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ABSTRACT

This volume contains 35 lessons designed to be used in secondary science classes to introduce the science/technology/society (STS) themes and issues. While the first 11 lessons focus on general STS themes, the other 24 lessons cover specific STS issues that fall under such categories as population growth, water resources, world hunger, food resources, air quality, war technology, energy shortages, land use, human health, disease, hazardous substances, plant and animal extinction, nuclear reactors, and mineral resources as well as scientific ethics and scientific inquiry. Except for the first three, all the lessons contain: (1) an introduction that provides a brief overview of the content and the teaching strategies used; (2) objectives for student learning; (3) subject and grade level recommendations; (4) time allotment; (5) materials needed and preparation; (6) step-by-step procedures; (7) suggestions for evaluation; (8) ideas for extension and enrichment; and (9) additional resources to enhance learning. The class activities vary from short, and easy to use lessons requiring little preparation to others that require more time and are more effective as introductions to STS units. A variety of teaching strategies are employed that include case studies, role playing, debates, discussion groups, decision making, simulations, small group work, and data analysis. To help use the lessons, three planning matrices are included. (DJC)

OLLUTION BIOMEDICAL ETHICS AC
BOTICS CRYOGENICS GENETIC ENGINEERING
OMPUTERS ENERGY NON-RENEWABLE RESOURCES
OXIC WASTES SPACE STATION SPACE TRAVEL LAS

SCIENCE
TECHNOLOGY
SOCIETY

MODEL LESSONS
FOR SECONDARY SCIENCE CLASSES

Edited By Janice V. Pearson

SOCIAL SCIENCE EDUCATION CONSORTIUM, INC.

PUBLIC POLICY N
SERVATION DECISION MAKING PUBLIC
PPORT SYSTEMS IN VITRO FERTILIZATION GROWTH E
DEVELOPMENT POPULATION OF OZONE
ACID RAIN DEPLETION

SCIENCE/TECHNOLOGY/SOCIETY: MODEL LESSONS FOR SECONDARY SCIENCE CLASSES

Janice V. Pearson, Editor

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Boulder, Colorado
1988

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CONTENTS

1. INTRODUCTION

Importance of Education on Science/Technology/Society

Modern societies, such as the United States, are increasingly propelled and changed by advances in science and technology—distinct and synergistic ways of knowing about and altering the world. Sciences (processes of knowing about nature and society) and technology (ways of using knowledge to satisfy human needs or wants) are combined in modern societies to provide increasing human control over natural and social environments. Tremendous, ongoing achievements have spawned great hopes, fears, and controversies associated with a plethora of developments (e.g., nuclear power, genetic engineering, organ transplantation, robotics, pesticides).

In a democracy, citizens have the right and responsibility—as voters, consumers, workers, and office holders—to participate in decisions about issues related to social uses of science and technology. The success of individuals and their society is tied to the quality of these choices, which varies with the knowledge and cognitive skills of decision makers. The vitality of our American democracy depends upon widespread ability of citizens to think effectively about developments in science and technology and their effects on the world. Therefore, a central mission of American schools should be education on science and technology in a social context.

Thus, the position statement on science, technology, and society, adopted by the National Science Teachers Association in 1982, states, in part: "Many of the problems we face today can be solved only by persons educated in the ideas and processes of science and technology. A scientific literacy is basic for living, working, and decisionmaking in the 1980s and beyond."[1]

Similarly, the position statement developed by the Science and Society Committee and adopted by the National Council for the Social Studies Board of Directors in 1982 states: "The impact of science and technology upon society, be it an environmental impact study, the energy problem, or other timely occurring issues, indicates a need for social studies and science educators alike to develop guidelines for teaching about science-related social issues. Science is a social issue, and the examination of scientific issues offers an excellent opportunity for helping students develop a synthesized perspective on science-related issues, a synthesis of the technical data coupled with social, political, economic, ethical, and philosophical information."[2]

These two position statements give major responsibility for education about social issues related to science and technology to teachers. Teachers must rethink the role they play in the development of STS education, particularly in reflecting the constant shifts in values, the need for an increased knowledge base, and the implementation of processes that convey knowledge while including students in active, participatory learning.

The introduction of STS issues and themes into the science and social studies curricula offers unique opportunities to achieve these goals. Whether STS is infused into an existing course or used as the foundation for a course, STS content should be presented so as to encourage students to think about the social and personal implications of the issues.

Purpose of This Project

To help educators meet this challenge, the Social Science Education Consortium has undertaken a project entitled "Building Support Networks for Improved Science/Technology/Society Education." Funded by the National Science Foundation, the project has developed a series of STS resources helpful to both science and social studies educators.

Science/Technology/Society: A Framework for Curriculum Reform in Secondary School Science and Social Studies provides a guide for designing units of study that integrate knowledge from science and social studies. Included are guidelines for selecting STS content, developing skills in analyzing STS issues, developing positive attitudes toward science and technology, assessing options for the design of STS curricula, and infusing STS into secondary science and social studies courses. The *Framework* also presents a powerful rationale for the STS curriculum movement.

Science/Technology/Society: Training Manual can be used by teachers, department chairs, curriculum supervisors, and other educators to design a training program covering the following phases of program development: building a rationale for STS, determining the most appropriate fit for STS issues in the curriculum, developing an integrated approach for teaching about STS issues, selecting and developing STS materials, and evaluating the STS program.

Science/Technology/Society: Model Lessons for Secondary Social Studies Classes and *Model Lessons for Secondary Science Classes* exemplify the guidelines provided in the curriculum framework and training manual. Although the lessons were designed for infusing STS topics into the science and social studies curricula, they could also be grouped to create an STS unit or be combined with other materials to form the basis for an STS course. Many of the activities are extant lessons identified as dealing with STS issues and themes. For each such activity, the original source is listed, thus enabling the user to locate additional materials with potential STS emphasis. Other lessons were developed by project staff to ensure at least modest coverage for each of the sources within the science and social studies curricula.

There is some overlap between the two volumes. However, users will find that some lessons provided only in the social studies volume, for example, are also useful in science classes. To facilitate maximum use of all the lessons, the matrices in the second section list all the lessons in both volumes.

