad
<table>
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1. **Fission and Fusion Process**

   **Given the definitions of fission and fusion, distinguish between them.**

   - **Given an example of fusion, the learner will be able to identify it as such.**
   - **Given a statement of why fission fragments are of concern to all of us, state that they are often highly radioactive.**

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
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<tr>
<td>STIMULUS</td>
<td>RESPONSE</td>
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<td>RESPONSE</td>
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</table>

- **Fission/Fusion** is the joining together of small, light nuclei to form larger and heavier nuclei.
- **Fission/Fusion** is the splitting of large, heavy nuclei into primarily two fragments.
- The joining together of hydrogen nuclei to form helium is an example of **fusion**.
- Fission fragments are of interest and concern to all of us because they are often highly radioactive.

- A. Fission
- B. Fusion
- Neither
- Both
- **(X)**

- **Given the definitions of fission and fusion, distinguish between them.**
- **Given a statement of why fission fragments are of concern to all of us, state that they are often highly radioactive.**

- **(X)**

- **Given an example of fusion, the learner will be able to identify it as such.**
- **Given a statement of why fission fragments are of concern to all of us, state that they are often highly radioactive.**

- **(X)**

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Given two products in addition to the fission fragments which are released when a uranium nucleus splits, state that both are correct.

Given two correct statements about mass being converted into energy which is released by nuclear fission and nuclear fusion, state that they are both correct.

Given a statement about the magnitude of energy released during nuclear fission and the energy released in a normal chemical reaction, state that the energy released during nuclear fission is usually much greater than the energy released in a normal chemical reaction.

What other products are released when a uranium nucleus splits?

A. two to three neutrons per fission
B. energy

Criterion Test Measures

In a normal chemical reaction, much greater than the energy released during nuclear fission is usually released during nuclear fission, state that the energy released in a normal chemical reaction is much greater than the energy released during nuclear fission.

STIMULUS

RESPONSE
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</table>
7. Given instruction to construct a mathematical equation which expresses the basic law of the conversion of matter into energy, write the equation: \( E = mc^2 \).

8. Given the description of the process which constitutes a chain reaction, name that process as a chain reaction.

9. Given a statement about critical mass and amounts of fissionable material, state that critical mass is the minimum amount of fissionable material that can sustain a chain reaction.
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</table>
10. Given the statement that the amount of fissionable material less than a critical mass would not sustain a chain reaction, identify that the reason is that the neutrons can escape from the mass before being absorbed by other nuclei.

Both

A. the neutrons can escape from the mass before being absorbed by other nuclei.

B. no neutrons would be absorbed by other nuclei.

Neither

11. Given the phrase thermonuclear process, state that nuclear fusion is another name for the thermonuclear process.

(Answer: fusion)
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</table>
12. Given two correct statements about the necessary conditions for fusion to occur, identify that:
(a) extreme heat is necessary and that (b) extreme pressure is necessary for sustained fusion to occur.

13. Distinguish that an A-bomb utilizes the fission process and not the fusion process.

14. Given a statement about atom bombs and the energy they yield, state that an A-bomb uses a fission process and that it yields energy equivalent to thousands of tons of TNT.

15. Given a statement about H-bombs and the amount of energy yielded, state that an H-bomb uses fusion and yields energy equivalent to millions of tons of TNT.

In order for sustained fusion to occur, there must be:

- A. extreme heat present
- B. extreme pressure present

Neither
Both

Criterion Test Measures

Instructional Objectives Hierarchy

Criterion Test Measures

In order for sustained fusion to occur, there must be:

- A. extreme heat present
- B. extreme pressure present

Neither
Both
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</table>
16. Given a statement about heat and pressure required for fusion to occur in an H-bomb, identify that the heat and pressure required for fusion to occur in an H-bomb is supplied by

- Neither
- Both
- H-bomb
- A bomb

17. Given a statement about how nuclear explosions differ from conventional explosions, state that nuclear explosions are accompanied by radiation.

- Neither
- Both
- A
- B

18. Given two correct statements and three products of explosions, state that nuclear explosions and conventional explosions produce heat, blast effect, and shock. The results of a nuclear explosion differs from a conventional explosion in that the nuclear detonation is accompanied by radiation.

- Neither
- Both
- A
- B

Criterion Test Measures

16. Given a statement about heat and pressure required for fusion to occur in an H-bomb, identify that the heat and pressure required for fusion to occur in an H-bomb is supplied by

- Neither
- Both
- H-bomb
- A bomb

17. Given a statement about how nuclear explosions differ from conventional explosions, state that nuclear explosions are accompanied by radiation.

- Neither
- Both
- A
- B

18. Given two correct statements and three products of explosions, state that nuclear explosions and conventional explosions produce heat, blast effect, and shock. The results of a nuclear explosion differs from a conventional explosion in that the nuclear detonation is accompanied by radiation.

- Neither
- Both
- A
- B

Informal Objectives Hierarchy

16. Given a statement about heat and pressure required for fusion to occur in an H-bomb, identify that the heat and pressure required for fusion to occur in an H-bomb is supplied by

- Neither
- Both
- H-bomb
- A bomb

17. Given a statement about how nuclear explosions differ from conventional explosions, state that nuclear explosions are accompanied by radiation.

- Neither
- Both
- A
- B

18. Given two correct statements and three products of explosions, state that nuclear explosions and conventional explosions produce heat, blast effect, and shock. The results of a nuclear explosion differs from a conventional explosion in that the nuclear detonation is accompanied by radiation.

- Neither
- Both
- A
- B
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19. Given two statements about nuclear technology and nuclear weapons, state that nuclear technology is primarily devoted to peaceful applications of nuclear energy, while nuclear weapons technology is primarily devoted to the development of destructive devices.

20. Given a definition of fallout, state that it is such.

Fission fragments from the detonation of a nuclear device in the earth's atmosphere are trapped in condensed material which was vaporized in the intense heat. The particles which settle out of the atmosphere to the earth's surface are called.

RESPONSE
(peaceful)
(destructive)

RESPONSE
(fallout)
<table>
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21. Given two statements about fallout, state which one describes immediate fallout and which one describes delayed fallout.

Stimulus
Fallout which settles out of the atmosphere in a few hours or days is called (immediate/delayed) fallout.

Response
Select one from A, B, C, D, E, or F.

A. 100 to 200 mrem per year
B. 10 to 20 mrem per year
C. 100 to 200 mrem per year
D. 1 to 5 mrem per year

22. Given six amounts of fallout, identify the approximate amount from previous atomic tests which adds to our exposure from radiation background.

Stimulus
The approximate amount of fallout from previous atomic tests which is added to our exposure is

Response
Select one from A, B, C, D, E, or F.

A. 1 to 5 mrem per year
B. 10 to 20 mrem per year
C. 100 to 200 mrem per year
D. 1 to 5 r per year
E. 10 to 20 r per year
F. 100 to 200 r per year
<table>
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</table>
Given a description of a government agency which checks fallout, name the agency.

Which government agency has the responsibility for continuously checking the amount of radioactive fallout?

(Public Health Service)
<table>
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<tr>
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I.E.3. Machine Sources of Radiation

1. Given a definition of an accelerator, name the term "accelerator" as best being described by the definition.

2. Given a list of instruments and devices, identify those which are accelerators. Circle the number next to those which are accelerators.

   Below is a list of instruments and devices:

   1. geiger counter
   2. cyclotron
   3. cosmotron
   4. simulator ray tube
   5. bevatron

   RESPONSE

   1
   4

   geiger counter
cyclotron

   RESPONSE

   STIMULUS

   The general term used for a device that increases the velocity and energy of charged elementary particles such as electrons or protons, by the application of electrical and/or magnetic forces is a(n) (accelerator).
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</table>
### Instructional Objectives Hierarchy

#### Criterion Test Measures

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither</td>
<td>(X)</td>
</tr>
<tr>
<td>Both</td>
<td></td>
</tr>
<tr>
<td>A. Changing levels of orbital electrons</td>
<td>(X)</td>
</tr>
<tr>
<td>B. Nucleus of the atom</td>
<td></td>
</tr>
<tr>
<td>Normally, gamma rays come from the nucleus of the atom.</td>
<td></td>
</tr>
</tbody>
</table>

4. Given a statement about X-rays, X-rays are (the same form/ a different form) of energy as Gamma rays. Normally, gamma rays come from the nucleus of the atom. Identify that X-rays and Gamma rays are the same form of energy.

