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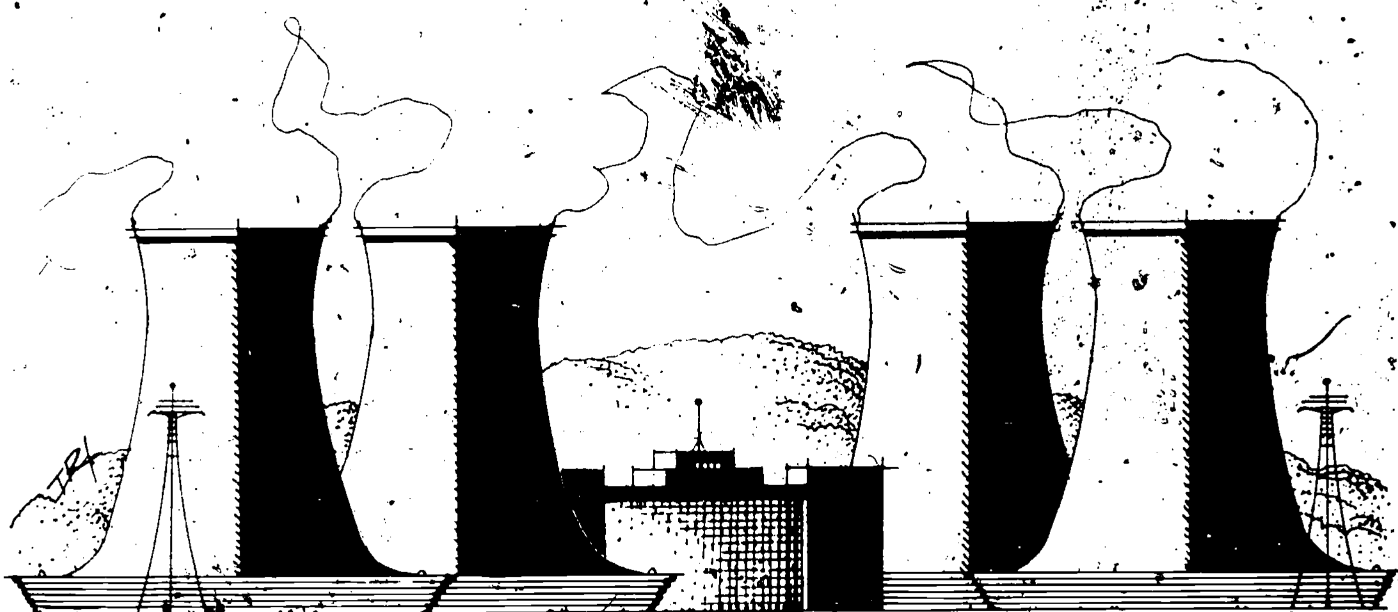
ABSTRACT

This teacher's guide accompanies a course concerning the need, environmental costs, and benefits of electrical power generation. Each chapter of this guide corresponds to a chapter in the course text, and includes the following: a list of behavioral objectives for the corresponding chapter, a list of suggested activities, recommended audio-visual aids, and a list of reference materials. At the end of the teacher's guide is a decision-making model to help the reader analyze the information received. The appendices include laboratory safety rules for working with radioactive substances and an achievement test. (MH)

ERDA-70

Teacher's Guide



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U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
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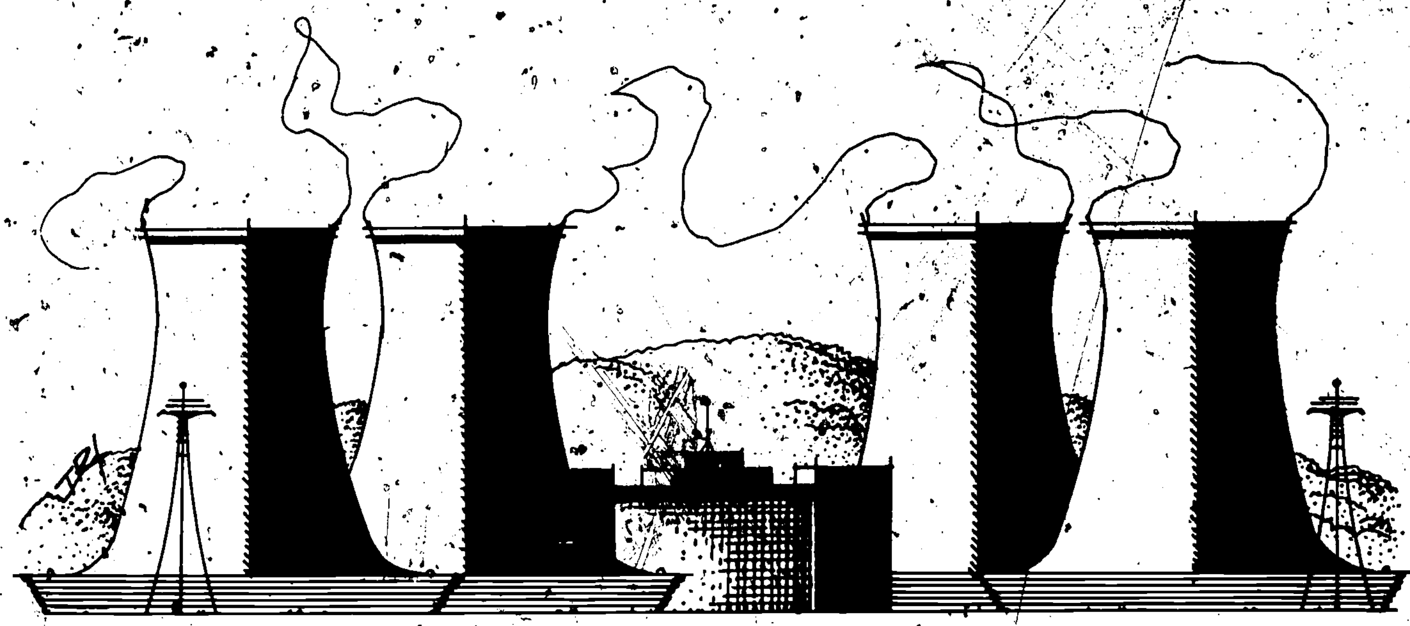

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PHILOSOPHY OF THE PROGRAM

The major goal of this minicourse is to have students gather pertinent information on the need for and generation of electrical energy, then make their own judgments on whether a need exists and, if so, how the need can best be filled. The students must be made aware of the advantages and disadvantages of each method of electrical generation without the teacher unduly emphasising one method. In short, the job of the teacher is to "*tell it like it is*" and then to encourage the students to evaluate the information and make their own judgments.

We urge you to use teaching techniques which involve students actively acquiring knowledge and to avoid, as much as possible, teacher-centered methods in which the learners play a passive part. Student-centered activities include individual studies of some aspects of the problem, seminar-type meetings, committee reports, debates, field trips, resource persons, and laboratory experimentation.

The educational objectives, suggested activities and other pertinent material are presented for each chapter. Feel free to modify the activities to fit your class needs.

PURPOSE OF COURSE

In an era when the requirement for additional sources of power is growing at an ever-increasing rate, and concern for the protection of our environment is rightfully coming to the fore, it is imperative that an unbiased, straightforward view of the advantages and disadvantages of the various methods of generation of electrical power be made available to our schools.

This course is an effort to describe the need, environmental costs and benefits of electrical power generation.

This minicourse was initiated by the U.S. Atomic Energy Commission, with the continued sponsorship of the Energy Research and Development Administration, and produced by the Pennsylvania Department of Education. It was written and compiled by a committee drawn from educators, engineers, health physicists, members of industry and conservation groups, and environmental scientists.