Content and Organization of the Model Lessons

This volume contains 35 lessons suitable for use in secondary science classes. The companion volume contains 36 lessons intended primarily for social studies classes. Except for the first three lessons, which are quick "grabber" activities, all the lessons are presented in a standard format. Each begins with an **Introduction**, which provides a brief overview of the lesson's content and the teaching strategies used. Student learning **Objectives** are listed, as are recommendations for the **Subject and Grade Level** for which the activity can be used. The **Time Required** to use the activity is given. Any **Materials and Preparation** needed are described. Step-by-step **Procedures** are presented; included are questions that can be used to stimulate discussion, probe the issue, or debrief a discussion or other activity. Suggestions for **Evaluation** of the activity are provided. Finally, ideas for **Extension and Enrichment** are given. In some cases, additional **Resources** that could be used to enhance learning about the lesson topic are listed.

The model lessons are divided into two major sections. First are "starter" activities that are included to help stimulate awareness about STS topics or issues and to help students brainstorm, generate discussion, and explore ideas about STS issues. many of these activities are short and easy to use, requiring minimum preparation and disruption from the regular curriculum. Others require a bit more time to use and are thus probably most effective as introductions to longer STS units.

In the second section are those lessons that focus on particular STS issues. The lessons are loosely grouped according to the following list of STS issues developed by Rodger Bybee[3] and ranked in this order of importance by U.S. science educators:

- Population growth
- Water resources
- World hunger and food resources
- Air quality and atmosphere
- War technology
- Energy shortages
- Land use

- Human health and disease
- Hazardous substances
- Extinction of plants and animals
- Nuclear reactors
- Mineral resources

Each volume also includes a few activities on such other issues as scientific ethics and scientific inquiry.

These lessons require anywhere from one class period to one week to complete. They can be included in science or social studies courses to help enrich the existing curriculum materials and provide an STS focus. The lessons employ a variety of teaching strategies, including case studies, role playing, debates, discussion groups, decision-making, simulations, small-group work, data analysis, and so on. Note that as these are model lessons, the strategy used in an individual lesson can often be adaptable to other issues or periods of history.

To facilitate use of the lessons, the following section presents three planning matrices. The first lists the lessons in this volume, indicating in which secondary science courses each can be most easily integrated. The second lists the lessons in the social studies volume, indicating those that can also be used in science courses. Certainly, lessons may be used in courses other than those marked in the matrices, which are intended to show only the most obvious links. The first two matrices also indicate the STS issue that is the major focus on each lesson. The final matrix lists the lessons in both volumes according to the primary teaching strategy used in each.

Notes

1. National Science Teachers Association, *Science-Technology-Society: Science Education for the 1980s* (Washington, DC: NSTA, 1982).

2. Science and Society Committee of the NCSS, "Guidelines for Teaching Science-Related Social Issues," *Social Education* 47 (April 1983), p. 258.

3. Rodger W. Bybee, "Teaching About Science-Technology-Society (STS): Views of Science Educators in the United States," *School Science and Mathematics* 87 (April 1987), pp. 274-85.

2. MATRICES FOR PLANNING USE OF THE LESSONS

Matrix of Lessons in This Volume by Science Course

Lesson	STS Issue	Life Science	Earth Science	Physical Science	General Science	Biology	Ecology	Environmental Studies	Chemistry	Physics
1. Short Takes	Adaptable to	X	X	X	X	X	X	X	X	X
2. Technology Mind Walk	any issue	X	X	X	X	X	X	X	X	X
3. Technology Timeline		X	X	X	X	X	X	X	X	X
4. The Futures Wheel		X	X	X	X	X	X	X	X	X
5. Global and Local Issues		X	X	X	X	X	X	X	X	X
6. Determining Priorities		X	X	X	X	X	X	X	X	X
7. Technology and Advertising		X	X	X	X	X	X	X	X	X
8. Science and Technology in the News		X	X	X	X	X	X	X	X	X
9. STS in My Life		X	X	X	X	X	X	X	X	X
10. Ten Inventions That Changed Our Lives		X	X	X	X	X	X	X	X	X
11. Bumper Sticker Position Statements	↓	X	X	X	X	X	X	X	X	X
12. Population Control: Where Do You Stand?	Population growth					X			X	
13. Groundwater Rights	Water resources		X		X	X	X		X	
14. Food Additives	Food resources					X			X	X

Lesson	STS Issue	Life Science	Earth Science	Physical Science	General Science	Biology	Ecology	Environmental Studies	Chemistry	Physics
15. Environmental Impact Statements	Air quality and atmosphere					X	X	X		
16. What Would You Do If...?	Air quality, energy	X		X	X	X	X	X		
17. Collecting Points of (pH)iew	Air quality	X	X	X		X	X	X		
18. The Biological Effects of a Nuclear Explosion	War technology				X	X			X	X
19. Energy Sources	Energy shortages			X	X			X		X
20. Energy Sources in the Good Old Days	Energy shortages			X	X			X	X	X
21. Life Without Petroleum	Energy shortages	X	X	X	X	X	X	X	X	X
22. Land Use	Land use	X	X		X	X		X		
23. The Artificial Heart: A Technological Alternative	Human health and disease control				X	X				
24. The Benefits of Technology: Conquering Disease	Human health and disease control					X			X	
25. Genetic Screening	Human health and disease control				X	X				
26. The Pine Beetle Controversy	Hazardous substances				X	X		X	X	
27. Pesticides: A Global Problem	Hazardous substances					X		X	X	

Lesson	STS Issue	Life Science	Earth Science	Physical Science	General Science	Biology	Ecology	Environ-mental Studies	Chemistry	Physics
28. Biodegradable and Nonbiodegradable	Hazardous substances	X	X	X	X	X	X	X		
29. Letters to the City Council	Hazardous substances	X	X	X	X	X	X	X	X	X
30. Ecology and the Government	Extinction of plants and animals		X		X	X	X	X		
31. Forest Products All Around Us	Extinction of plants and animals	X				X		X		
32. Nuclear Energy: Risks Involved in a New Technology	Nuclear reactors							X	X	X
33. Can We Continue to Use Things Up?	Mineral resources						X	X	X	X
34. Soil Deterioration	Mineral resources		X		X	X	X	X		
35. Scientific Experimentation with Animals	Ethics				X	X			X	