5. Given a correct statement about the origin of Gamma rays, identify that they come from the nucleus of the atom. Normally, gamma rays come from the nucleus of the atom. Identify that X-rays and Gamma rays are the same form of energy.

### Sample Response

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
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<tbody>
<tr>
<td>Neither</td>
<td>(X)</td>
</tr>
<tr>
<td>Both</td>
<td></td>
</tr>
<tr>
<td>A. In a straight path in a cyclotron</td>
<td></td>
</tr>
<tr>
<td>B. In a curved path in a linear accelerator</td>
<td></td>
</tr>
</tbody>
</table>

3. Given two incorrect statements about the acceleration of subatomic particles, state that they are incorrect. The acceleration of subatomic particles are accelerated.
<table>
<thead>
<tr>
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<th>Curriculum Index</th>
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<td></td>
<td></td>
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<td>SEC. II B</td>
</tr>
</tbody>
</table>

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6. Given a correct statement about the: 
   - Origin of X-rays, identify that X-rays come from the changing levels of orbital electrons. 
   - Both: None of the options are correct.
   - X-rays: Correct answer.
   - Gamma rays: Incorrect answer.

7. Given two correct statements about the use of Gamma and X-rays to make pictures with photographic film, state that: 
   - They are both correct.
   - Both: Gamma rays can be used to make pictures very similar to X-ray pictures.
   - Neither: Both statements are incorrect.

8. Given two correct statements about hazards with Gamma rays and X-rays, state that: 
   - They are both correct.
   - Both: Care should be taken with both Gamma and X-rays to avoid hazards.
   - Neither: Both statements are incorrect.
<table>
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<th>Curriculum Index</th>
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</table>
Instructional Objectives

9. Given a description of a device, name
   the device to be a nuclear reactor.

10. Given an incomplete statement about
    the three major uses of nuclear
    reactors, state the three major uses.

11. Given two correct statements about
    fuel used in nuclear reactors, identify
    uranium and plutonium as the types of
    fuels used.

STIMULUS

A device used to control the release of energy
from a fission process is called a(n) nuclear reactor.

RESPONSE

1. Sources of
   (heat)

2. Production of
   (neutrons)

3. As a tool for
   (research)

The three major uses of nuclear reactors are:

1. (research)
2. (neutrons)
3. (heat)

The type of fuel used in a nuclear reactor is

A. uranium
B. plutonium

Either

Neither

STIMULUS

Given two correct statements about the types of
fuel used in nuclear reactors, identify

STIMULUS

11. Given an incomplete statement about
    the three major uses of nuclear reactors,
    state the three major uses.

10. Given two correct statements about
    fuel used in nuclear reactors, identify
    uranium and plutonium as the types of
    fuels used.
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</table>
12. Given the function of the coolant in a nuclear reactor, name the coolant as the part of a nuclear reactor which performs that function.

13. Given a correct statement that shielding is necessary to prevent radiation from escaping and injuring operating personnel, state that it is correct.

14. Given two correct statements, identify both carbon, in the form of graphite, and water as common materials for a moderator. Identify both carbon, in the form of graphite, and water as common materials for a moderator.

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STIMULUS

RESPONSE

Criterion Test Measures

Institutional Objectives Hierarchy
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### Instructional Objectives Hierarchy

<table>
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<tr>
<td>15. Given the correct statement that heavy water is a common material used as a moderator, state that it is the correct answer.</td>
</tr>
<tr>
<td>16. Given two correct statements about the material used for control rods, identify both boron and cadmium as materials most commonly used for control rods in a nuclear reactor.</td>
</tr>
<tr>
<td>17. Given instructions to write the four examples of materials that are commonly used for shielding against radiation from a reactor, state any of the four including lead, concrete, steel, dirt, air, water. (lead, concrete, steel, dirt, air, water)</td>
</tr>
</tbody>
</table>

**RESPONSE**

1. Neither
2. Both
3. Neither
4. Both

**STIMULUS**

Write your examples of materials that are commonly used as moderators for control rods.

1. __________
2. __________
3. __________
4. __________

15. A common material used as a moderator is

- A. light water
- B. heavy water

16. A material most commonly used for control rods is

- A. boron
- B. cadmium

17. Given two correct statements about the material used for control rods, identify both boron and cadmium as the material used for control rods.

16. Given two correct statements about the material used for control rods, identify both boron and cadmium as the material used for control rods.

15. A common material used as a moderator is

- A. light water
- B. heavy water

16. A material most commonly used for control rods is

- A. boron
- B. cadmium
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<td>CHAP. 8</td>
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<td></td>
<td>SEC. III A 2</td>
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</tbody>
</table>
18. Given a statement describing the differences between a nuclear reactor and a bomb, state that a nuclear reactor is unlike a bomb because the arrangement of the fissile materials is different.

19. Given one correct statement about a nuclear power plant, identify it as a correct statement.

20. Given a correct explanation of a precaution against steam explosion in a nuclear power plant, state that it is correct.

STIMULUS

RESPONSE
<table>
<thead>
<tr>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Objectives Measured</th>
<th>Recommended Achievement</th>
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<td>Science-8 TEXT B CHAP. 8 SEC. III</td>
<td>20</td>
<td>90/100</td>
</tr>
</tbody>
</table>
21. Given a correct statement about how fission products are released into the atmosphere, state that it is correct.

Fission products might be released into the atmosphere as the result of a steam explosion with a

A. nuclear power plant
B. conventional steam generator plant

Neither
Both
Neither

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Fission products are released into the atmosphere as the result of a steam explosion with a
A. nuclear power plant
B. conventional steam generator plant

Neither
Both
Neither

Instructional Objectives Hierarchy: Criterion Test Measures
<table>
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<tr>
<th>Media-Resource</th>
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</thead>
<tbody>
<tr>
<td>Curriculum Index</td>
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<tr>
<td>Framework Index</td>
</tr>
<tr>
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</table>

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</table>

237
Biological Effects of Radiation

1. Given a statement about the effects of radiation, be able to describe what happens to living tissue, physically, when it is exposed to radiation other than

2. Given two correct statements concerning radiation effects, be able to describe what happens to living tissue when it is exposed to various types of radiation.

3. Given a statement about exposure to radiation, be able to describe what happens to living tissue when it is exposed to various types of radiation.

Radiation has a more serious effect on growing embryos and children than on adult cells because

A. The adult cells are stronger physically, and can resist the action of radiation better than young, active cells.

B. Radiation can alter or hamper the growth process of breakdown products of cellular structures and altering the structure of a particle striking a cellular structure.

Radiation effects are

A. A direct effect of a particle striking a cellular structure.

B. An indirect effect resulting from the formation of breakdown products.

Neither

Both (x)

Radiation has a more serious effect on growing embryos and children than on adult cells because

A. The adult cells are stronger physically, and can resist the action of radiation better than young, active cells.

B. Radiation can alter or hamper the growth process of breakdown products of cellular structures and altering the structure.

2. Given two correct statements concerning radiation effects, be able to describe what happens to living tissue when it is exposed to various types of radiation.

A. Radiation can alter or hamper the growth process of breakdown products of cellular structures and altering the structure.

B. An indirect effect resulting from the formation of breakdown products.

Neither

Both

A. The adult cells are stronger physically, and can resist the action of radiation better than young, active cells.

3. Given a statement about exposure to radiation, be able to describe what happens to living tissue when it is exposed to various types of radiation.

A. The adult cells are stronger physically, and can resist the action of radiation better than young, active cells.

B. Radiation can alter or hamper the growth process of breakdown products of cellular structures and altering the structure.

Neither

Both

Radiation has a more serious effect on growing embryos and children than on adult cells because

A. The adult cells are stronger physically, and can resist the action of radiation better than young, active cells.

B. Radiation can alter or hamper the growth process of breakdown products of cellular structures and altering the structure.

3. Given a statement about exposure to radiation, be able to describe what happens to living tissue when it is exposed to various types of radiation.

A. The adult cells are stronger physically, and can resist the action of radiation better than young, active cells.

B. Radiation can alter or hamper the growth process of breakdown products of cellular structures and altering the structure.
<table>
<thead>
<tr>
<th>Media-Resource</th>
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<td>UNIT 6 CHAP. 4 C</td>
<td>I, II, III, IV</td>
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</table>
4. Relate the outward symptoms of radiation exposure to the levels of radiation involved.

5. Given two correct statements about cells that are particularly sensitive to radiation, which are sensitive to radiation, state both statements are correct.