The Committee

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PREFACE

Generation of electrical power has provided a vital link in the everyday life of almost every member of the human race. Recent ominous warnings, however, regarding potential detrimental effects of by-products of wide scale power generation and distribution networks have made headlines in the news media. While students in our classrooms may not express as much enthusiasm for the scientific and engineering principles behind power generating facilities as their teachers, they have great interest in environmental protection problems. Thus a discrepancy has been generated between the benefits and hazards of providing a source of the "*good things*" in life. A wise teacher recognizes the potential for stimulating interest and learning inherent in the presence of a *cognitive discrepancy* (a discrepancy between what a person predicts should happen and what actually happens). Science teachers often attempt to stimulate their students by carefully drawing their attention to apparent discrepancies in nature to spur information-seeking, problem-solving and cognitive learning.

This minicourse attempts to capitalize on the discrepancies heightened by the news media. It attempts to serve in two ways. Frist, it provides information relative to power generation which may be useful in reducing the discrepancy. Second, it attempts to maintain a certain level of discrepancy by not providing a comprehensive list of answers; instead it provides some information which may be useful in formulating such answers.

Out of this argument stems the first *how to* recommendation for this minicourse. Prior to beginning the minicourse,

HAVE EACH STUDENT FORMULATE A LIST OF QUESTIONS ABOUT ENVIRONMENTAL PROTECTION PROBLEMS ASSOCIATED WITH ELECTRICAL POWER GENERATION.

Ask the student to check off the questions as they are answered and add more questions as they are raised. A reasonable goal is to end up with a longer list than he/she started with.

The minicourse is designed to be flexible to permit its most meaningful application by the teacher. As such there are numerous alternative ways it can be used.

- As an integral part of a science course.
- As an optional, nonrequired part of a science course.
- As an independent study unit in an individualized approach.
- As a springboard for further study into other areas of environmental protection.
- As a basis for an adult information and/or education course.

INTRODUCTION TO THE TEACHER'S GUIDE

Each chapter of this teacher's guide corresponds to a chapter in the minicourse text. There are four sections in each chapter.

The first section of each chapter consists of behavioral objectives for that chapter. A behavioral objective is a statement which describes student observable behavior or products of student behavior. Science advances by making valid inferences on the basis of observed phenomena. So, too, it is extremely difficult to determine the amount and extent of learning that has taken place without making valid inferences based on observable acts, such as test performance. A test provides a limited amount of observable products from which to infer the unobservable process of learning. A comprehensive set of behavioral objectives provides a wider and thus more valid basis for describing the act of learning. Behavioral objectives can be a great aid to learning. But how do you use them with your students?

If your experience with behavioral objectives is limited, read recent literature in education about behavioral objectives.

Objectives in the file or mind of the teacher are essentially locked away from the students. This fosters student dependency on the teacher and results in the game of guessing what objectives the teacher is going to place on the next examination. Both of these situations are highly inefficient. Therefore the first thing you need to do with the objectives of the course is to communicate them to the students. Later, construct tests around these objectives.

Most educational activities are followed by some form of evaluation to estimate the amount of student learning. Test items have been written for this minicourse and appear in Appendix II. These test items have alternative ways of being used. Use them to (1) evaluate the learning of each on each of the objectives; (2) evaluate the learning of each student relative to the others in the class; (3) let the students interpret their degree of learning from the test. The latter course of action may be used when you wish to encourage independent functioning on the part of your students.

The evaluation of the test items is necessarily limited to basic terminology and concepts of power generation and environmental protection. In a larger way, the questions raised by the inquiring mind are extremely difficult to evaluate. In addition, there are many questions which do not have definitive answers. It is extremely important to recognize this in the classroom activities. It is also imperative to remember that while many questions raised by students do not have definitive *yes* or *no* answers, there is a way to determine whether a student's answer is valid or not. Does the answer or solution (1) violate respected assumptions of known facts; (2) demonstrate logical inconsistency with other parts of the solution and known facts; (3) violate all common sense? Finally, a most necessary requirement is that of demanding accountability from the student. Can a student back up his/her solution or answer with evidence, either of an empirical or authoritative nature? The teacher should become schooled in the asking of questions like, "*What is the basis for your assertion?*"

The second section of each chapter is a list of suggested activities for that chapter. These activities, plus others which you may construct, are designed to aid you make your instruction more student-centered.

All teachers at some point in their careers assume that teaching is lecturing. If the teacher just presents a lecture lucidly describing the essentials of a concept, the listeners will be *taught*. Of course, presenting the information should include the appropriate voice inflections, projection techniques, and gesturing to dramatize the information, and "*lucidly*" usually implies that the listeners can clearly understand the information being presented.

To say lecturing is categorically bad is bad in itself. But lecturing has serious drawbacks which should cause us to consider alternatives. For example, it is difficult, if not impossible, to deliberately select and present the exact combination of words which will communicate the proper message. Secondly, even when this criteria is met, the learner may (1) have brought into the session all the content that was lectured; (2) not have heard the words in the context in which they were spoken; (3) have had experiences opposite to those stated by the lecturer.

Finally, lecturing either directly or indirectly encourages student dependence upon the teacher and discourages practice in independent student thinking. If your objective is to have students be able to repeat or recognize certain facts, regardless of their truth or accuracy, lecturing is a highefficient method. If, on the other hand, you seek to promote the ability of learners to synthesize or evaluate information, to demonstrate their ability to take a position with respect to several plausible alternatives, and to provide evidence (hopefully scientific and empirical) for his/her position, then use questioning techniques as opposed to lecture, as much as possible.

To guide your question-asking verbal behavior in the classroom, the following categories should be studied and practiced. These are taken from Robert B. Ribble and Charles B. Schultz, "Social-Substantive Schedule, Mirrors of Behavior," Vol. 12, Philadelphia: Research for Better Schools, Inc., 1970. An audio tape of your classroom will provide a basis for checking how many of these behaviors you are actually using. Teachers invariably grossly overestimate the amount of questioning and underestimate the amount of telling that transpires in their classroom.

1. *Checking:* asks the student to recall or find previously encountered material.
   St: Are these three batteries hooked up all right?
   T: What cautions did your instructions point out?

2. *Exploring:* asks the student to try another idea or add to what he/she has said or done.
   St: It says to make sure the batteries must all face the same way.
   T: What else do you think would be important?

3. *Pursuing:* asks the student to support his/her statement.
   St: Oh, it also says to be sure the needle swings up.
   T: Where did you find that statement?

4. *Eliciting:* asks the student to make an assertion.
   St: Right here in frame 16-14.
   T: I see. What do you think will happen if the cells are hooked in parallel?

5. *Translating:* asks if a paraphrased version of the student statement is accurate [Note: (a) The student must know he/she may answer either *yes* or *no*; otherwise the statement tends to be coercive. (b) A good paraphrase eliminates one or more of the possible interpretations of the student statement.]
   St: Not as much electricity will flow.
   T: Do you mean that the needle will deflect less?

6. *Supporting:* tells the student that his/her performance is acceptable. This response should be used to build the student's self-confidence in his/her own performance. Hence, right answers should not be the prime target. Instead student performance should be weighed in terms of previous results, techniques, hypotheses, and models.
   St: Yeh, that's what it did when the battery needed charging.
   T: Sounds reasonable. Let me know how your prediction turns out.

7. *Focusing [informing]:* presents additional information. This technique should be used sparingly since the student is supposed to obtain most of the information from performing the exercises. Normative information, examples, or reasons for a procedure are most easily justified.
   St: Is this OK?
   T: I believe that your set-up is close enough to permit some readings.

8. *Directing:* suggests a procedure for the student to follow. Acceptance of the suggestion should be a student option.
   St: What will happen if I use thinner copper wire around the carbon?
   T: Why don't you try it and compare your results with John and Pete?

For other suggested activities besides those given in this guide, see *Energy and Man's Environment*, an elementary-through-secondary interdisciplinary activity guide available from Energy and Man's Environment, 2121 Fifth Avenue, Seattle, Washington, 98121.

The third section of each chapter is a list of audio-visual aids, most of which may be borrowed at no charge. They are from widely-varying sources, and may not all be suitable for a given age or educational level. So, preview any you plan to use.