Matrix of Lessons in Companion Volume by Science Course

Lesson	STS Issue	Life Science	Earth Science	Physical Science	General Science	Biology	Ecology	Environmental Studies	Chemistry	Physics
1. Short Takes	Adaptable to		Duplicated from this volume							
2. Mobiles in the Classroom	any issue	X	X	X	X	X	X	X	X	X
3. STS Scavenger Hunt		X	X	X	X	X	X	X	X	X
4. Technology Tree		X	X	X	X	X	X	X	X	X
5. Knowledge, Skills, and Attitudes for the Year 2000		X	X	X	X	X	X	X	X	X
6. Reaction Statements Warm-Up		X	X	X	X	X	X	X	X	X
7. Trivialized Technology		X	X	X	X	X	X	X	X	X
8. Science and Technology in the News			Duplicated from this volume							
9. STS in My Life			Duplicated from this volume							
10. Ten Inventions That Changed Our Lives			Duplicated from this volume							
11. Bumper Sticker Position Statements	↓		Duplicated from this volume							
12. World Population Growth	Population growth					X		X		
13. Energy Production and Population	Population growth and energy			X	X			X		

Lesson	STS Issue	Life Science	Earth Science	Physical Science	General Science	Biology	Ecology	Environ-mental Studies	Chemistry	Physics
14. Fish Kill in Riverwood	Water resources						X	X	X	
15. Solving the Problems of the World	Food resources, population growth		X							
16. It's a Natural!	Food resources	X			X				X	
17. Furrows to the Future	Food resources	X								
18. People and Machines	Food resources, technology and the economy									
19. Doing Something About the Weather	Air quality and atmosphere								X	X
20. Simulating the Strategic Defense Initiative	War technology									
21. The Effects of Individual Actions on Technology and Society	War technology									X
22. Giving Up the Gun	War technology									
23. Renewable Energy and the American Age of Wood	Energy shortages									
24. Energy Milestones	Energy shortages			X	X			X		
25. Preparing Environmental Impact Statements	Land use					X		X		
26. The Freeway Planning Game	Land use									

Lesson	STS Issue	Life Science	Earth Science	Physical Science	General Science	Biology	Ecology	Environmental Studies	Chemistry	Physics
27. The Organ Hunter	Human health and disease	X				X				
28. Warning Future Generations	Hazardous substances, nuclear reactors							X		X
29. The Environment and Participatory Democracy	Environmental protection						X	X		
30. A Resource-use Warm-Up	Mineral resources		X					X		
31. The Ocean Resources Game	Mineral resources		X					X		
32. God and the Alarm Clock	Technology and change									
33. A Social History Approach: Machine and Social Change in Industrial America	Technology and change									
34. Technology and Transportation	Technology and change			X	X					
35. Science, Technology, and the Constitution	Government									
36. The Structure of Scientific Revolutions	Scientific inquiry									X

Matrix of Lessons by Teaching Strategy*

Strategy	Science Lessons	Social Studies Lessons
Brainstorm	Technology Mind Walk The Futures Wheel Technology and Advertising Energy Sources in the Good Old Days Pesticides Forest Products All Around Us	Knowledge, Skills, and Attitudes for the Year 2000 It's a Natural! Bumper Sticker Position Statements
Case Studies	Environmental Impact Statements Land Use The Benefits of Technology Genetic Screening The Pine Beetle Controversy Letters to the City Council Ecology and the Government Soil Deterioration	People and Machines Doing Something About the Weather
Classifying	Population Control: Where Do You Stand? Food Additives Forest Products All Around Us	Knowledge, Skills, and Attitudes for the Year 2000 It's a Natural!
Data Analysis	Technology and Advertising Science and Technology in the News Food Additives Collecting Points of (pH)iew Energy Sources	Science and Technology in the News World Population Growth Energy Production and Population Preparing Environmental Impact Statements
Debate/Panel Discussions	Scientific Experimentation with Animals Soil Deterioration	Doing Something About the Weather The Organ Hunter
Field Experiences	Soil Deterioration	

*Note: Discussion is part of virtually every lesson, so it is not listed here.

Strategy	Science Lessons	Social Studies Lessons
Interview	Ten Inventions That Changed Our Lives Energy Sources in the Good Old Days	Ten Inventions That Changed Our Lives
Problem Solving/ Decision Making	What Would You Do If ...? Energy Sources The Artificial Heart Genetic Screening Ecology and the Government Scientific Experimentation with Animals	Solving the Problems of the World The Effects of Individual Actions on Technology and Society Renewable Energy and the American Age of Wood
Reading	Ten Inventions That Changed Our Lives Collecting Points of (pH)iew The Biological Effects of a Nuclear Explosion The Artificial Heart Pesticides Biodegradable and Nonbiodegradable Nuclear Energy Can We Continue to Use Things Up? Scientific Experimentation with Animals	Ten Inventions That Changed Our Lives People and Machines Renewable Energy and the American Age of Wood The Organ Hunter God and the Alarm Clock
Resource Person	Food Additives	The Environment and Participatory Democracy The Structure of Scientific Revolutions
Role Plays/ Simulations	Groundwater Rights Land Use	Fish Kill in Riverwood A Social History Approach: Machines and Social Change in Industrial America World Population Growth Simulating the Strategic Defense Initiative The Freeway Planning Game A Resource Use Warm-Up The Ocean Resources Game