6. Relate the delayed and/or hidden effects or symptoms of radiation exposure to the levels of radiation involved.

7. Given two correct statements about living tissue, state both statements are correct.

8. Given two correct statements about subjecting a human being to radiation, state both statements are correct.

A. Blood cells and the living layer of skin
   - Both

B. Growing embryos and children
   - Neither

A. At the instant of contact (immediately)
   - Both

B. Only if the exposure is prolonged
   - Neither

A. The amount of tissue damage which will result
   - Neither

B. The value of the information to be gained
   - Both

A. Given two correct statements about subjecting a human being to radiation, state both statements are correct.

Which of the following would contain cells that are particularly sensitive to radiation?
<table>
<thead>
<tr>
<th>Curriculum Index</th>
<th>Framework Index</th>
<th>Objectives Measured</th>
<th>Media-Resource</th>
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<td>CHAP. I A, b</td>
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</table>
9. Given two correct statements about the advisability of exposure to radiation through diagnostic X-rays, state that both statements are correct.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Correctness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. The amount of tissue damage associated with diagnostic X-rays is very small.</td>
<td>Both</td>
</tr>
<tr>
<td>B. A great deal of information is gained by the use of diagnostic X-rays.</td>
<td>Both</td>
</tr>
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</table>

Both statements are correct.
<table>
<thead>
<tr>
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<th></th>
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<tr>
<td>Recommended Achievement</td>
<td>( \frac{90}{100} )</td>
</tr>
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</table>
10. Given a scale of levels of radiation, the learner will be able to:

1. Name the approximate levels of radiation for visible symptoms of radiation;
2. Lethal level of radiation;
3. The level to cause serious radiation sickness;
4. The approximate amount of naturally received background radiation per year;
5. The approximate amount of radiation received in the usual diagnostic X-ray.

STIMULUS:

Place the letter from the scale above beside the statement which is appropriate to the approximate amount of whole body radiation (single dose) which would cause detectable symptoms of radiation sickness.

RESPOSE:

1. (C)
2. (E)
3. (D)
4. (A)
5. (A)
<table>
<thead>
<tr>
<th>Media-Resource</th>
<th>Curriculum Index</th>
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<td>I, II, III, IV</td>
<td>10</td>
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</table>
11. Given a statement about the types of cells most sensitive to radiation, the student will identify:

- Bone cells and brain cells
- Rapidly dividing cells
- Both
- None of the above

The types of cells most sensitive to radiation damage are:

- Bone cells
- Both
- None of the above

12. Given a statement about the types of cells particularly sensitive to radiation, the student will name:

- Liver, kidney, and muscle of adult
- Cancer
- Both
- Neither

13. Given a statement about the effects of exposing living tissue to radiation, the student will be able to identify that the effects may not show up immediately and that key molecules that control the activities of cells are ionized.

- Neither
- Both
- Cancer
- None of the above

When living tissue is exposed to significant radiation:

- The effects may not show up immediately
- Key molecules that control the activities of cells are ionized
- Both
- Neither

Which of the following would contain cells that are particularly sensitive to radiation?

- Liver, kidney, and muscle of adult
- Cancer
- Both
- Neither
<table>
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<th>Framework Index</th>
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<td>90/100</td>
</tr>
<tr>
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<td>I, II, III, IV</td>
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<td>13</td>
<td>90/100</td>
</tr>
<tr>
<td>Instructional Objectives Hierarchy</td>
<td>Criterion Test Measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>--------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given a statement about the level of radiation below which tissue damage will not occur, the student will be able to identify that it is not yet known.</td>
<td>STIMULUS</td>
<td>Circle one of the numbers below.</td>
<td></td>
</tr>
<tr>
<td>Given a statement about the symptoms after radiation exposure, state that if symptoms do not appear, one cannot be sure that damage did not occur.</td>
<td>RESPONSE</td>
<td>not occur.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STIMULUS</th>
<th>RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There is no minimum level.</td>
<td>(cannot)</td>
</tr>
<tr>
<td>2. 25 r of whole body radiation</td>
<td>3. Not yet known</td>
</tr>
<tr>
<td>3. The level of radiation below which tissue damage will not occur is not yet known.</td>
<td>4. There is no minimum level.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STIMULUS</th>
<th>RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>given a statement about the symptoms do not appear, one cannot be sure that damage did not occur.</td>
<td>1. Given a statement about the symptoms do not appear, one cannot be sure that damage did not occur.</td>
</tr>
<tr>
<td>able to identify that it is not yet known.</td>
<td>4. Given a statement about the level of radiation below which tissue damage will not occur, the student will be able to identify that it is not yet known.</td>
</tr>
<tr>
<td>Recommended Achievement</td>
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<tr>
<td>-------------------------</td>
<td>---------------------</td>
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<tr>
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<td>14</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>90/100</td>
<td>15</td>
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</tr>
</tbody>
</table>

249
16. Given a statement about the early effects of massive doses of radiation, identify them as:
   (1) nausea, (2) loss of appetite, (3) rupture of blood vessels in digestive organs, (4) will show up in a matter of a few weeks, (5) skin reddening, (6) loss of white blood cells, (7) tumors, (8) leukemia, (9) skin reddening, (10) dizziness, (11) loss of appetite, (12) loss of red blood cells.

17. Given a statement about the possible delayed effects of massive doses of radiation, identify them as (1) bone diseases, (2) may not be apparent, (3) leukemia, (4) tumors, (5) mutations.

Place the appropriate B-Column numbers in the space below the A-Column statements:

A-Column

- Early effects of massive doses of radiation
- Possible delayed effects of radiation

B-Column

1. nausea
2. bone diseases
3. may not be apparent
4. loss of red blood cells
5. loss of appetite
6. rupture of blood vessels
7. dizziness
8. will show-up in a matter of a few weeks
9. skin reddening
10. skin reddening
11. loss of white blood cells
12. loss of vision
13. tumors
14. leukemia
15. mutations
16. loss of hearing
17. Given a statement about the early effects of massive doses of radiation.
18. Given a statement about the possible delayed effects of massive doses of radiation.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<tbody>
<tr>
<td>90/100</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>UNIT VII</td>
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<td></td>
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<td></td>
<td>CHAP. IV A</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>CHAP. VA</td>
<td></td>
</tr>
</tbody>
</table>
II.B.1 Radiation Genetics—Mutation

1. Given statements about the genetic damage due to radiation, state that (1) it occurs only when the mutation is to reproductive cells, (2) it more often results in slight effects than in marked effects.

2. Given two incorrect statements about reoccurrence of mutations in the children of the individual who has a defect, state that both statements are incorrect.

3. Given a statement about mutations, state that a mutation is a change or alteration in the heredity characteristics of an individual.

Genetic damage due to radiation:

- A. occurs only when the mutation is to reproductive cells
- B. occasionally results in slight effects and almost never in marked effects (such as the creation of a monstrosity)

(X) Both

Neither

If mutations occur, the defect will definitely appear in the children of the individual if:

- A. the mutation occurs in a reproductive cell
- B. the mutations occur in a cell other than a reproductive cell

(X) Neither

STIMULUS

Mutation is a change or alteration in the __________ characteristics of an individual.

RESPONSE

(heredity)
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<tbody>
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<tr>
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<td>2</td>
<td>II,III,IV</td>
<td>Science-Biology  UNIT VI</td>
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<td></td>
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<td></td>
<td>CHAP 3 A</td>
<td></td>
</tr>
<tr>
<td>90/100</td>
<td>3</td>
<td>II,III,IV</td>
<td>Science-Biology  UNIT 6</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>CHAP 3 A,1</td>
<td></td>
</tr>
</tbody>
</table>
Given statements about mutations, identify that mutations appear as malfunctions of the inner physiological process of the body chemistry.