The fourth section of each chapter is a list of references. Some are booklets which can be ordered. You may also wish to check the list of references in the appendix of the minicourse text.

At the end of the teacher's guide is a decision-making model to help the reader analyze the information he/she has received. This also appears as an appendix to the minicourse text. Finally, there are two appendices, the first concerning laboratory safety rules for working with radioactive substances, and the second an achievement test.

CHAPTER 1

THE DEMAND FOR ENERGY

A. Objectives

1. The student will discuss two reasons for the increasing world energy demands.

2. The student will discuss the growth in electrical energy use in the United States.

B. Activities

1. Have students discuss the role which electricity plays in supporting our current standard of living and the adaptations which we would be forced to make if this energy supply were seriously curtailed.

2. Hold a class debate: *Is pollution necessary? Can we live in a pollution-free society?*

3. Have students complete the activity *"How much electricity do you use?"* in the supplementary section at the end of Chapter 1 in the text.

4. Have a group discussion of which home appliances could be discarded to reduce electrical consumption.

5. Interpret population projection charts to determine the most probable population growth in the U.S.

6. Discuss *"Will recycling reduce electrical consumption?"*

7. Consider the following situation: Flood, high winds or some other unusual event has severely reduced electrical power. You are to form an advisory committee and set up priorities, since electricity will have to be rationed. What groups should be represented on this committee (e.g., city government, hospital, factory, etc.)? Determine priorities, such as who will get power and who will not, and to what degree.

8. Collect cartoons related to power generation or the energy crisis and make a bulletin board display. Include other items as you see fit.

9. Present the following problem to students, with or without time for them to prepare answers or possible solutions: Electric power has been rationed due to recent damage by violent weather. In spite of warnings to the contrary, your best friend's family continues to use total air conditioning. The brownout seriously hinders the full use of certain equipment at the local hospital. Ask the students, *"What is your reaction? What are you going to do about it? What should you do about it?"*

10. Identify the materials used in a new automobile and the source of these materials. Estimate what percentage comes from oil-based sources.

11. Have each student in a section, class or school individually rank the importance of the items listed below. Then collect information on how many number 1 votes, number 2 votes, etc., each item receives. Have each student compare his/her rankings with the composite rankings.

Rank from 1 (most important) to 15 (least important).

a. pure water
b. clean air
c. acceptable noise levels
d. an understanding of ecology
e. conservation of our natural (including human) resources
f. a practical environmental life style
g. elimination of litter
h. stabilized population growth
i. ban on use of biocides (pesticides and herbicides)
j. efficient consumer practices
k. reduction in energy consumption
l. rational land usage
m. reduction in private and commercial solid waste products
n. control of thermal pollution
o. sensitivity to one's surroundings (environmental awareness)

12. Have a group of students, playing the roles of ambassadors from an underdeveloped country, develop and present an argument at the United Nations for a more equitable share of the world's resources. Use real data from actual countries if you wish.

13. Time's choice for *Man of the Year* in 1975 was the late King Faisal of Saudi Arabia. What reason did Time give for this selection?

14. Construct collages from magazines and papers on the topics *energy, pollution and quality of life.* Or use photographs from the school and community for such a collage.

15. Have students read about electric meters and do the "*Reading Electric Meters*" activity in the supplementary section at the end of Chapter 2 in the text.

C. **Audio-Visual Materials**

1. *The Energy-Environment Game*, a simulation dealing with society's demand for energy and its effect on the environment. Edison Electric Institute, 90 Park Ave., New York, New York, 10016.

2. *Environmental Health: Energy and the Environment*, a teaching kit including records and filmstrips prepared for Southern California Edison Company by H.R.A., Inc., P.O. Box 3036, Granada Hills, Calif. 91344.

3. *Nuclear Power and the Environment*, 16mm sound, 14 min. Takes up the problems that stem from the growing demands for electricity in the U.S. Discusses the care taken in studying and controlling the effects of nuclear power plants on the environment.

4. *The Petroleum Tree*, a chart showing products obtainable from crude oil. Single copies available from U.S. Department of Interior, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pa. 15213.

5. *Encounters with Science*, 33-1/3 RPM audiodiscs, each containing eight short sequences. Many are on energy-related matters. Available from National Science Foundation, A/V Production Officer, Room 531, 1800 G St., N.W., Washington, D.C. 20550.

D. **References**

1. *The Search for Tomorrow's Power*, National Geographic, November 1972, pp. 650 ff.

2. *Managing the Power Supply and the Environment*, Report of the Federal Power Commission's National Power Survey Task Force on Environment, July 1971. Federal Power Commission, Washington, D.C. 20426.

3. *The Significance of Arab Oil*; booklet available in single copies from League of Arab States Information Center, 35th Floor, 747 3rd Ave., New York, N.Y. 10017.

4. Energy and the Future, book giving a general view. Published by American Association for the Advancement of Science, 1973.

CHAPTER 2

MEETING THE DEMAND FOR ELECTRICAL ENERGY

A. Objectives

1. The student will describe the production of an electric current and relate this to the generation of electrical power.

2. The student will identify the present methods of generating electricity, some possible alternative methods and the limitations of each in meeting our energy requirements.

B. Activities

1. Have the students use a hand-operated generator to produce enough energy to light a small incandescent bulb. This generator might then be operated by a model steam engine, producing, in effect, a miniature power generating system.

2. Demonstrate the magnetic lines of force by sprinkling iron filings on a piece of heavy paper placed over horseshoe and bar magnets.

3. Conduct a field trip to one or more of the following: power plant, strip mine, deep mine, transmission substation.

4. Allow the students to experiment with Oersted's loops. Can they devise ways to increase the amount of electricity they can get from this apparatus?

5. Build a model windmill or water wheel generator. Measure its output.

6. Prepare a small bank of photoelectric cells hooked up to a milliammeter. Determine the electrical output under varying light conditions.

7. Have the students prepare and present reports to the class on alternative sources of electricity.

8. Try to devise alternative schemes of generating electricity.

9. Have an electric company representative discuss:

   a. How their local generating station operates.
   b. How a power grid (transmission and distribution system) works.
   c. How they try to solve their environmental problems.

10. Assume that a space platform in stationary orbit over the U.S. converts solar energy to electrical energy. Brainstorm all methods you can think of to transport that energy to the earth. Next, examine the advantages and disadvantages of each method suggested.

11. Have students read about electric meters and do the *"Reading Electric Meters"* activity in the supplementary section at the end of Chapter 2 in the text.

C. Audio-Visual Materials

1. *World Behind your Light Switch*, 16mm sound, 28 min. On transmission of electricity. Bonneville Power Administration, U.S. Department of the Interior, P.O. Box 3621, Portland, Oregon, 97208.

2. *Inertia*, 16mm sound, 28 min. On transmission of electricity. Same source as Number 1 above.

3. *Electric Power Generation in Space*, 16mm sound, 26-1/2 min. On solar cells, fuel cells. NASA—order from NASA Regional Film Library serving your state.

4. *Birth of an Era*, 16mm sound, 27 min. On hydropower. U.S. Army Engineer District, 200 E. Julian St., P.O. Box 889, Savannah, Ga. 31402.

5. *Trees and the Energy Crisis*, Reel audiotape, 7-1/2 ips, 15 min. On wise use of resources. American Forest Institute, Education Division, 1619 Massachusetts Ave., N.W., Washington, D.C. 20036.

6. *Natural Gas Fuel Cell*, 16mm sound, 28 min. Shows production of electricity from fuel cells. Brooklyn Union Gas, Public Relations and Advertising Dept., 195 Montague St., Brooklyn, N.Y. 11201.

7. *To Bottle the Sun*, 16mm sound, 5-1/2 min. On fusion. ERDA (formerly USAEC) Film Library, P.O. Box 62, Oak Ridge, Tenn. 37830.

D. References

1. *The Search for Tomorrow's Power*, National Geographic, November 1972, pp. 650 ff.