Strategy	Science Lessons	Social Studies Lessons
Small-group Cooperative Learning	Determining Priorities What Would You Do If ...? The Biological Effects of a Nuclear Explosion The Benefits of Technology The Pine Beetle Controversy	Knowledge, Skills, and Attitudes fo. the Year 2000 Solving the Problems of the World Furrows to the Future Giving Up the Gun Preparing Environmental Impact Statements Warning Future Generations Technology and Transportation Science, Technology, and the Constitution
Survey/ Inventory	Global/Local Issues Science and Technology in the News Collecting Points of (pH)iew Biodegradable and Nonbiodegradable Nuclear Energy	Science and Technology in the News STS Scavenger Hunt Knowledge, Skills, and Attitudes for the Year 2000 Reaction Statements Warm-Up
Using or Creating Graphics	Technology Timelines The Futures Wheel Ten Inventions That Changed Our Lives Bumper Sticker Position Statements Energy Sources Life Without Petroleum Forest Products All Around Us The Technology Tree	Mobiles in the Classroom Technology Tree Trivialized Technology Ten Inventions That Changed our Lives Bumper Sticker Position Statements World Population Growth Energy Production and Population Solving the Problems of the World Furrows to the Future The Effects of Individual Actions on Technology and Society Energy Milestones Technology and Transportation Science, Technology, and the Constitution
Writing	Life Without Petroleum Letters to the City Council	Fish Kill in Riverwood Renewable Energy and the American Age of Wood Warning Future Generations Bumper Sticker Position Statements

3. INTRODUCTORY LESSONS

1. SHORT TAKES

The "short takes" teaching strategy was developed by Richard Brinckerhoff, a science teacher at Phillips Exeter Academy in New Hampshire. Brinckerhoff began to accumulate bits and pieces of information and turn them into short items any science teacher could use as examples of the societal or ethical consequences of a principle or law. The same strategy can be used in social studies classes to focus attention on the effects of scientific or technological development on historical events or the science- and technology-related aspects of public policy decisions.

A "short take" can be a challenging question, a powerful analogy, an "instant fact," an example of disagreement among experts in the same field, or an error once generally acknowledged as truth. The criteria for an item's inclusion as a "short take" are:

- It must be short—typically only a few sentences. No preparation time should be required to incorporate these items into the curriculum.
- The item should enhance, not distract from, conventional topics. It should also relate to students' day-to-day experiences or to an issue that appeals to an adolescent's imagination and curiosity.
- It should provoke thought and discussion, leading naturally to making some choice or judgment.
- If the item poses a question, responses should be within the scope of students' knowledge. If library research is needed, the item is too time demanding.

A few examples of the "short takes" strategy are provided below.

Chemistry

When sprinkled into some kinds of clouds, dry ice (solid carbon dioxide) or crystals of sodium iodide create immense numbers of ice crystals and often produce rain. This may be good for parched farmlands and depleted reservoirs, but it can mean disaster for recreation areas and may even produce dangerous flash floods. Who should decide where and when to seed clouds?

Physics

When a group of college students and members of the League of Women Voters were polled on how they ranked the hazards of daily living, they placed nuclear power plants ahead of motor vehicles and smoking. Yet nuclear power plants take fewer lives each year than does climbing mountains, using power lawn mowers, or even playing high school football! How do you explain this ranking?

Biology

The state of California has spent hundreds of millions of dollars to eliminate the Mediterranean fruit fly. Yet many entomologists say that massive doses of malathion spray, plus quarantines, trapping, fruit stripping, and the release of sterilized flies—all on an enormous scale—are unnecessary. These scientists say that eventually, because of the insect's own biological makeup, the flies will diminish naturally. Yet many citizens, agronomists, and retailers insist on action. What should lawmakers and regulators do?

Source: Adapted from "Short Takes: Science in Society," by C. Arthur Compton, *The Science Teacher* (September 1983), pp. 30-33. Reprinted by permission of the National Science Teachers Association.

2. TECHNOLOGY MIND WALK

Another strategy for getting students to think about the pervasive effects of technology is the technology "mind walk." Ask students to mentally review everything they have done since they got up this morning. As they think about their activities, they should notice the different technologies they used in the activities. Construct a class list of all the technologies used. As with any brainstorming activity, do not quit when students first "run down." Instead, ask some probing questions to get them started again.

When students have compiled a lengthy list, ask them what this list shows about the effects of technology on our lives. Are most of the technologies they mentioned helpful? Can they identify any on the list that have harmful effects as well?

Introduce students to the objectives related to technology that your upcoming lesson, unit, or course will address. If compatible with these objectives, you may want each student to choose one technology from the class list and conduct research on how it was developed, the risk involved in its development, the benefits it has created, and any costs involved with the technology.

3. TECHNOLOGY TIMELINES

To get students thinking about the impact of various technological developments, create a technology timeline for any time period your class is studying or for the current month. Have students look for evidence in the classroom (or in their own lives) of the impact of this development on society.

Examples for one time period of history and one month of the year are provided below as models.

March

1
2
3
4
5
6
7
8 Fingerprint identification first used to convict a criminal, 1911
9
10 First telephone message transmitted, 1876
11
12
13 First earmuffs patented, 1877
14 New York City hired a rainmaker after a long drought, 1950
15
16
17
18 First walk in space, 1965
19
20
21
22
23
24 First American-made car sold, 1898
25
26
27 First coast-to-coast color-TV broadcast, 1955
28
29 Coca-Cola invented, 1886
30 First use of ether as an anesthetic by a physician in surgery
31

1860-1869

1860— First practical internal-combustion engine built
Cork linoleum invented

1861— First machine-chilled cold storage unit built

1862— Gatling gun invented
Fact that starch is produced through photosynthesis discovered

1863— Microstructure of steel discovered, leading to development of science of metallurgy
Open-hearth steel furnace developed

1864— Pasteurization for wine invented

1865— Antiseptic surgery developed (use of carbolic acid on a wound)
Mendel enunciates Law of Heredity
Silkworm disease cured, saving French silk industry

1866— Fundamental law of biogenetics written
Dynamite invented
Underwater torpedo invented

1867— Reinforced concrete process patented

1868— Skeleton of Cro-Magnon man found in France

1869— Celluloid invented

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4. THE FUTURES WHEEL

Introduction:

The futures wheel is a teaching tool that encourages students to think creatively in exploring the implications of a particular event. There are no right answers when completing a futures wheel, and no decision-making occurs. Students simply look at an occurrence and ask, "What might happen if...?" This lesson employs the futures wheel to help students examine the effects of scientific or technological developments.