Given statements about mutation occurrence in a reproductive cell, identify that if a mutation occurs in a reproductive cell (1) the fact may remain hidden for many generations, (2) the fact cannot be detected in the individual; (X) the fact identity that a mutation occurs occurrence in a reproductive cell, mutations are:

- A. readily detectable within the individual in whom they occur
- B. appear as malfunctions of the inner-physiological process
- Neither
- Both

If a mutation occurs in a reproductive cell, the fact:
- A. may remain hidden for many generations
- B. cannot be detected in the individual
- Neither
- Both

Mutations are:
- Both
- Neither

Given statements about mutations:
- Logical process of the body chemistry
- Malfunction of the inner physiological process
- Neither
- Both

4. Given statements about mutations, identify that mutations appear as malfunctions of the inner-physiological process:
- Neither
- Both

Instructional Objectives Hierarchy

Criterion Test Measures
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>ObjectivesMeasured</th>
<th>FrameworkIndex</th>
<th>CurriculumIndex</th>
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<tbody>
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<td>UNIT 6</td>
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<td></td>
<td></td>
<td>CHAP 3,D</td>
</tr>
<tr>
<td>90/100</td>
<td>5</td>
<td>II,III,IV</td>
<td>Science-Biology</td>
<td>UNIT 6</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>CHAP 3,D</td>
</tr>
</tbody>
</table>
II. Radiation Safety

1. Given statements about the safe handling of radioactive materials, name the three major variables that control the degree of exposure to which the individual is exposed.

   A. Receive three times the amount of radiation
   B. Receive about nine times less radiation
   Neither

2. Given statements about increasing distance from radioactive material by three times, determine by applying the inverse square law, the decrease in radiation as one moves away from the source.

   If you increase your distance from radioactive material by three times, you will:
   A. Receive three times the amount of radiation
   B. Receive about nine times less radiation
   Neither

   Use of proper (shielding) 
   Adequate (distance) 
   Limit to (time) 

   Concern are: name the three major variables of handling radioactive materials, the three major factors of In the safe handling of radioactive materials, the three major factors of

1. Given statements about the safe handling of radioactive materials, the three major factors of

   A. Use of proper shielding
   B. Adequate distance from source
   C. Limit to time of exposure

   Concern are: name the three major variables of handling radioactive materials, the three major factors of

   II. (Radiation Safety)
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>SEC IV</td>
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</tbody>
</table>
II.C.2 Shielding

Given a list of materials and a list of the types of radiation, identify in terms of the density of material, the amount of shielding required for each type of radiation.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Alpha particles</td>
<td>sheet aluminum</td>
</tr>
<tr>
<td>b) Beta particles</td>
<td>plastic</td>
</tr>
<tr>
<td>c) Gamma rays</td>
<td>sheet of paper</td>
</tr>
<tr>
<td>d) X-rays</td>
<td>thick lead sheets</td>
</tr>
</tbody>
</table>

**Response**

- a) (3)
- b) (1, 2, 5)
- c) (4)
- d) (4)
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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</table>
| 90/100                  | 1                   | I,II,III,IV     | Science-Chemistry
|                         |                     |                 | UNIT XI        |
|                         |                     |                 | SEC 4 C,1,2,    |
|                         |                     |                 | 4 E,1           |
|                         |                     |                 | Science-Physics |
|                         |                     |                 | UNIT X          |

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II.C.3 Decontamination

1. Given a definition of decontamination, name the definition as such.

- Decontamination consists of removing all radioactive contaminants from the surfaces of equipment by cleaning and washing and disposing of the contaminant in a safe location. This is extremely important to the safe handling of radioactive materials.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>SEC III A2</td>
<td></td>
</tr>
</tbody>
</table>
Instructional Objectives Hierarchy

Criterion Test Measures

1. Given statements about the disposal of long-lived radioactive waste material, identify the disposal problem, and is accomplished by containers buried at sea.

2. Given statements about Alpha particles, identify that Alpha particles require a minimum of shielding and also present a particular hazard to the human body if ingested or inhaled.

The disposal of long-lived radioactive waste material is a major problem and is accomplished by:

- Containers buried at sea
- Burial in underground tanks and in containers buried at sea

- Alpha particles present a particular hazard to the human body if ingested or inhaled.
- Alpha particles require a minimum of shielding.
- Alpha particles, identity that Alpha particles, identity that Alpha particles require a minimum of shielding and also present a particular hazard to the human body if ingested or inhaled.

Both

Neither

A. not a major problem

B. accomplished by burial in underground tanks and in containers buried at sea
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<tr>
<td>90/100</td>
<td>2</td>
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<td></td>
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<td></td>
<td>CHAP 7</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SEC III A</td>
</tr>
<tr>
<td>Stimulus</td>
<td>Response</td>
<td></td>
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<tr>
<td>----------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Once a radioactive isotope is free in nature, it will become concentrated by the thyroid gland.</td>
<td>Unpredictable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strontium is apt to be concentrated by the thyroid gland.</td>
<td>Both</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lutetium is apt to be concentrated by the thyroid gland.</td>
<td>Neither</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different radioactive isotopes are apt to be concentrated in the body in accordance with the chemicals which have similar properties. For example:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Iodine is apt to be concentrated by the thyroid gland.</td>
<td>Unpredictable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Strontium is apt to be concentrated in the bones and teeth.</td>
<td>Unpredictable</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Criterion Test Measures
II.C.5 Entrance of Fission Products into Human Body

1. Given a statement about the characteristics of behavior of radioactive isotopes, state that once a radioactive isotope is free in nature, it will become concentrated in unpredictable locations.

2. Given a statement about the characteristics of behavior and the dangers of radioactive isotopes, state that the human body cannot distinguish radioactive from non-radioactive isotopes and so will metabolize them in the same way.

3. Given a statement about the concentration of radioactive isotopes in the body, state that (1) iodine is apt to be concentrated by the thyroid gland, (2) strontium is apt to be concentrated by the thyroid gland, (3) both, (4) neither.
<table>
<thead>
<tr>
<th>Recommended Achievement</th>
<th>Objectives Measured</th>
<th>Framework Index</th>
<th>Curriculum Index</th>
<th>Media-Resource</th>
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<td>CHAP 3, B</td>
</tr>
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<td>I,II,III,IV</td>
<td>Science-Biology</td>
<td></td>
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<td></td>
<td>CHAP 3, B</td>
</tr>
<tr>
<td>90/100</td>
<td>3</td>
<td>I,II,III,IV</td>
<td>Science-Biology</td>
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<td></td>
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<td></td>
<td></td>
<td>CHAP 3, B</td>
</tr>
</tbody>
</table>
I. Background Concepts in Nuclear Energy

A. Atomic Structure

1. Historical Development

a. Democritus—300 B.C.: together with his teacher Leucippus, founded a Greek school of thought which taught that all material things were made up of small indivisible units which Democritus called "atoma" (= "indivisible").

b. Dalton—1808: developed atomic theory to explain certain observable phenomena; first quantitative measurements to explain theory; laid foundation for later work.

c. Thompson—1897: the electron as a constituent of matter; measured ratio of change to mass for electron.

d. Rutherford—1911: from experiments postulated the existence of a nucleus in the atom.

e. Planck—1901: first to postulate quantum theory.

f. Bohr—1913: proposed the idea of permissible orbits and the release of energy when an electron drops to a lower state.

<table>
<thead>
<tr>
<th>Content</th>
<th>Level of Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Background Concepts in Nuclear Energy</td>
<td>Be able to give a brief quantitative description of the historical development of the atomic concept.</td>
</tr>
<tr>
<td></td>
<td>Identification of a specific person with his contribution is of secondary importance.</td>
</tr>
<tr>
<td></td>
<td>Memorization of specific dates unnecessary.</td>
</tr>
</tbody>
</table>
Present Concepts of Atomic Structures

2. Level of Understanding

- Recognize the common forms of electromagnetic energy.
- Wave-particle duality of matter.
- Quantum nature of orbital electron energy levels.
- Reason for and significance of the arrangement of the elements in the periodic chart by being able to differentiate between atomic ions, neutrons, and electrons in atoms of different elements.
- Understand how the structure of the atom determines to which element it belongs and also determines the chemical properties of the element.
- Develop concepts of size and space within the atom.
- Be able to describe or diagram a Bohr atom. Name the particles.