2. Following are the names of seven chapters from the book *Mineral Facts and Problems.* One copy of up to 10 of these chapters may be requested in booklet form on official stationery from U.S. Department of the Interior, Bureau of Mines, Publications Distribution, 4800 Forbes St., Pittsburgh, Pa. 15213.

Anthracite
Bituminous Coal and Lignite
Energy Resources
Natural Gas
Petroleum
Shale Oil
Uranium

3. *Power and Progress*, a booklet on general facts about electricity. Single copies available from Edison Electric Institute, 90 Park Ave., New York, N.Y. 10016.

CHAPTER 3

NUCLEAR FUEL GENERATING STATIONS

A. Objectives

1. The student will describe in general terms the process of fission. This will include the concept of the chain reaction as a necessary phenomenon for the continuation of the process.

2. The student will list and describe the functions of the major components of a nuclear reactor. Major components mean fuel assembly, moderator, coolant, control rods and shielding.

3. The student will compare the various reactor types in terms of the cooling systems used.

4. The student will describe the concept of the breeder reactor and the types of breeder reactors.

5. The student will describe the safety features of reactors, including natural safeguards and engineered safeguards.

B. Activities

1. Have your students construct a model nuclear power station.

2. Arrange for a tour of a reactor facility near you. Make certain that your students are well prepared for the trip and that follow-up activities are conducted when you return.

3. Conduct mock hearings relative to the licensing of an imaginary power reactor in your school district. Divide your class into groups representing the utility company, the Nuclear Regulatory Commission, the state regulatory agency and a watchdog conservationist group. Discuss the situation from all aspects. (Refer to **Nuclear Power and the Public**, pages 124-194. See reference in Section D of this chapter.)

4. Contact the American Nuclear Society to suggest speakers and materials concerning nuclear power plants. Write Octave J. DuTemple, Executive Secretary, American Nuclear Society, 244 East Ogden Avenue, Hinsdale, Illinois 60521.

5. Prepare a list of similarities and differences between a nuclear reactor and an atomic bomb.

C. Audio-Visual Materials

1. *Atomic Power Today: Service with Safety*, 16mm sound, 28-1/2 min. A 15-minute abridged version is also available. ERDA (formerly USAEC) Film Library, Technical Information Center, P.O. Box 62, Oak Ridge, Tenn. 37830.

2. *Tomorrow's Power–Today*, 16mm sound, 5-1/2 min. Available from same source as Number 1.

3. *The Experimental Boiling Water Reactor*, 16mm sound, 30 min. Available from same source as Number 1 above.

4. *Power Unlimited*, 16mm sound, 12-1/2 min. Available from same source as Number 1.

5. *A Breeder in the Desert*, 16mm sound, 29 min. Available from same source as Number 1.

6. *The Piqua Nuclear Power Facility*, 16mm sound, 23 min. Animated comparison of various power reactor types. Available from same source as Number 1.

7. *Dresden Nuclear Power Station*, 16mm sound, 15 min. Available from same source as Number 1.

8. *Landmark*, 16mm sound, 14 min. On breeders. Available from same source as Number 1.

9. *My Nuclear Neighbors*, 16mm sound, 15 min. Illustrates how nuclear generating stations fit into communities. Klein Company, Walter J., Distribution Director, 6301 Carmel Rd., Charlotte, N.C. 28211.

10. *Now that the Dinosaurs are Gone*, 16mm sound, 28 min. Rental fee, but may be available free from local utilities. Atomic Industrial Forum, Inc., 475 Park Ave. S., New York, N.Y. 10016.

D. References

1. A complete set of the *Understanding the Atom* series may be obtained free by teachers writing to ERDA (formerly USAEC), P.O. Box 62, Oak Ridge, Tenn. 37830.

Nuclear Power Plants
Nuclear Reactor
Plutonium
Research Reactors
Snap; Nuclear Space Reactors
Breeder Reactors

2. **Nuclear Power and the Public**, Harry Foreman, editor, University of Minnesota Press, Minneapolis, Minn. (1970).

3. *The Four Big Fears about Nuclear Power*, Ralph E. Lapp, **The New York Times Magazine**, Feb. 7, 1971.

4. *More Energy from the Atom–But Will It Come in Time?* **U.S. News and World Report**, Feb. 19, 1973.

CHAPTER 4

FOSSIL-FUELED ELECTRICAL GENERATING STATIONS

A. Objectives

1. The student will identify the methods of using fossil fuel to produce electricity by steam generation.

2. The student will discuss existing reserves of fossil fuels and their predicted availability.

3. The student will discuss the particular problems related to the use of coal in the production of electricity.

B. Activities

1. Have your students construct, demonstrate and discuss Hero's Engine, made from a toilet tank float and copper tubing.

2. Perform destructive distillation of a sample of soft coal. Describe the products.

3. Visit a fossil-fueled electrical generating plant.

4. Arrange a class visit to a nearby coal mine or gas or oil well.

5. Compare the methods of transporting coal, oil, gas and electricity.

6. Using a Polaroid camera, photograph the stack emissions from a power plant over a one-week period.

C. Audio-Visual Materials

1. *Invasion by Oil*, 16mm sound, 27 min. On oil spills. U.S. Army Engineer District, Attention PAO, P.O. Box 4970, Jacksonville, Fla. 33201.

2. *The Invisible Power of Coal*, 16mm sound, 28 min., National Coal Assn. Available from Modern Talking Picture Service. Must be booked from their exchange nearest you.

3. *Natural Gas and Clean Air*, 16mm sound, 20 min. American Gas Assn., Film Service Library, 1515 Wilson Blvd., Arlington, Va. 22209.

4. *Power from Paradise*, 16mm sound, 32 min. On construction of a coal-burning plant. Tennessee Valley Authority, Film Services, Information Office, Knoxville, Tennessee, 37902.

5. *Strip Mine Reclamation*, 16mm sound, 17 min. Available from same source as Number 4.

D. References

1. *Coal in Today's World*, a booklet available in classroom quantities from National Coal Assn., Education Division, 1130 Seventeenth St., N.W., Washington, D.C. 20036.

2. *Protecting our Resources*, a booklet on petroleum available in single copies from American Oil Co., Public Relations Department, 910 S. Michigan Ave., Chicago, Ill. 60605.

3. *Coal is Cheap, Hated, Abundant, Filthy, Needed*, Jane Stein, Smithsonian, February 1973, pp. 19-27.

4. *The Story of Petroleum*, booklet available in classroom quantities from Shell Oil Co., Public Relations, Attn. Room 1541, One Shell Plaza, Box 2463, Houston, Tex. 77002.

5. *Map of Coal Areas in the U.S.*, shows coal deposits, gives reserve and production figures. Available from same source as Number 1.

CHAPTER 5

BASIC ECOLOGY: PRINCIPLES AND IMPLICATIONS

A. Objectives

1. The student will describe nutrient and energy cycles.

2. The student will discuss the concept of community succession in a given ecosystem.

3. The student will describe natural control and balance within an ecosystem and how this balance has been upset by human activities.

B. Activities

1. Obtain several samples from the bottom of a nearby stream. Identify several dominant organisms. Hold these samples at different temperatures for 24 hours and determine what changes, if any, occur in the frequency of the various organisms.

2. Chill about one liter of water to approximately 10 degrees Centigrade. Shake the bottle vigorously to dissolve as much oxygen as possible. Separate into several portions. Determine the amount of dissolved oxygen in the samples as they warm to room temperature.

3. Grow green plants in a sealed terrarium. Introduce sulfur dioxide and determine the effects on the plants.

C. Audio-Visual Materials

1. *Web of Life: Endless Chain,* 16mm sound, 28 min. On ecological balance and its upset by man. ERDA (formerly USAEC) Film Library, P.O. Box 62. Oak Ridge, Tenn. 37830.

2. *Sierra Club Educators General Information Packet,* information on how to obtain Sierra Club teaching aids for conservation education. Sierra Club, Educational Information Office, Room 1050, Mills Tower, 220 Bush St., San Francisco, Calif. 94104.