Objectives: Students will be able to:

1. Understand that every technological or scientific development has numerous effects.

2. Create a futures wheel to explore the effects of a scientific or technological development.

3. Recognize the value of the futures wheel as a tool for thinking about the effects of scientific and technological developments.

Subject/Grade Level: Any secondary science or social studies course

Time Required: 1/2-1 class period

Materials and Preparation: Make copies of Handout 4-1 for all students. You will also need to provide posting paper and marking pens for each group.

Procedures:

1. Explain that every event (whether present, past, or future) has an impact on other events or factors. Distribute Handout 4-1 and "talk" the students through an interpretation of this diagram, beginning at the center circle and proceeding outward. Make sure students see that each circle that is directly linked with the center circle will be influenced by banning bikes for those under 16. Those circles connected to this ring by double lines are caused by the primary effects, and so on.

2. Divide the class into groups of four to six students. Give each group several pieces of posting paper and a marker. Tell the students that they are to select a possible future scientific or technological development as the subject for their futures wheel. Each group should select a recorder to draw the futures wheel on the posting paper. The recorder should write the development selected by the group in the center of the page and put a circle around it.

3. Next students should ask themselves "What might happen if...?" Each group should come up with three to five answers to this question. The recorder should write these questions around the center circle. Explain that these first responses are called the first-order connections. A circle should be drawn around each response, and a single line should connect these responses to the central event.

4. Then each group should ask "What might happen if...?" about each of the first-order connections. The second set of responses—second-order connections—should be written around the first-order connections. A double line should connect each second-order connection with the first-order connection that caused it. As students work, remind them to think of both positive and negative connections.

Source: Adapted by the New York State Department of Education from "Futures Wheel," *Curriculum Grades 4-8* (St. Paul, MN: The Acid Rain Foundation, Inc., 1985). Reprinted by permission of the publisher.

5. Students can continue this process and develop third-, fourth-, and fifth-order connections. However, the third-order is a good level at which to stop when doing a futures wheel for the first time.

6. Call the groups back together when there are 15 minutes left in the period. Ask each group to share its futures wheel, explaining the central event and one example each of first-, second-, and third-order connections.

7. Debrief the activity with the following question:

- Were the effects of each occurrence very broad or very narrow? Did each occurrence affect lots of people or just a few?
- What were the similarities and differences among the futures wheels?
- Was this fun? Why or why not?

Evaluation:

Because a futures wheel has no right or wrong answers, evaluating achievement of the lesson objectives involves determining whether students understand how the futures wheel is useful in decision-making. Ask students for oral or written responses to the following question:

- How could a futures wheel be helpful in decision-making?

Extension/Enrichment:

1. Provide students with different science and technology issues and let students develop their own futures wheels.

2. Encourage students to use futures wheels at home with their families. This could be helpful with a topic of special interest to the family, such as whether the family should get a pet, whether teens should get a part-time job, etc.

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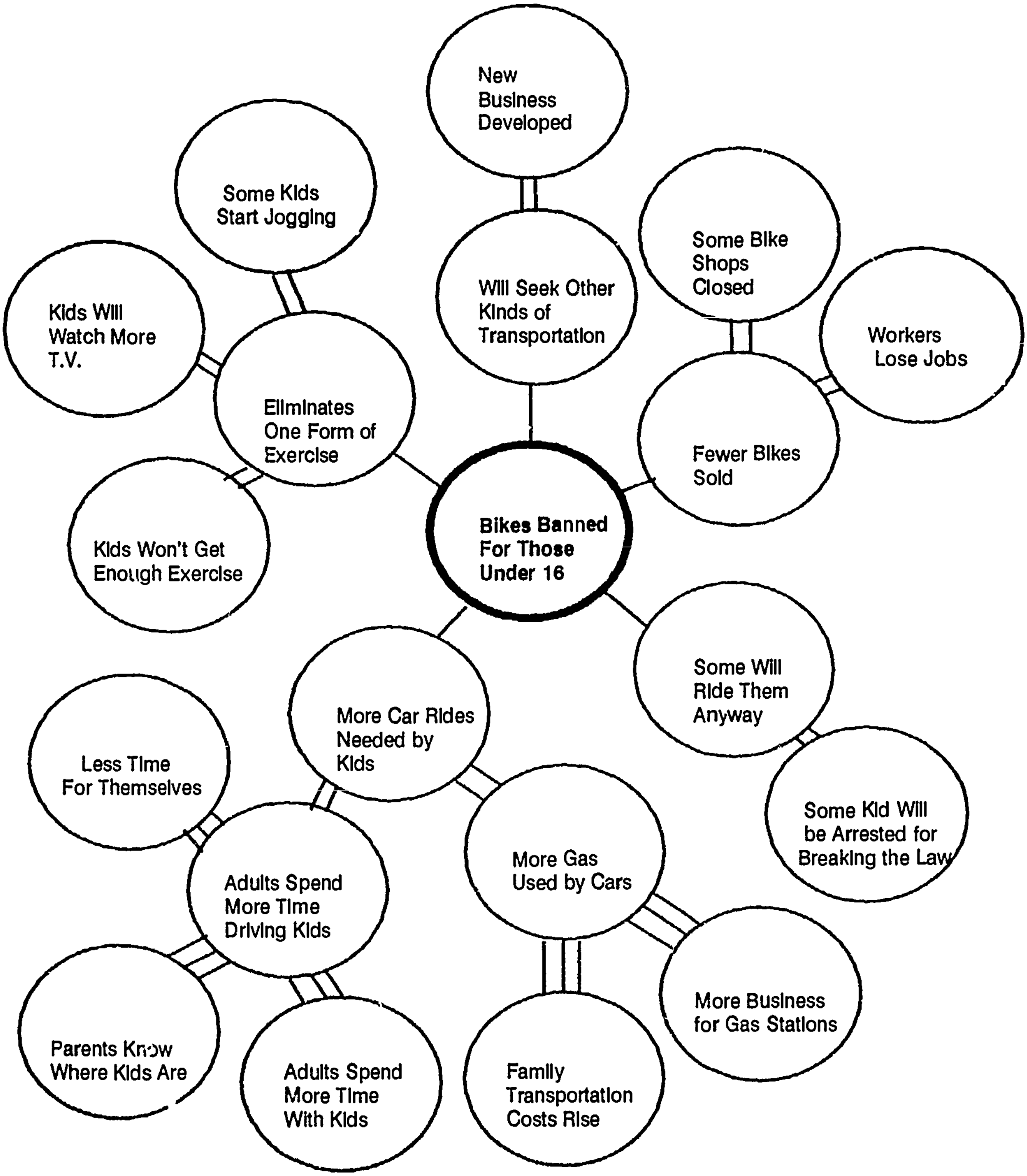
FUTURES WHEEL