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2. Content

- Electromagnetic radiation spectrum,
- Periodicity of the elements
- Definition of an isotope, nuclide,
- Atomic number Z (superscript)
- Mass number A (subscript)
- Symbol
- Terms and symbols
- Ionization potential
- Energy levels, binding energy, ion-
- Orbital energy level
- Nucleus composed of:
- Neutrons
- Protons
<table>
<thead>
<tr>
<th>Content</th>
<th>Level of Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B. Nuclear Radiation</strong></td>
<td>To discern the interrelations of scientific discoveries and their contribution to each other in advancing our understanding of the atom.</td>
</tr>
<tr>
<td><strong>1. Historical Development</strong></td>
<td>Know that contribution and development to present understanding of nuclear science is international.</td>
</tr>
<tr>
<td>a. Roentgen—1895: discovery of X-rays</td>
<td></td>
</tr>
<tr>
<td>b. Becquerel—1896: discovery of radioactivity</td>
<td></td>
</tr>
<tr>
<td>c. Marie and Pierre Curie—1898: announced discovery of two new radioactive elements, polonium and radium</td>
<td></td>
</tr>
<tr>
<td>d. Rutherford: determined that radiation was composed of Alpha and Beta rays while Curie and Villard determined that radiation was composed of Gamma rays.</td>
<td></td>
</tr>
<tr>
<td><strong>2. Kinds of Nuclear Radiation—Properties</strong></td>
<td>Composition and charge of each particle or ray and the implications for range of penetration, ability to ionize, and for radiation dosimetry.</td>
</tr>
<tr>
<td>symbol</td>
<td>Make student aware of existence.</td>
</tr>
<tr>
<td>a. Alpha particles</td>
<td></td>
</tr>
<tr>
<td>b. Beta particles</td>
<td></td>
</tr>
<tr>
<td>Negatrons</td>
<td>or</td>
</tr>
<tr>
<td>Positrons</td>
<td>or</td>
</tr>
<tr>
<td>c. Gamma rays</td>
<td></td>
</tr>
<tr>
<td>d. Neutrons</td>
<td></td>
</tr>
<tr>
<td>e. Protons</td>
<td></td>
</tr>
</tbody>
</table>
Level of Understanding

I. Sub-nuclear particles:
- Neutrino

Exotic particles:
- Mesons, etc.

II. Characteristics of Radioactive Decay
Recognize that physicists discovered almost 50 nuclear fragments in their experiments. No satisfactory unifying concept postulated.

a. Specific ionization

b. Continuous energy distribution

(1) X- and Gamma rays
(2) Electrons
(3) Heavy charged particles

- Ion for Beryo decay

III. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

IV. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

V. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VI. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

VIII. Interaction of Radiation with Matter

a. Specific ionization

b. Continuous energy distribution

- Ion for dispersed radiation

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<td>b. Processes by which energy from X- and Gamma radiation is absorbed by matter</td>
<td>Understand process and implications.</td>
</tr>
<tr>
<td>(1) Photoelectric effect</td>
<td>Memorization of specific terms of secondary value.</td>
</tr>
<tr>
<td>(2) Compton collisions</td>
<td></td>
</tr>
<tr>
<td>(3) Pair production</td>
<td></td>
</tr>
<tr>
<td>C. Units of Measurement of Radioactivity and Radiation Dosimetry</td>
<td></td>
</tr>
<tr>
<td>1. Basic Units</td>
<td></td>
</tr>
<tr>
<td>a. Curie</td>
<td>Understand process and implications.</td>
</tr>
<tr>
<td>b. Roentgen</td>
<td>Memorization of specific terms of secondary value.</td>
</tr>
<tr>
<td>c. Rad</td>
<td></td>
</tr>
<tr>
<td>d. Rem</td>
<td></td>
</tr>
<tr>
<td>2. Prefixes</td>
<td></td>
</tr>
<tr>
<td>a. Milli</td>
<td>Know what the units measure, how they are used, and the reasons why one measure is preferable to another in a given situation.</td>
</tr>
<tr>
<td>b. Micro</td>
<td>Specific memorization of definitions not required.</td>
</tr>
<tr>
<td>c. Nano</td>
<td></td>
</tr>
<tr>
<td>d. Pico</td>
<td></td>
</tr>
<tr>
<td>3. Minimum Detectable Weight</td>
<td></td>
</tr>
<tr>
<td>a. Proportional to half-life and mass number.</td>
<td>Comparison between common amounts of radioactive material encountered, and also between amount of radiation received from various sources should be included.</td>
</tr>
<tr>
<td>4. Standards</td>
<td>Should also include relative biological effect and M.P.D.</td>
</tr>
<tr>
<td>a. Use in instrument calibration and nuclear medicine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Radiation standards similar to standards established for other units of measure. They are controlled by the National Bureau of Standards, and by the use of relatively simple techniques, comparisons can be made with these standards so that dose rates can be accurately determined.</td>
</tr>
</tbody>
</table>
Content

Level of Understanding

D. Methods of Detection and Measurement of Radioactivity

1. Specific Detection Techniques

Radioactivity Detection and Measurement

E. Sources of Radiation

1. Natural Sources

- Cosmic radiation - 125 mrad/yr.
- From the earth and building materials - 125 mrad/yr.

2. Artificial Sources

- Medical Scanners and Cameras
- Pulse Height Analyzers
- Proportional Counters
- Total Body Counters
- Medical Scanners and Cameras
- Pulse Height Analyzers
- Proportional Counters
- Total Body Counters

D. Methods of Detection and Measurement of Radioactivity

Specific Detection Techniques

- Detectors
  1. Electroscope
  2. Photographic emulsions (film badge)
  3. Cloud Chamber
  4. Bubble Chamber
  5. Ionization Chamber
  6. Ionization Chambers
  7. Proportional Counters
  8. liquid scintillation detector
  9. Geiger-Müller Tubes
  10. Proportional Counters
  11. Electroscope

- Recorder
  1. Scalers
  2. Ratemeters
  3. Pulse Height Analyzers
  4. Medical Scanners and Cameras
  5. Total Body Counters

Recognize the names of the other common detectors and recorders.

Some detail about the operation of film, a Geiger tube, and a scintillator.

General concept that all detectors depend on the effect of the radiation on matter.

Define cosmic radiation as radiation coming from outer space.

To identify information re: atomic energy which if dispersed to the public might dispel their fears.

The amounts from these sources should be quantified in order to make meaningful comparisons.

The associated "block boxes" contain the mechanical and electronic devices to amplify, convert and record the signal from the detector and to supply the high voltage to the detector when needed.
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<tr>
<td>c. Internal radiation - 25 mrad/year.</td>
<td>Describe the liquid drop model of fission. Formation of fission products, themselves, often highly radioactive.</td>
</tr>
<tr>
<td>2. Fission and Fusion Process</td>
<td>Understand that the loss of mass and the release of energy is far greater than that which is released from normal chemical reactions, and the fact that several neutrons are released per fission.</td>
</tr>
<tr>
<td>a. Process, products, energy released</td>
<td>Provides an application for Einstein's equation.</td>
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<tr>
<td>b. Maintaining a chain reaction</td>
<td>Basic requirements of a chain reaction: an initial source of neutrons; fissile atoms; and a moderator to slow down fast neutrons.</td>
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<tr>
<td>c. Conditions for criticality</td>
<td>Student should be able to recite conditions for criticality: fuel mass and geometry that allow criticality to be attained.</td>
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<tr>
<td>d. Fusion</td>
<td>Compare and contrast fission and fusion.</td>
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<tr>
<td>e. Nuclear Weapons</td>
<td>Recognize that nuclear energy can be used to trigger fusion of light elements into heavier ones (e.g., Helium).</td>
</tr>
<tr>
<td>(1) Historical development of nuclear energy</td>
<td>How they work; what are the dangers: heat, blast, shock, as well as radiation.</td>
</tr>
<tr>
<td>(2) Wartime considerations</td>
<td>Comparison between conventional explosions and a nuclear detonation.</td>
</tr>
<tr>
<td>(3) Post-war developments</td>
<td>To differentiate between nuclear technology and nuclear weapons technology.</td>
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<tr>
<td>(4) Growth of limited wars</td>
<td>To identify arguments for the development and utilization of nuclear weapon systems and strategies connected with them.</td>
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<td></td>
<td>To identify the influence of nuclear weapons on international politics.</td>
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I. 

1. Nuclear Reactions

2. X-ray machines

3. Accelerators

4. Machine Sources of Radiation

5. Reactors

6. Reactors may explode

F. Fallout

6. The balance of terror notion.

5. Growth of detente between the Soviet Union and the USA

4. Treadles (proliferation, test ban?)

3. Need to know potential dangers: Ingestion, uptake with food.

2. Extern exposure.

1. Constant check at centers for radiation measurement by Public Health Service.

Growth of detente between the Soviet Union and the USA

(a) Treaties (proliferation, test ban?)

(b) Other

(c) Etc.