3. *Energy Vs. Ecology—The Great Debate,* 16mm sound, 27-1/2 min. On coal, surface mining and restoration. Modern Talking Picture Service. Book from Service Library nearest you.

4. *For Man and Nature,* 16mm sound, 28-1/2 min. On protection of man and nature. Available from same source as Number 3.

5. *Ecology,* a classroom poster and discussion guide to help provide students a better idea of the meaning of ecology. Ex-Cello-O Corp., P.O. Box 386, Detroit, Mich. 48232.

D. References

1. **Fundamentals of Ecology** by E. P. Odum, W. B. Saunders Company, Philadelphia, Pa., 1971.

2. **Natural Ecosystems** by W. B. Clapham, Jr. Macmillan Company, New York, N.Y., 1973.

3. **Ecology and Field Biology** by R. L. Smith, Harper and Row, New York, N.Y., 1974.

4. **Concepts of Ecology** by E. J. Kormondy, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1969.

5. **Communities and Ecosystems** by R. H. Whittaker, Macmillan Company, New York, N.Y., 1970.

CHAPTER 6

WASTES IN THE PRODUCTION OF ELECTRIC POWER

A. Objectives

1. The student will compare the current methods of managing waste heat produced in the generation of electricity.

2. The student will compare the magnitude of thermal pollution from both nuclear and fossil electrical power stations and state the reasons for the differences.

3. The student will describe the sources of radioactive waste in power generation.

4. The student will describe the waste management methods for gaseous, liquid and solid radioactive wastes, including the current and projected volumes and activities of these wastes.

5. The student will describe the wastes resulting from the burning of fossil fuels.

B. Activities

1. To illustrate the elimination of radioisotopes by natural radioactive decay, experimentally determine the half life of a short-lived radioisotope such as indium-113m (104 minutes), barium 137m (2.6 minutes) or yttrium-90 (64 hours). These radioisotopes are available from minigenerators distributed by Union Carbide Company, Tuxedo, N.Y. Have the students determine half life by taking a series of one-minute counts of a sample at intervals for a period of time covering several half lives. Be certain to determine background and subtract it from each count. On graph paper, plot a graph of activity versus time. Graphically determine the half life.

2. Use a wet-dry bulb thermometer or sling psychrometer to illustrate evaporative cooling.

3. Devise an air filter, using a vacuum cleaner and filter paper. Compare air pollution samples from various areas of your city. Use a portion of a clean vacuum cleaner bag as the filter.

4. To determine air currents which tend to disperse pollutants over your local area release a number of helium-filled balloons with postcards attached. The postcards should be self-addressed and contain a checklist of the information which you wish to receive, such a location, date, time and name of finder. This will increase student understanding that others are affected by what anyone at any place does.

5. Determine water currents in lakes, rivers or bays, using plastic containers with postcards inside.

6. How can wastes from electrical generating plants be used advantageously? Consider the following waste heat, ash, oxides of sulfur, oxides of nitrogen, radioactive fission products, mining wastes.

7. Obtain ash from a coal furnace or a sample of coal. Run a small amount of water through the coal. Note any changes in pH of the water by means of an indicator paper.

8. Weigh a sample of coal, burn the coal and then weigh the ash.

9. Place 100 ml of heating oil in a beaker and determine its weight. Burn the oil and weigh the ash.

C. Audio-Visual Materials

1. *High Activity Waste*, 16mm sound, 17 min. ERDA (formerly USAEC) Film Library, P.O. Box 62, Oak Ridge, Tennessee, 37830.

2. *Transportation of Radioactive Materials, Part II: Accidents*, 16mm sound, 34-1/2 min. Available from same source as Number 1.

3. *Project Salt Vault*, 16mm sound, 11 min. On disposal of radioactive waste in vacant salt mines. Available from same source as Number 1.

D. References

1. From the Understanding the Atom series, a complete set of which may be obtained free by teachers by writing ERDA (formerly USAEC), P.O. Box 62, Oak Ridge, Tenn. 37830.

Radioactive Wastes

2. **Nuclear Power and the Public, Harry Foreman, editor, University of Minnesota Press, Minneapolis, Minn., 1970.**

3. ***Plans for the Management of AEC-Generated Radioactive Wastes*, WASH-1202(73). Division of Waste Management and Transportation, July 1973. For sale by Superintendent of Documents, GPO, price 80 cents.**

CHAPTER 7

HEALTH EFFECTS: A COMPARISON

A. Objectives

1. The student will identify and describe the major types of radiation from radioactive materials.
2. The student will identify the basic units of radiation dose.
3. The student will compare, in order of dose rate received, the major sources of radiation to the public at this time.
4. The student will describe the somatic and genetic effects of both acute and chronic exposure to radiation.
5. The student will recognize the factors which influence the biological effects of radiation.
6. The student will recognize the assumptions that are made when radiation protection guidelines for low-level exposure are established.
7. The student will list the gaseous effluents from the combustion of fossil fuels for electric generation and their effects on human health and the physical environment. (Gaseous effluents include oxides of sulfur and nitrogen and particulate matter.)
8. The student will describe the concept of benefit-versus-risk.

B. Activities

1. Demonstrate absorption and assimilation of phosphorus-32 from water by fish. (See **Radioactivity: Fundamentals and Experiments**, by Hermias and Joecile, Holt, Rinehart and Winston, 1963, pp. 155-157.)

2. Conduct a student experiment on effects of radiation on the germination of seeds. (See Hermias and Joecile, op.cit., pp. 148-151.) Have beans or corn irradiated at a local hospital or buy irradiated seeds from a commercial source. Keep the number of seeds for each sample above 100, varying the radiation dosage. Study rates of germination and percentage of germination.

3. Have a local radiologist meet with the students to discuss effects and use of radiation and radioisotopes.

4. Have students perform various experiments on the biological effects of radiation. Many are described in Hermias and Joecile (op. cit.) or in **Nuclear Science**, Chase, Rituper, and Sulocoski, Burgess Publishing Company, 1970.

5. Determine the half life of a short-lived radioisotope such as barium-137m. (These may be obtained from commercially produced radioisotope generators available from Union Carbide Corporation, Tuxedo, New York.)

6. Have the students compute their own radiation dosage from the activity in the supplementary material at the end of Chapter 7 in the student text.

7. In class discussion, have students define *quality of life* and describe risks they are willing to take to maintain this quality.

C. Audio-Visual Materials

1. *Atomic Medicine,* 16mm sound, 27 min. ERDA (formerly USAEC) Film Library, P.O. Box 62, Oak Ridge, Tenn. 37830.

2. *Radiation and the Population,* 16mm sound, 29 min. On genetics. Available from same source as Number 1.

3. *Air is for Breathing,* 16mm sound, 29 min. On biological effects of air pollution. Shell Film Library, 450 N. Meridian St., Indianapolis, Ind. 46204.

4. *No Turning Back,* 16mm sound, 27-1/2 min. Shows AEC's long-term commitment to environmental research. Available from same source as Number 1.

5. *A Sea We Cannot Sense,* 16mm sound, 28 min. Discussion of low level radiation effects, both natural and man-made. Available from same source as Number 1.

D. References

1. From the Understanding the Atom series, a complete set of which may be obtained free by teachers, writing to ERDA (formerly USAEC), P.O. Box 62, Oak Ridge, Tenn. 37830.

   Your Body and Radiation
   Radioisotopes and Life Processes
   The Genetic Effects of Radiation

2. **Nuclear Power and the Public,** Harry Foreman, editor, University of Minnesota Press, Minneapolis, Minn., 1970.

3. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation,* Superintendent of Documents, GPO, Price $2.75.

CHAPTER 8

PLANT SITING AND ENVIRONMENTAL IMPACT

A. Objectives

1. The student will describe the ecological, geological, meteorological, geographical, and demographic considerations which must be taken into account in plant-site selection.