5. GLOBAL AND LOCAL ISSUES

Introduction:

As future decision-makers, students will have to deal with many local and global problems. Even as teenagers, students have the capacity to affect both local and global issues. Learning about and understanding public sentiment regarding such issues can help students put their own values into perspective.

In this lesson, students survey other students, teachers, family members, and members of the community to determine how important they think various issues are. The class then tallies the results of the survey to determine the overall priorities of the people surveyed. They discuss why these priorities are similar to or different from their own priorities.

Objectives: Students will be able to:

1. List at least 15 local and/or global issues.
2. Recognize how these issues affect them personally.
3. Gather information through a survey.
4. Evaluate the results of the survey.
5. Value individual differences and priorities.
6. Appreciate the contribution they can make in solving local and/or global problems.

Subject/Grade Level: Any secondary science or social studies course

Time Required: 2 class periods over 3 or 4 days

Materials and Preparation: Make enough copies of Handout 5-1 for each student to have three copies. Prepare a list of all the issues on the handout on the chalkboard or on poster paper. This will be used in tallying the survey responses.

Procedures:

1. Give each student three copies of Handout 5-1. Review each item on the survey so students understand why the issue is included. Ask students to complete their own surveys individually.

2. Tell students that analyzing their responses to the survey would give an accurate picture of the class's views on the importance of these issues. Would it give a good picture of the general public's views? Why or why not? How could students improve their ability to draw conclusions about the general public's views?

3. Tell students that as a homework assignment, they are to find two other individuals to complete the survey. Before students begin the survey, you may want to inform them of a few basic rules of survey etiquette: (1) they should explain that they are taking a brief poll about people's opinions on local and global issues, (2) they should ask if the person has time to complete the survey, and (3) they should thank the person when they are finished.

4. Allow students two or three days to complete this task. On the day the homework is due, have students report their own responses as well as the responses from the other participants. As students report, tally the responses on the chalkboard or poster paper list.

5. Review the rankings. Using only the responses in the "Major Problem" category, rank order each item. Have students rank order those issues they personally rated as "Major Problems." Discuss how the overall rankings are similar to or different from their own rankings. Ask students to suggest reasons for differences.

6. Next, look at the global issues and the local issues. Ask students:

- What differentiates the two categories?
- How can students personally affect local issues?
- How can students personally affect global issues?
- Since not all who completed the survey ranked the same items as major problems, what does this tell us about individual values and concerns?

Evaluation:

Ask each student to determine the one issue on the list he/she feels is most important. Then ask students to write a paragraph or two on why this issue was ranked number one and how the student feels he/she could help solve this problem. Students should be graded on how well they defend their choices.

Extension/Enrichment:

1. Choose four or five items that are ranked as "Major Problems" by the majority and have teams of students research and report on the issues.

2. Highly motivated students might obtain a copy of *Forecast 2000: George Gallup, Jr. Predicts the Future of America* (New York: William Morrow and Co., 1984), which summarizes the results of a poll of 1.346 "national opinion leaders." Students could report to the class on the ten "future forces" that those polled thought would influence national and world events over the next 16 years.

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GLOBAL AND LOCAL ISSUES

	Major Problem	Minor Problem	Not a Problem
1. Crime in my community			
2. World population growth			
3. Unemployment in my community			
4. Air pollution			
5. Public transportation			
6. World hunger			
7. Day care for children			
8. Quality of education			
9. Inflation			
10. Threat of nuclear war			
11. Adequate housing			
12. Adequate police protection			

	Major Problem	Minor Problem	Not a Problem
13. Health care costs			
14. Care for the elderly			
15. Worldwide availability of potable water			
16. Land use			
17. Nuclear reactors			
18. Recreational facilities			
19. Hazardous substances (toxic chemicals, waste dumps)			
20. Extinction of plants and animals			
21. Water pollution			
22. Energy shortages			
23. Human health and disease			
24. Litter			

6. DETERMINING PRIORITIES

Introduction:

Decision-making bodies, such as Congress, state legislatures, county commissions, and city councils, study, analyze, and consider many issues. Often when there are too many issues to address, priorities must be established. Establishment of these priorities can be a difficult process.

In this lesson, each student selects, from a newspaper article, an issue that has personal significance. The issue must be one that would be dealt with by a decision-making body; some examples are the building of a new highway or dam, the establishment of speed limits on city streets, providing aid to a foreign country, or air or water pollution. Students analyze why their issue is significant. Then, working in groups, students prioritize all of the issues, selecting one group issue for continued analysis.

Objectives: Students will be able to:

1. List four to six local or global issues.

2. Identify an issue that has personal significance.

3. Analyze several issues to establish priorities.

4. Determine who is affected by a particular issue and how this issue became a problem.

5. Value individual and group abilities to solve major problems.

Subject/Grade Level: Any secondary science or social studies course. You may want to narrow the selection of individual issues to the general topic of the unit currently being studied, such as pollution, hazardous waste, nuclear reactors, environmental impact, land use, etc.

Time Required: 1 class period

Materials and Preparation: Make copies of Handout 6-1 for all students. Provide extra newspapers for those students who do not have access to a local newspaper or who forget to find an article.

Procedures:

1. Assign as homework the task of selecting from the local newspaper one issue (either local, national, or global) important or significant to the student. (For those students who do not have access to a newspaper or forget to get an article, have a supply of newspapers available.)