Levels of Understanding

1. Basic understanding

2. Average understanding

3. Above average understanding

4. Superior understanding

5. Exceptional understanding

6. Complete understanding
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<td>2. Fission and Fusion Process</td>
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<td>a. Process, products, energy released</td>
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<td>Basic requirements of a chain reaction: an initial source of neutrons; fissile atoms; and a moderator to slow down fast neutrons. Student should be able to recite conditions for criticality: fuel mass and geometry that allow criticality to be attained. Compare and contrast fission and fusion. Recognize that nuclear energy can be used to trigger fusion of light elements into heavier ones (e.g., Helium). How they work; what are the dangers: heat, blast, shock, as well as radiation. Comparison between conventional explosions and a nuclear detonation.</td>
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<td>c. Conditions for criticality</td>
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11. Biological Effects of Radiation

The Committee made a few suggestions relative to content in this area. Because of this we have supplemented those specific statements previously noted with what seems to us appropriate understanding. Your reactions regarding accuracy, relevancy, level and completeness are invited.

A. Biochemical and Cellular Effects

1. Damage
   a. Ionizing effects early - delayed
      (1) Individual awareness of the dangers and advantages of the use of radiation and radio-active materials.
   b. Somatic damage
   c. Low-level

The damage to living tissue by radiation is caused primarily by the ionizing effect of the radiation on key molecules that control the activities of the cell.

The damage occurs at the instant of radiation, but the damage may take a long time to show itself.

To identify medical needs of the population.

It is not yet known whether there is or is not a threshold below which somatic damage would not occur.

The decision to subject any human to radiation must be arrived at after evaluation of the relative hazard compared with the value of the information gained.

For low levels of radiation such as might be involved with diagnostic X-rays, the damage is so slight that the information gained is of greater value than the slight additional hazard.
Exposure to radiation other than neutrons cannot make one become radioactive.

Radiation damage that causes mutations that can be handed down to succeeding generations can occur only if the individual's reproductive cells are radiated.

Genetic damage may remain hidden for many generations.

Levels of Understanding

Late effects may not be apparent for many years.

Loss of white cells from the blood? and a high possibility of infection? by loss of appetite? rupture of blood vessels in the digestive organs? Some of the early effects include skin reddening, nausea, followed by loss of appetite? nausea, followed by loss of appetite.

Cells most sensitive to damage are rapidly dividing cells, i.e., growing embryos, children, the living layer of skin, cancer, etc.

Lower forms of life can survive much higher doses of radiation than humans can survive. (Examples.)

Idea of amount of radiation required to produce above symptoms, along with a comparison with background and amount of radiation medically applied.

Bone diseases, tumors and mutations.

Delayed effects include an increase in the possibility of leukemia,

Injection of amount of radiation required to produce above symptoms, along with a comparison with background and amount of radiation medically applied.


d. Early

e. Delayed

f. Dosimetry

g. Sensitivity

h. Identification

i. Cause of mutation

1. Mutation

b. Identification

c. Degree of mutation
### Radiation Safety

1. **Principles of Safe Handling of Radioactive Materials**
   - a. Protection
   - b. Inverse square law

2. **Shielding**

3. **Decontamination**

### Disposal of Radioactive Wastes

5. **Entrance of Fission Products into Human Body**
   - a. Transfer of radioactive material through food chains.

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<td>Most mutations appear as malfunctions of the inner physiological processes of the body chemistry which cannot be detected without special study.</td>
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<td>Mutations resulting in slight effects are more common than those with marked effects.</td>
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<tr>
<td>Understand three major factors of protection from radiation: time of exposure, distance from source, use of shielding.</td>
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<tr>
<td>Application of inverse square law.</td>
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<td>Different kinds of radiation require a different choice of shielding material. (Ex.)</td>
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<tr>
<td>Essentially careful cleaning up and getting rid of radioactive material.</td>
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</tr>
<tr>
<td>Identify problem and ways to cope with it. Continuous research effort going on to deal with problem.</td>
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<tr>
<td>To identify some disadvantages associated with the use of nuclear energy.</td>
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<tr>
<td>Particular hazard of internal radiation from alpha particles.</td>
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<tr>
<td>Significance of half-life and method of metabolizing. (Ex.)</td>
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<tr>
<td>Concentration of some specific isotopes.</td>
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<tr>
<td>Distribution of isotopes difficult to predict once they are free in nature.</td>
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On the basis of the module shown in a previous section, several other social studies modules could be developed to demonstrate the social impact of nuclear technology. What follows is a compendium of basic need-to-know data relative to various social issues and/or problems. No attempt was made to be exhaustive, only illustrative and extrapolations regarding future political, social and economic changes were kept as tightly constrained by the empirical data as was possible.

The categorization technique employed for arranging the data is simply to identify significant areas of need and of change or potential change, and the role that would be played by nuclear technology. In the left hand column were placed the items of greatest concern, as identified by the social science consultants and Project staff. In the right hand column are the need-to-know data relative to each need, concern, or issue. More detailed information regarding specific content can be gained by consulting the Bibliography.
Air pollution is caused in part by contaminants coming from the burning of fossil fuels and waste control, prevention of decay. Air pollution is caused in part by contaminants coming from crop improvement, insect sterilization processes, controlled mutations for crop improvement, and genetic modification of crops. These techniques include, inter alia, postirradiation and genetic modification of crops.

As the population grows, the demand for food will also increase. Nuclear energy, therefore, will help to alleviate the problem of air pollution when utilized in urban areas. Nuclear energy will allow for greater population and industrial dispersion and thus help to alleviate population problems.

Levitate population problems. Nuclear energy, therefore, will allow for greater population and industrial dispersion and thus help to alleviate population problems. Desalination of the world's oceans will be a great asset to those areas of the U.S.A. and the underdeveloped world which have arid or semi-arid conditions. Desalination will allow for greater population and industrial dispersion and thus help to alleviate population problems.

Water needs

As the population grows, the demand for fresh water will grow tremendously. Nuclear energy is now being used and will continue to be used to desalinate sea water and thus produce abundant supplies of fresh water for all potential uses in the future. Desalination through nuclear means will be a great asset to those areas of the U.S.A.

Food needs

As the population grows, the demand for food will also increase. Nuclear science and technology are developing techniques to improve the quality and quantity of food. These techniques include, inter alia, pasteurization and sterilization processes, controlled mutations for crop improvement, and genetic modification of crops. Desalination of the world's oceans will be a great asset to those areas of the U.S.A. and the underdeveloped world which have arid or semi-arid conditions. Desalination will allow for greater population and industrial dispersion and thus help to alleviate population problems.

Relatable need-to-know social science data

and problems relative to nuclear energy.

Social, economic, and political trends, issues, and problems relative to nuclear energy.
POWER NEEDS

The traditional energy sources in the U.S.A. have been fossil fuels. These fuels are being rapidly depleted as the power demands of our country expand; this in turn creates the need for searching for new sources of power. The major new source of power is nuclear energy which rests on a raw materials base which is relatively abundant and which will, when breeder reactors have been perfected, become almost limitless. Factors which illustrate this general statement follow:

A high standard of living depends upon the power that is available to a country. Little power usually means an underdeveloped economic system and a low standard of living. Exploitation of all sources of power, then, becomes necessary if the U.S.A. is to maintain its standard of living.

Current reserves of fossil fuels will be exhausted in 200 years with those most easily mined gone in 100 years. (estimated)

Energy consumption in the U.S.A. doubles every ten years.

America's need for power has been growing at an average rate of four percent over the last decade and with population growth and continued industrial expansion, this power needs growth will continue at a faster rate.

U.S. population is growing at a constant rate of 1.7% per year from 1900-1967 and while some leveling off is to be expected, it is also expected that the U.S.A. will have a population of over 320,000,000 by the year 2000. (estimated)
Nuclear reactors are already in use in the U.S. to generate power and have added greatly to American power capacity and have demonstrated their great safety.

Nuclear reactors have been perfected
- Reactors have been perfected in 1700 years and will be limitless when breeder reactors have been perfected

Reactor fuels have been perfected
- Reactor fuels will go down as nuclear power

Stated by power needs
- Stated by power needs

Be opened and/or industry will no longer be con-

Industrial areas will help to lessen air pollution
- Industrial areas will help to lessen air pollution

Utilization of nuclear power will allow for indu-

Since pollutants from reactors is insignificant
- Since pollutants from reactors is insignificant

Fuel requirements are lower
- Fuel requirements are lower

Electricity generated by nuclear fuel will last at least
- Electricity generated by nuclear fuel will last at least

Overall costs of generation of electricity are equal
- Overall costs of generation of electricity are equal

Nuclear power has certain advantages over traditional fuels

Linkyclear power needs to traditional fuels, overall costs of generation of electricity are equal. Nuclear power has certain advantages over traditional fuels.
The development of nuclear power sources in the underdeveloped world is one of the most necessary actions for those nations since most of them lack traditional power sources and often lack even fossil fuels.