B. Activities

1. Have students prepare reports on possible alternative siting for power plants, such as underground or offshore.

2. Have a speaker from a state or federal agency discuss power plant site selection.

3. Choose sites for one or more hypothetical generating plants in your sate. Discuss these proposed sites in light of the considerations in the chapter. Also discuss the reactions to each site by a banker, an educator, an industrialist, a conservation club president, a hospital manager, a farmer, a realtor, a supermarket owner, etc. What are your own reactions?

4. Assume that a nuclear plant will be built on a nearby site. Have the students determine the procedure for obtaining a construction permit. Ask the advice of your local utility. Do the same for a fossil-fueled plant.

5. Obtain an environmental impact statement for a new power plant. Review it in detail.

C. Audio-Visual Materials

1. *Earthquake*, 16mm sound, 13-1/2 min. Describes earthquake studies and engineering adaptations in building construction. Available from Film Associates booking service nearest you.

D. References

1. **Nuclear Power and the Public,** Harry Foreman, Editor, University of Minnesota Press, Minneapolis, Minn., 1970.

2. *Considerations Affecting Steam Power Plant Site Selection,* a report sponsored by the Energy Policy Staff, Office of Science and Technology, 147 pp., 1968, Superintendent of Documents, GPO, R1.25.

3. **Nuclear Power Plant Siting: A Handbook for the Layman**, by Dennis L. Meredith, Marine Advisory Service Sea Grant, University of Rhode Island, Marine Bulletin Number 6, 32 pp. $1.00.

4. 10 CFR Part 100, Reactor Site Criteria, Seismic and Geological Siting Criteria.

CHAPTER 9

ENERGY CONSERVATION

A. Objectives

1. The student will identify the modes of energy consumption in the United States and the methods of conserving energy.

B. Activities

1. Have students discuss advances which may make automobile engines more efficient than present internal combustion engines.

2. The mandatory addition of anti-pollution devices to automobiles had reduced gasoline mileage on most American cars. This is an example of a trade-off: Less efficient fuel use for cleaner air. Is this a wise decision at a time of gasoline shortages? Discuss this on a risk-to-benefit basis.

3. Have students design a mass transit system for your community. How would this reduce pollution while increasing efficiency of fuel use?

4. Compare the pollution effects of current transportation systems with those from transportation systems using electrically-powered vehicles. Compare advantages and disadvantages.

5. Consider the following hypothetical situations.

a. Due to a national emergency, the nation's home consumption of electricity must be reduced. In your community, each dwelling must submit a list of electrical appliances which, when removed from the home, will reduce the home consumption by 25 per cent. The appliances removed will not be returned for a year. What will your family give up? The list of appliances in Activity 3 of Chapter 1 will be helpful.

b. Placed in your home will be a device that will turn off electricity after a monthly consumption of 70 percent of your last month's electrical consumption is reached. Plan how to budget your electricity to meet your needs.

6. Review past electric bills for your home, over as long a period as the bills are available. Construct a graph to show cost, consumption and time. Note on the graph, if possible, when major appliances were added.

7. Survey your community. Identify unnecessary uses of electricity which, if stopped, would have no real impact on your lifestyle.

8. Review popular magazines for utility advertising. Classify this advertising as promotional, conservation, public image or other.

9. Visit grocery stores and compare prices of returnable and nonreturnable soda bottles and cans. Read about and discuss Oregon's non-return law.

10. Develop a system to reward people who travel to work or school in car pool or on public transportation.

C. Audio-Visual Materials.

1. *Crisis in Energy*, 16mm sound, 23 min. General view of energy crisis. Brooklyn Union Gas, Public Relations and Advertising Dept., 195 Montague St., Brooklyn, N.Y. 11201.

2. *Three E's* 16mm sound, 28 min. Shows how energy, economics and environment are related. Exxon co., Public Affairs Dept. 1251 Avenue of the Americas, New York, N.Y. 10020.

D. References

1. *You–What Oil Conservation Means to You.* Booklet discussing dependence on oil and gas. Interstate Oil Compact Commission, Educational Section, P.O. Box 53127, Oklahoma City, Okla. 73105.

2. *Conserve Energy–Our Spaceship Earth–Needs More Fuel!* Comic book tells methods of home energy conservation. Single copies from Edison Electric Institute, 90 Park Ave., New York, N.Y. 10016.

CHAPTER 10

SUMMARY

At this point the student must proceed to synthesize the concepts which have been presented in the various chapters of the course. The student should arrive at decisions which, in his/her own mind, are logical and based upon the information. These decisions should include:

1. Do we wish to maintain our standard of living, or do we wish to give up some or all of the conveniences and products we now enjoy?
2. Do we wish to continue as we are, ignoring the environmental cost? If we do, are we willing to pay the ultimate price?
3. How can we produce the electricity we need at the least expenditure of our mineral resources and at the least cost to our environment?
4. What are the alternatives to the nuclear generation of power? Will these be sufficient for our needs?
5. Are the advantages of nuclear generation (or any other method of generation) worth the price?

As the student formulates these decisions, do not attempt to guide him/her in any way or bias his/her judgments to conform to your own personal attitudes or opinions. Your task is to *tell it like it is* and then to turn the decision-making process over to the student. This, of course, is difficult. We as teachers, tend by our statements, facial expressions and gestures to communicate our own value judgments to our students, but in this case we must absolutely refrain from doing so, even though we will undoubtedly undergo some emotional strain as we watch our students making what may be, to us, the *wrong* decision. However, each student should decide for himself/herself, or as a member of a group of peers. This, after all, is the democratic process.

Engage your students in decision-making. Use the *Flowchart of Basic Decision-Making Model* for resolution of environmental problems found in Appendix III of the student manual and reproduced here.

Flowchart of Decision-Making Model

The reader has been confronted with numerous issues regarding the conflict between enjoying the supposed benefits of a technological society and reducing the quality of our environment to intolerable levels. Decisions to resolve the conflict must be made; they will be made. If knowledgeable people refuse to make these decisions, less knowledgeable persons will. The attitude of *letting George do it* is a gross shirking of responsibility.

But how do persons with a bit of knowledge about the problem, (such as that acquired through this minicourse) make such decisions? How do they evaluate the available data? How do they know when they have surveyed all the data? How do they test for logical inconsistencies within the reports? The problem of analyzing large sets of information and formulating workable solutions to problems perceived is one of the most mind-boggling and difficult endeavors of the human mind; it is also one of the most rewarding.

A model, or guide, to this decision-making process, presented in Figure 1 in the form of an instructional flowchart, suggests things to do (rectangles) and includes crucial questions (diamonds) which help pinpoint errors in interpretation of the data and conclusions. The rectangles and diamonds are logically interconnected by arrows to suggest which way to proceed.

Each main point in the flowchart requires a brief explanation. First, be intellectually aware of the environmental problems caused by electrical generation and be interested in the identification of solutions of these problems.

Stage 1. *Use your knowledge of power resources and environment* to acquire factual information and understanding of basic issues involved. Completion of the minicourse is useful here.

Stage 2. *Identify questions you may have about the issues* for further refinement and analysis.

Stage 3. *Have others raised similar questions?* Answering this question can provide access to discussions of the issue which have already been completed and tends to reduce the phenomenon of *reinventing the wheel.* In addition, the knowledge that may be raising relatively new question can be an enlightening and rewarding experience.

NOTE: Diamonds represent decisions in the form of questions which lend themselves to *Yes, No or ?* answers. The path one takes on the flowchart is determined by the answer to the question.

Stage 4. *Have solutions been posed?* If Stage 3 was answered in the affirmative, we now begin to investigate the merits of the solutions.

Stage 5. *Are solutions based on solid evidence?* If Stage 4 was answered in the affirmative, we can now ask if there is substantial and logical evidence to support the solution under question.