2. Have students complete Handout 6-1 as part of the homework assignment or at the beginning of the next class period.

3. Have students form groups of four to six students. Each student should report on the issue he or she selected for consideration and summarize the information recorded on Handout 6-1.

4. After each student in the group has reported, the group should rank the issues, determining:

- Which issue would affect the most people?
- Which problem is most urgent?
- Which problem could students help solve?
- Which problem could be most easily solved?

From this information, students should be able to determine the one issue that is the most important.

5. Each group should appoint a member to report to the class, describing the issue that was selected and why it was selected.

6. To debrief, discuss the following questions:

- Why do important problems not always affect large numbers of people?
- Why do some important problems not need urgent solutions?
- Why does each person have the responsibility to help solve local, national, and global problems?
- Would this process of prioritizing issues be helpful to law makers and policy makers? Why or why not?

Evaluation:

Students should be evaluated, not on the issue selected, but on the process used to justify selection of the issue. You might also give students a group grade based on the reporter's description of how the issues were prioritized. If you plan to give a group grade, students should be informed of this in advance.

Extension/Enrichment:

1. Have the groups do further research on the issue to which they gave top priority. Set aside one class period for all groups to present 10-minute panel discussions on their issues.

2. Invite a member of a decision-making body, such as a local city council member, to talk with the class about how the body prioritizes the issues it faces. Have students prepare some questions in advance so they will be able to maximize what they learn from the visitor.

SELECTING AN ISSUE

1. What issue did you select? ______________________________

____

2. Why is this an important issue? ______________________________

____

3. Who is affected by this issue? ______________________________

____

4. Does this issue affect you personally? How? ______________________________

____

____

5. Why are you interested in this issue? ______________________________

____

6. How can this issue be solved? ______________________________

____

____

7. Can you personally help solve this issue? How? ______________________________

____

____

8. Why do you think this issue is worth consideration by the group? Write a paragraph explaining your answer.

7. TECHNOLOGY AND ADVERTISING

Introduction:

Much scientific and technological research goes unnoticed by the general public. Even controversial research, such as genetic engineering, medical research, or space research, is little more than a headline to most Americans. Yet scientific and technological developments affect our lives every day, providing us with products and conveniences that make our lives easier. And these products do not go unnoticed. Daily we are bombarded with advertisements on television, on radio, in newspapers, and in magazines for new products that we must have!

In this lesson, students research the print and electronic media to find five advertisements displaying new technologies. These advertisements are analyzed to determine what technologies they represent and how society is being convinced to purchase these new technologies. Students are asked to look beyond the commercialism to determine what is merely innovative and attractive and what is really a necessary or valuable contribution.

Objectives: Students will be able to:

1. List new scientific and technological developments.

2. Describe how advertisements entice people to buy or use these new developments.

3. Analyze advertisements to determine what is being presented and how it is being marketed.

4. Value the ability to choose among new technologies being advertised.

Subject/Grade Level: Any science or social studies class/grades 9-12. The advertisements students are to find can be tailored to your specific course. For example, in a biology course, you might narrow the choice of advertisements to ones that offer better or increased quality of life, such as an ad for a new kind of hearing aid or drug.

Time Required: 1-2 class periods

Materials and Preparation: You may want to have some newspapers and magazines on hand for use by students who do not have access to such resources at home.

Procedures:

1. Begin the lesson by having students brainstorm a list of scientific and technological developments that they use in everyday life.

2. Then have the students brainstorm a list of similar developments that have changed the course of history in one way or the other. This list might include gunpowder, nuclear energy, antibiotics, etc.

3. Ask students why science and technology have been so important to all people—not just scientists.

4. Give students the assignment to find five advertisements featuring new products that are a result of scientific or technological development. Ads can be from radio, television, newspapers, or magazines. Print ads can be clipped or copied. Radio or television ads should be described—in writing—in as much detail as possible.

5. On the day of the activity, ask each student to be prepared to share with the class—or a small group—at least one of the advertisements. In their reports, students should describe the following:

- What is the product being advertised?
- What is so unique about this new product?
- How would this product be beneficial?
- Is a cost for the new product given?
- How persuasive is this advertisement to you?
- How would this new product improve the quality of human life?
- Would you be willing to purchase this new product?

6. After all students have had an opportunity to share their favorite advertisements with the class, conclude the activity with the following questions:

- Are science and technology improving the quality of life? In what ways?
- Why did you select the advertisements you selected?
- Should government controls be imposed upon the kinds of scientific and technological research that are done?
- Should anyone be allowed to do any type of research that he or she would like to do? Why or why not?
- Who should pay for scientific and technological research?
- Do any of these ads show controversial products? Why are the products so controversial?

Evaluation:

The kinds of advertisements students present to the class will give you an indication of whether they understand what is meant by new scientific and technological developments. It is essential that students see through the advertising jargon to the products being presented. Having students write answers to the questions listed under step 5 of the Procedures for another one of their ads would also provide an evaluative mechanism.

Extension/Enrichment:

1. Have students make a class bulletin board out of the ten "best" advertisements selected from those submitted by the class.

2. Have students find specific ads that advertise particularly controversial products. Discuss the products and determine why they are so controversial.

8. SCIENCE AND TECHNOLOGY IN THE NEWS

Introduction:

Most citizens get their information about science and technology from the popular media—newspapers, television, and popular magazines—rather than the scientific press. In this lesson, students analyze the amount of coverage given to news about science and technology in various forms of news media. They examine how the medium affects the coverage given to such issues, and they suggest areas for improvement.

Objectives: Students will be able to:

1. Identify science and technology issues in the news media.

2. Gather data on coverage of science and technology issues in the news media.

3. Compare and contrast coverage in various media.

4. Suggest improvements in news coverage of science and technology issues.

5. Value the role of the press in providing the public with information about issues related to science and technology.

Subject/Grade Level: Any secondary science or social studies course

Time Required: 2 class periods

Materials and Preparation: Check the newspaper and television news programs for several nights prior to using the lesson to compile a list of scientific and technological developments in the news. Make copies of Handout 8-1 for all students.