Nuclear power can more easily be located. Nuclear power can open new living areas and therefore reduce population pressures in traditional areas. Nuclear power in the long run is cheaper than fossil fuels which will allow for the generation of additional investment capital to be utilized for other purposes for economic growth.
Radioactive isotopes are currently being utilized to improve the quality and increase the quantity of industrial products and processes.

Radioactive isotopes are also used to judge the wearing capabilities and so forth.

Cities are becoming increasingly congested, which develops a number of social problems which affect health: traffic, slums, pollution, etc. A nuclear powered society will allow for industrial and population dispersal since neither industry nor populations will need to concentrate around fuel supplies or power sources. Dispersal will help to eliminate pollution and relieve other urban problems.

Nuclear power can provide for more suitable living environments within cities considered unlivable.

Nuclear power can provide water and power for habitation in areas previously considered uninhabitable.

Radioactive isotopes are also used to trace the flow of liquids in closed containers (e.g., pipes) to help determine trouble spots and so forth.

Radioactive isotopes are used to improve the quality and increase the quantity of industrial products and processes.

URBAN AREA NEEDS

Cities are becoming increasingly congested, which develops a number of social problems which affect health: traffic, slums, pollution, etc. A nuclear powered society will allow for industrial and population dispersal since neither industry nor populations will need to concentrate around fuel supplies or power sources. Dispersal will help to eliminate pollution and relieve other urban problems.

Nuclear power can provide water and power for habitation in areas previously considered uninhabitable.

Nuclear power can provide for more suitable living environments within cities.

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INDUSTRIAL NEEDS

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RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA

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Radioactive isotopes are also used to trace the flow of liquids in closed containers (e.g., pipes) to help determine trouble spots and so forth.

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TO NUCLEAR TECHNOLOGY AND PROBLEMS RELATIVE POLITICAL TRENDS, ISSUES, SOCIAL, ECONOMIC, AND

Radioactive isotopes are also used to judge the wearing capabilities and so forth.

Radioactive isotopes are also used to trace the flow of liquids in closed containers (e.g., pipes) to help determine trouble spots and so forth.

Radioactive isotopes are currently being utilized to improve the quality and increase the quantity of industrial products and processes.
Nuclear weapons have had a great impact on American and World Society. They are still controversial with arguments which oppose and support development and use of nuclear weapons.

A. Those in favor maintain, inter alia, the following position

- Weapons of such destruction help to deter aggressors from attacking since they will fear atomic annihilation
- Nuclear weapons are needed to balance the manpower preponderance of our potential enemies
- Threat of nuclear war limits potential enemies' freedom of action on a global scale
- Maintenance of weapons superiority gives the U.S.A. an opportunity for greater freedom of action vis-à-vis potential enemies
- Weapons superiority makes it more likely, and believable to potential enemies, that the U.S.A. will be able to not only destroy potential enemy weapons but also to threaten his cities

B. Those opposing maintain, inter alia, the following position

- Nuclear weapons are so powerful that in the event of war no victor could emerge; only civilization be destroyed
Spread of nuclear weapons will allow lesser powers to practice nuclear coercion. Nuclear weapons do not deter war but lead to different forms of war (e.g., limited war, guerilla war, insurrections). Fear of mutual destruction has developed a balance of terror which appears to mitigate the use of atomic bombs and has given rise to new forms of war: limited wars, guerrilla war, insurrections, etc.

Fear of mutual destruction has also led to a number of treaties aimed at lessening the rivalry in nuclear weaponry. For example, a test-ban treaty between the U.S.A. and Soviet Union which stated that neither side would conduct atmospheric tests of atomic weapons thus reducing the radioactive contamination of air. A similar treaty was signed between the U.S.A. and Great Britain. These treaties have given rise to new forms of war: limited wars, guerrilla war, insurrections, etc.

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Whatever the pro and con arguments, nuclear weapons have had a profound effect on foreign policy. Fear of mutual destruction has developed a balance of terror which appears to mitigate the use of atomic bombs and has given rise to new forms of war: limited wars, guerrilla war, insurrections, etc.

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FOREIGN POLICY AND NATIONAL SECURITY NEEDS
(Continued)

RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA

a nuclear non-proliferation treaty in which the major powers (except France and the People's Republic of China) agreed not to share their nuclear capabilities with non-nuclear powers

a treaty which bans the military use of atomic power in outer space

POLITICAL TRENDS RELATIVE TO TECHNOLOGICAL INNOVATION

The traditional governmental pattern of the U.S.A. is rapidly changing. In place of the many foci of power and decision making, governmental and non-governmental, there is arising a centralized administrative source of power. Major decision making now rests with the Administrative Branch of the Federal Government. Congress has neither the funds nor the expertise to compete in influence with the Administration. Professional bureaucrats have developed such expertise that communication between the Administration and Congress regarding technical questions is exceedingly difficult. Expenditures for research and development and therefore the direction of technological change rests at the moment in the hands of the Administration.

In terms of nuclear technology and innovation which exemplifies these developments, the Government has established a body called The Atomic Energy Commission which is an agency independent of Congress or any other agency of the Federal Government. Its members are appointed, with the consent of Congress, by the President, and the AEC is directly responsible to the executive. It has its own corps of experts and carries on research into the military, medical, agricultural and industrial application of nuclear energy. It also makes decisions regarding the funding of basic research in the nuclear field. In terms
of its control over other areas of the society, it has the power to declare certain information secret and may control any information given to the public as it sees fit.

It has the power to license and control use of atomic sources, regulate, inspect, and so forth, all that is connected with the development of atomic energy. The AEC is an example of how the Government is moving into areas traditionally thought of as outside the prerogatives of government; e.g., the AEC funds the building of power plants, hires university scholars for special projects, determines prices for radioactive materials, regulates industries, and even establishes semi-private industries as watchdogs (e.g., Sandia Corporation); all of these things conflict with the traditional notion that government should stay out of business and let the system operate as it will.

With this growing power of agencies connected with the Administrative Branch of the Government, we also see the development of controlled news issued to the public and Congress upon which decisions would or could be made regarding developments in nuclear technology and science. Thus, Congress is losing power in relationship to the Executive Branch; the public cannot determine what is occurring and is thus losing its ability to vote wisely; and bureaucrats are making basic decisions once reserved for elected officials. The relationship between government and the academic community has changed. The fundamental prerogative for the development and control of atomic energy rests with the Administrative Branch of the Federal Government and while it has shared to an extent control with state governments which demonstrate their capacity to take on regulatory responsibility, the basic decision to involve or not to involve state governments rests with the Federal Government.

Another indicator of growing centralization is the apparent growth of regional planning, industrial-political interlocking cooperation and diminution of intellectual independence. Regional planning, industrial-political interlocking cooperation, and even establishment of semi-private industries are all examples of how the Government is moving towards the building of power plants, hiring university scholars for special projects, determining prices for radioactive materials, establishing semi-private industries, and so forth. All of this is in contrast to the traditional notion that government should stay out of business and let the system operate as it will.

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RELATE TO NUCLEAR TECHNOLOGY AND PROBLEMS RELATIVE TO POLITICAL TRENDS, ISSUES, TRENDS, AND POLITICAL PROBLEMS
Interstate agreements are developing to aid states incapable of carrying on expensive programs in nuclear energy by themselves and also to face up to interstate problems (such as water pollution) arising from the utilization of nuclear energy. The funding of research by the Federal Government in the field of nuclear energy has made a number of scholars and universities heavily dependent on federal funds to carry on their activities which in turn makes these traditional sources of independent inquiry more receptive to the demands of the Government. Industry too has a new special relationship with the Federal Government. In its drive to acquire more or a larger share of federal money, interlocking jobs are arising whereby personnel from industry become employed by the Government and where governmental workers become employed by private industry when it is in the interest of both the Government and industry. Industry is also growing larger and multi-based industries (those with many products and services) are growing to capitalize on the multiple needs of government. Because the Government is spending such huge sums, industry is also becoming more influenced and directed by the decisions of government. Thus, the influence of government at the national level on other governments, industry and the academic community has grown so great that the Federal Government has extraordinary power to affect the direction of technological change and is using that power on the basis of national interest as defined by the people in the Administrative Branch. Defining the national interest is a difficult task for those in government. Apparently, it has decided that social problems (race, housing, smog, etc.) are becoming too complex and too expensive to be solved on the local level. These problems, then, are becoming nationalized and more and more controlled by the Federal Government. Military or defense needs have also added to the growth of decision making power of the Federal Government as well as the decision of the recent administrations that the Federal Government had to insure the continuous and smooth growth of the economy. In addition to the growth of federal power, there are other phenomena to show the increasing
centralization of decision making in the U.S.A.: local and state governments are finding it necessary to develop their own bureaucracies to cope with technological change generally: increased cooperation among constitutional states, growing decision making within states, and greater centralization in the nature of and role of government which could be profitably pursued by educators concerned with individualism which could be important for the individual in a technological society and which could be important for educators in technological developments.