Stages 6-9. A negative response in either Stage 3, 4 or 5 directs the decision-maker into the key branch of the flowchart. Stage 6 directs the learner to *survey information related to the problem (or solution)*, or to examine specific issues which relate to the problem under consideration. Caution! Avoid the temptation to switch to a related problem! Stick to the issue at hand! In Stage 7 *list alternative solutions to the problem;* that is, determine, without excessive evaluation at this point, if there are other possible solutions to the problem. In Stage 8, start the process of evaluating the main and alternative solutions from Stage 7 by *listing advantages and disadvantages of each solution.*

Now that you have examined the evidence and tabulated the pros and cons of the problem or solution, evaluate each as to its practicability. Then *rank solutions from best to poorest* (Stage 9).

After Stage 9, the flow is cycled back to Stage 10.

Stage 10. *Are there unsolved problems?* Presuming affirmative answers to Stages 3, 4 and 5, we are now where we see if all important questions have been asked. It is recognized that *important questions* obviously involves value (subjective) judgments, but value judgments in technological applications are unavoidable.

A negative answer to Stage 10 recycles the flow back to Stage 2, and a positive response sends one to the EXIT of the decision-making program.

Two additional comments regarding this decision-making flowchart are in order. First, it represents a series of intellectual processes and you must try it to understand it.

Second, the flowchart only represents the complex mental process involved in human problem-solving. It is hoped that it will be most valuable when it is considered in its present form, which is neither exceedingly simple nor excessively complicated.

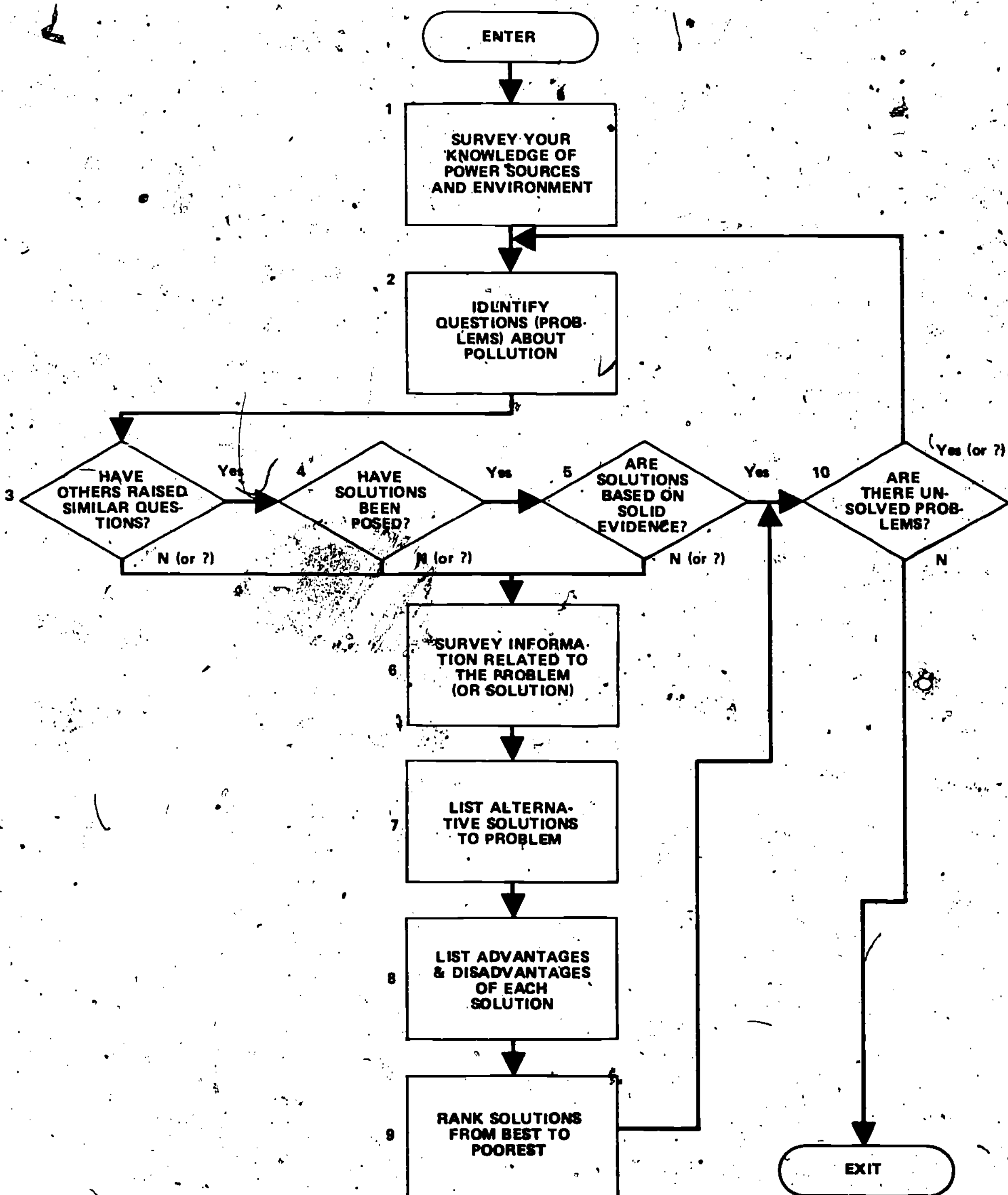

Figure I.
Flowchart of Basic Decision-Making Model for Resolution of Environmental Problems

APPENDIX I

LABORATORY SAFETY

If you plan to use radioactive materials in your laboratory exercises, observe certain safety precautions to reduce the exposure to radiation which your students may receive.

The following rules are taken from the Pennsylvania Department of Education publication, *Nuclear Science: A High School Course.*

LABORATORY SAFETY PRECAUTIONS FOR WORKING WITH RADIOACTIVE MATERIALS.

A. All possible precautions must be taken in order to prevent inhalation, ingestion or skin contact with radioisotopes. Therefore, the following rules will be in effect:

1. There will be no eating, drinking or smoking in this laboratory.
2. Keep your hands away from your mouth, nostrils and eyes.
3. All work with unsealed sources must be done in the fiberglass work trays. These trays will be lined with non-absorbent paper to retain spills and facilitate decontamination.
4. Laboratory coats must be worn at all times when working in this laboratory.
5. Rubber gloves will be worn at all times when handling unsealed solutions. These gloves must be monitored, washed with detergent and water, remonitored, and rewashed if contaminated before removal. The hands will then be washed and monitored.
6. Signs indicating radioactivity must be in prominent display during any experiment with unsealed sources.
7. All contaminated materials must be plainly labeled.
8. Radioactive waste will be placed in the plainly marked *hot* waste can. No other type of waste will be placed in this can, and no radioactive materials will be disposed of elsewhere.
9. The instructor will be consulted before any radioisotopes may be disposed of, to insure proper disposal.
10. There must be no pipetting by mouth. A propipetter or hypodermic syringe should be used.
11. All spills must be reported immediately, and decontamination procedures initiated under immediate supervision of the instructor.
12. All radioactive sources must be sealed before handling or counting.

If rules similar to this are inaugurated and enforced, there should be complete safety from contamination in the laboratory, barring human error.

Contamination of the equipment, the furniture and the laboratory itself must be avoided to prevent the contamination of other students and to prevent raising the background count in the laboratory to the extent that it interferes with the proper functioning of the sensitive Geiger-Muller counters. To achieve this, the teacher must be familiar with the general rules of radioisotope safety techniques.

All work with unsealed radioisotopes should be done in nonporous trays of a chemically inert substance, such as fiberglass and heat-resistant plastic. The tray should be lined with nonabsorbent paper. The paper on which material is spilled can then be rolled up and properly disposed of. Any material spilled on another surface should be blotted; the surface should be scrubbed with detergent and water, dried, monitored and rescrubbed if necessary to remove the contamination. The scrubbing and monitoring should be continued until no trace of activity remains. Of course, the activity of the isotopes used in a high school laboratory is so low that decontamination is simple.