Although the expansion of the Administrative Branch of the Federal Government in the area of decision making vis-a-vis technological development is clear, there are also signs that decentralization tendencies are developing which could be profitably pursued by educators concerned with individualism which could be important for the individual in a technological society and which could be important for educators in technological developments.

The essential problem for the individual is: how does he devise means by which to affect decisions which makes individual involvement that much more difficult. The essential need here is increased cooperation and ties between government and business and there is increasing cooperation between government and business and the need for finding it necessary to develop their own bureaucracies to cope with technological change generally: centralization of decision making in the U.S.A.: local and state governments and technological society.
Under the impact of technological change, the traditional market mechanisms (i.e., supply-demand balance, open competition, etc.) in this country are rapidly changing, especially in those industries having close ties with the government. Businesses' relationship with government has changed from the traditional pattern of no governmental interference, to a cooperative arrangement whereby business is given a free hand to carry out tasks defined by the government as essential. Governmental contracts are written on a cost plus basis which means that the Government is taking the risks and that competition is being reduced since one contractor is utilized rather than open competition and many businesses being involved. This phenomenon arose primarily from the Government's military needs and from the fact that R & D expenditures for the kinds of products and systems needed by the Government are much too expensive for any single business to afford, thus the Government spends more on R & D than all other sources combined. The expenditures of R & D by the Federal Government means that it has a much greater impact on economic decision making than heretofore. As a result the public and private sector of the economy are growing closer and closer together.

Another outgrowth of government involvement in business has been the rise of the supercorporation which is capable of handling the multiple demand of the Government and the consequent decline in smaller corporations.

Thus there is a continued move toward bigness in government and business. Businesses are attempting to rationalize their operations and thus again there is a shift from ownership power to manager and professional power. Organization has now become one of the greater formers of individual opinion and values.
The process of technological change is no longer the result of spontaneous market forces but is the deliberate creation of public and quasi-public efforts. Because technological change is a conscious effort, it is capable of being controlled and directed. Because there is a drive for a higher standard of living and constant economic growth that has involved business, government, and universities, an informal cooperative group among the bureaucrats of each institution has formed to maintain the U.S.A. in a permanent technological revolution. To maintain growth and innovation, the Federal Government has established a number of non-profit, semi-private businesses for which the Government puts up the money for which the Government puts up the money, resulting in the establishment of a number of non-profit, semi-private businesses.

This development of semi-private corporations is largely a result of nuclear technology since the first one was established by the AEC, the Sandia Corporation, to supervise the many development projects sponsored by the AEC. Since then another fifteen corporations have been established by the AEC, the Department of Energy, etc. The development of semi-private corporations is largely a result of the development of semi-private corporations.

The lives of individuals in America will be affected by the political and economic changes described above. The individual will have a decisive effect — the individual will have a decisive effect — not only on the economic decisions of individuals but also on political and economic decision making. The individual has the power to affect the economic decisions of individuals. The individual is becoming more conscious of the impact of economic decisions on his or her life. The individual is becoming more conscious of the impact of economic decisions on his or her life. The individual is becoming more conscious of the impact of economic decisions on his or her life.
Social, Economic, and Political Trends, Issues and Problems Relative to Nuclear Technology

Social Trends Relative to Technological Innovations (Continued)

Organizations Concerned with Nuclear Technology

United States Government

Joint Committee on Atomic Energy

This committee is made up of members from both houses of Congress. Its responsibility lies primarily in the development of basic legislation regarding the development and control of nuclear technology. Through its hearings it helps to clarify issues, problems and proposals relative to nuclear technology. It publishes transcripts of hearings and annual reports which may be obtained from the Government Printing Office.
energy. Reports are published and available.
worker skills needed by industries utilizing nuclear
radioactive and has an apprentice program for developing
organizations concerned with nuclear energy or
This department determines health and welfare stand-

Atomic Energy Commission, U.S.A.

Department of Labor

other materials which can easily be obtained from
energy. It publishes numerous books, pamphlets and
agency in the United States concerned with nuclear
active materials, etc. It is the single most powerful
as the problems, waste disposal, transfer of radio-
solving problems associated with atomic energy such
is many applications? How? Considering and
controlling or regulating the use of nuclear energy in
areas of need; developing atomic weapons research;
vigilant research and development funds and identifying
the development of nuclear technology through pro-
position by the President. Its responsibilities include
organized departments, even to a board of
Government. It does not fall under the jurisdiction
This agency is an independent agency of the Federal

Atomic Energy Commission, U.S.A.

ORGANIZATIONS CONCERNED

(continued)
WITH NUCLEAR TECHNOLOGY

RELEVANT TO NUCLEAR TECHNOLOGY
AND PROBLEMS RELATIVE
POLITICAL TRENDS, ISSUES,
SOCIAL, ECONOMIC, AND

(continued)
### Department of Health, Education and Welfare

This department's Food and Drug Administration investigates and maintains standards for public health regarding the use of radioactive materials when involved with processing or treating foods from the farm to the container. It also develops policies regarding the use of radiation techniques in the food industry. This department also has a children's bureau which is especially concerned with the effects of radiation on children. Reports are published and available.

### Department of Commerce

The department's Bureau of Standards establishes standards concerned with permissible dosages of radiation and means of measuring radiation. This department also is concerned with the packaging of radioactive materials to make them safer to handle. Reports are published.

### Department of Agriculture

This department carries on experimental programs on the use of radiation techniques for the improvement of plants, insect control, and similar things. It also establishes standards for workers involved with radioactive materials in agriculture. Publishes reports.
SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY

Organizations concerned with nuclear technology

(continued)

RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA

Interstate Commerce Commission

The commission is responsible for establishing controls on the interstate transportation of radioactive materials. The commission is interested in the interstate transportation of radioactive materials.

Atomic Industrial Forum

This group is primarily concerned with the dissemination of information regarding the industrial use of nuclear energy and to act as a pressure group of the dissemination of information regarding the industrial use of nuclear energy.

American Nuclear Society

Publishes magazines, reports, and annual reports.

Other Agencies

Research and development of nuclear energy and to act as a pressure group of the dissemination of information regarding the industrial use of nuclear energy.

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This society is made up of university, business, and government scientists.
Power Companies

Most power companies in the U.S.A. now have some direct or indirect concern with the development of atomic power plants. They publish reports and other materials which generally support the full use of nuclear power through private companies and to assuage fears related to atomic energy.

Edison Electric Institute - an association of private electric power companies

It publishes reports for laymen which demonstrate the advances made by private industry in the development and utilization of nuclear energy.

Inter-American Nuclear Energy Commission

An agency of the organization of American states responsible for inter-American cooperation in peaceful nuclear fields.
Europe-wide development of nuclear energy.
The European Economic Community working for the
European agency overlapping but more inclusive than

EURATOM

This agency is made up of an international team of
experts in nuclear science and technology. The
agency is primarily an information gathering and
dissemination agency on the relationship of nuclear
energy and technology to world problems. They
publish many technical journals and publications
which are available from the United Nations.

Atomic Energy Authority, United Kingdom

This agency is responsible for furthering the develop-
ment of nuclear technology in the United Kingdom
and for the safety of nuclear applications. They
publish reports.

International Atomic Energy Commission

This agency is made up of an international team of
experts in nuclear science and technology. The
agency is primarily an information gathering and
dissemination agency on the relationship of nuclear
energy and technology to world problems. They
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Organizations concerned

with nuclear technology

and problems relative
to nuclear technology,
and political trends, issues,
and social, economic, and
social science data.
International Atomic Energy Agency

Located in Vienna, Austria, this agency supports research, teaching and other developmental aspects of nuclear technology. The IAEA is a major organization associated with the United Nations involved in the international cooperation on the peaceful exploitation of nuclear technology.