"*. . . Decontamination is considered complete when radioactivity from radioisotope groups I and II is not in excess of one millirep per hour average as measured in a small volume of air above any two square inch area. This corresponds to approximately one thousand counts per minute when a Geiger counter is placed as close as possible to the contaminated area . . . Note that in many high school experiments the actual counting rate will not greatly exceed that which meets the AEC definition of uncontaminated.*"[6]

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[6]Miner et. al. *Teaching with Radioisotopes*, U.S.A.E.C. Washington, D.C. 1959.

A clearly marked radioactive waste can should be available for the deposition of all contaminated materials. A 20-gallon covered trash can is quite suitable. The container should not be emptied with uncontaminated trash, but should be subject to special handling. The paper can be safely incinerated, thus dissipating the radioactivity, while the other material can be buried. Another method is to store the can and its contents for a year. At the end of this period, the activity will be reduced by normal radioactive decay. Small animal carcasses contaminated with radioactivity should be placed in glass containers and buried. The containers will prevent the carcasses from being dug up and scattered by foraging animals.

Low-activity isotope solutions used in the high school laboratory may be safely poured down the drain. If the tap is allowed to run for five minutes before pouring the isotope and 20 minutes after, the activity will be so diluted as to be practically undetectable. It would be well for each teacher to contact his/her local health or civil defense authorities concerning this matter.

Any vaporization or sample drying of radioactive material should be done in a hood to prevent the inhalation of radioisotopes.

All laboratory glassware used for radioactive material should be rinsed, washed with detergent and stored separately from noncontaminated glassware.

The supply of radioisotopes should be stored in a plainly labeled, locked metal container. A metal chest lined with cinder brick has proven to be quite satisfactory for this purpose. The cinder brick acts as a protective shielding and gives the box sufficient weight to prevent its being moved.

As a precaution to careless handling, all contaminated substances should be clearly marked with warning tape.

During the laboratory period, one student should be assigned as laboratory safety officer, whose duty would be the constant monitoring of the laboratory for spills or any other contamination. He/she should immediately report any spills and aid in decontamination procedures. This will also, by the way, aid in teaching proper safety techniques. The instructions for the safety officer will be found with the experiments.

At this point it should be reiterated that radioisotopes, used in conjunction with the proper safety precautions, are no more dangerous than the corrosive acids used routinely in every high school chemistry course.

APPENDIX II

ACHIEVEMENT TEST

Part 1: Multiple Choice

1. Which of the following concepts now being studies uses electrically conductive gases from the combustion of fossil fuels to make a highly efficient source of electricity?

   a. Coal Gasification
   b. Fusion
   c. Magnetohydrodynamics
   d. Thermal Conversion

2. The breeder reactor depends on the conversion of——————material to——————material.

   a. Non-radioactive, radioactive
   b. Radioactive, fertile
   c. Fertile, fissionable
   d. Radioactive, fissionable

3. Which of the following has been a recent development in fossil fuel electrical generation?

   a. Increased efficiencies by use of higher steam pressures and temperatures
   b. Increased plant size
   c. Higher stacks
   d. All of the above

4. What is the approximate genetically significant average radiation dosage from man-made sources for persons in the U.S.?

   a. 60 rem/year
   b. 600 mrem/year
   c. 60 mrem/year
   d. 6 rem/year

5. The most important radioactive wastes in terms of radioactivity content are

   a. Solid wastes from processing plants
   b. Liquid wastes from processing plants
   c. Radioactivity release into the air
   d. Radioactive wastes released into waterways

6. Which is the greatest single energy user in the home?

   a. color T.V.
   b. Frost-free freezers
   c. Heating and cooling system
   d. Water heaters

7. Which of the following fuels provided the greatest amount of electrical energy in 1974?

   a. Gas
   b. Coal
   c. Oil
   d. Uranium

8. During radioactive decay, three principal types of radiation are emitted from an atom. Which of the following is not one of these types?

   a. Gamma- and x-rays
   b. Beta particles
   c. Alpha particles
   d. Deuterons

9. The single most important factor in maintaining an ecological balance is

   a. competition
   b. succession
   c. predators
   d. lack of pollution

10. Which of the following is a factor which influences the biological effects of radiation?

   a. Rate at which dose was received
   b. Part of the body irradiated
   c. Both a and b
   d. Neither a nor b

11. Nuclear power plants have more of a problem with waste heat disposal than fossil-fueled plants because

   a. Nuclear plants generally have a greater generating capacity than fossil fueled plants
   b. Nuclear plants are less efficient
   c. Nuclear plants discharge nearly all their waste heat into their cooling water
   d. All of the above

12. In a water moderated power reactor, what would happen if the rate of fission were to increase significantly?

   a. The excess heat from the fissions would cause a decrease in the number of neutrons available to be captured by fissioning atoms, and the rate of fission would automatically slow down.
   b. The reactor would explode
   c. The core would melt from excess heat
   d. It is not possible for the rate of fission to increase significantly in a water moderated power reactor.

13. What is the basic difference between most types of electrical generating plants?

   a. Amount of thermal pollution
   b. Cost of fuel supply
   c. Source of energy to produce steam
   d. Operating temperatures and pressures

14. The component of a nuclear reactor that acts as a *"neutron sponge"* is the

   a. Moderator
   b. Fuel rods
   c. Core
   d. Control rods

15. Which of the following is a problem associated with the use of coal as a fuel for electrical generation?

   a. Its geographic distribution
   b. Mining hazards
   c. Shortage of railroad cars
   d. All of the above

16. When one or more electrons is separated from an atom, the atom is said to be

a. An isotope
b. Ionized
c. Electrolized
d. None of the above

17. The *"acute radiation sickness syndrome"* refers to

a. Any sumptoms of biological damage from radiation
b. Any radiation exposure causing death
c. An illness afflicting uranium miners
d. Effects of large sudden whole-body doses of radiation

18. Why are the transuranium nuclides particularly dangerous?

a. They are alpha emitters and are retained in the body.
b. They have long half-lives
c. They are man-made
d. All of the above.

19. A—————of radioactive materials will sustain nuclear—————by capturing neutrons.

a. Stable mass, decay
b. Critical mass, fission
c. Fragment, fission
d. Critical mass, decay

20. The term *"fast"* in fast breeder reactors refers to

a. The rate of fuel consumption
b. The rate of electrical production
c. The average velocity of the fission neutrons
d. None of the above

21. All the plant and animal species that live and interact in a particular environment are called

a. An ecosystem
b. A community
c. A food web
d. A succession

Part 2: True-False

1. The multiple barrier concept in reactor systems is designed to guard against the escape of radioactive substances into the environment.

2. The health effects of the oxides of sulfur are related to injury to the blood-forming organs.

3. In the United States, most of an individual's per capita consumption of electricity is for industrial processes to maintain our standard of living.

4. Rapidly dividing cells are especially radiosensitive.

5. In the case of both radiation and traditional air pollutants, most of the data on human effects was obtained by experimenting with small doses.

6. Certain air pollutants may interact with each other to cause more serious biological problems than they would cause alone.

7. About half of all uranium is fissionable uranium-235.

8. The *"roentgen equivalent man"* is a measure of energy deposited by radiation and also its resulting biological effect.

9. The basic difference between the light water reactors and the gas cooled reactor is the type of fuel used.

10. Every power plant built should construct a cooling water tower to end thermal pollution.

11. It is predicted that by 1990 there will be no natural gas available for use as fuel for electric utilities.

12. It is possible for a coal-burning plant to release more radioactivity into the environment than a nuclear plant.

13. The main reason for the increasing demand for electrical production in the United States is our growing population.

14. Exposure limits for radiation are set using very conservative assumptions because the effects of low-level chronic exposure to radiation are hard to measure.

Answers:

Part 1

1.	c	8.	d	15.	d
2.	c	9.	a	16.	b
3.	d	10.	c	17.	d
4.	c	11.	d	18.	a
5.	b	12.	a	19.	b
6.	c	13.	c	20.	c
7.	b	14.	d	21.	b

Part 2

1.	T	8.	T
2.	F	9.	F
3.	T	10.	F
4.	T	11.	T
5.	F	12.	T
6.	T	13.	F
7.	F	14.	T