Procedures:

1. Make a chalkboard list of the scientific and technological developments that have been in the news recently. Poll the students to find out how many are aware of why these developments have made "news" in the past few days.

2. Discuss with students where they get most of their information about science and technology. Do they learn more from newspapers, television, and newsmagazines, or from specialized science publications? Discuss the importance of the popular media in shaping public perceptions of science and technology.

3. Tell students they will be analyzing how the news media cover scientific and technological developments. Divide the class into three groups and distribute copies of Handout 8-1. Assign one group to conduct a content analysis of daily newspapers, the second groups to analyze television news programs, and the third group to analyze weekly newsmagazines. Students should use the analysis instrument for a specific amount of time; one or two weeks is recommended.

4. After the analyses have been completed, ask the students to compare the emphasis the different news media give to science and technology and to speculate why time/space was allocated as it was. Students should also attempt to determine how the technology involved in each medium affects the way news is covered (for example, television focuses on stories that have a strong visual component, has great immediacy, can bring a story to the audience as soon as it happens, etc.). The following questions may be used to summarize the discussion:

- Do the news media take a positive, negative, or balanced view of developments in science and technology?
- How do the news media influence the way the public thinks about science and technology?
- Do the news media show the effects of science and technology on society?
- How would you improve coverage of issues related to science and technology by newspapers? television? newsmagazines?

Evaluation:

Have students individually or with other members of their groups write letters to the editor of one medium suggesting improvements in coverage of science and technology issues. The letters should address such concerns as balance and depth of coverage.

Extension/Enrichment:

Let students plan their own "newscasts" on science and technology issues. Their programs should address the problems they identified in doing their analyses.

NEWS MEDIA ANALYSIS FORM

Use this form to record the amount of attention devoted to issues related to science and technology by ______________________________ during the period ____________________

Publication or broadcast date	% of time/space devoted to science/technology	Science/technology issues covered	Was coverage positive, negative, or balanced?	Was the effect of science and technology on society covered?

9. STS IN MY LIFE

Introduction:

This warm-up lesson sets the stage for further activities on the interactions of science, technology, and society. Students may be unaware of the degree of interconnections between these three aspects of society and the high degree of dependence our society has on the products of science and technology.

Objectives: Students will be able to:

1. Describe one way in which they depend on technology in their everyday lives.

2. Make inferences about the level of dependence on technology in our society on the basis of the example analyzed.

3. Formulate a position on whether dependence on technology is desirable or not.

Subject/Grade Level: Any secondary social studies course

Time Required: 1/2 class period

Materials and Preparation: None

Procedures:

1. Read the following instructions to students and allow them 2-3 minutes to think.
   - Look around the room. Look at each other and yourselves. Examine the clothing you are wearing. How many of the items you are wearing could you exactly duplicate at home? That includes making the fabric and other materials, as well as making the clothing items.
2. Discuss their responses for a few minutes, then ask these extensions of the question:
   - What things would be most useful in trying to copy the fabrics? Is it possible to duplicate them at home? If you used all of the resources available at your school, would it help? At your parents' work places? What is the limiting factor? (Exactly what is it that would keep us from duplicating these things if we wanted to?)
   - How does this compare to the types of clothing we would wear if we lived in central Africa? Antarctica? In the year 1900? 1700? 500 B.C.?
   - What does this say about our society's dependence on science and technology? Do you think such great dependence on technology is good? What weaknesses might technological societies have because of that high degree of dependence?

3. Encourage students to express their opinions freely. Probe for factual examples to support their positions.

Evaluation:

The discussions should lead easily into brief essay-writing exercises or development of posters that illustrate points made. These products could be used for evaluation purposes.

Extension/Enrichme

1. Have students use the same procedure to analyze their dependence on technology in another area of their lives, such as food or shelter.

2. You might encourage students to conduct the same discussion with their family members. Did parents have a different view on the desirability of depending heavily on technology? If so, what are the reasons for the differences?

10. TEN INVENTIONS THAT CHANGED OUR LIVES

Introduction:

This lesson acts as a discussion starter to introduce students to science, technology, and society issues. The interconnections of these three aspects of culture are explored through a brief reading, a categorizing exercise, discussion, and a webbing chart. Throughout the exercise, students should be encouraged to examine their opinions for deeper insights.

Objectives: Students will be able to:

1. Explain the impact of ten innovations on society.
2. Recognize the relationships among these innovations.
3. Give examples of society's role in shaping technology.
4. Interview adults to gather information.
5. Value diverse opinions about the importance of particular technologies.

Subject/Grade Level: Any social studies course/grades 9-12

Time Required: 2-3 class periods

Materials and Preparation: Prepare copies of Handouts 10-1, 10-2, and 10-3 for all students. You may want to make overheads of the STS chart from Handout 10-2 and the webbing chart on Handout 10-3. The best preparation for this exercise is for teachers to work through it themselves. Teachers should note areas where they can provide extra, analogous examples to illustrate the interconnections.

Procedures:

1. Distribute Handouts 10-1 and 10-2 and allow 25-30 minutes for reading and work. (This assignment could be done in small groups.)

2. Begin the debriefing. Since this is primarily a discussion starter exercise to sensitize students to STS topics, student thought and opinion are of primary importance. The "correct answers" are those answers that demonstrate logic, perception, and the persuasive use of evidence.

3. The categorizing exercise (question 1) will probably be frustrating for students because of the difficulty of assigning some items to only one category. Force them to make a choice even though the categories are too rigid and exclusionary. Redirect student opinions/objections back to other members of the class for analysis.

4. Complete the debriefing through Question 6. Write the following homework assignment on the board:

Write a paragraph containing at least five sentences. The paragraph should explain how society directs changes in science and technology. To better understand how society can have that effect on science and technology, you will need to interview your parents or several other adults. In your paragraph use one of the examples they suggest to illustrate that relationship. You must include one quotation from an interview in your paragraph. This assignment is due: ________________.

5. Pass out Handout 10-3. This exercise is somewhat repetitive, but it gives a different slant on the information and extends the discussion of the interaction of science and society. Allow 10-15 minutes for the webbing, then begin the debriefing. Stress ways that society might direct the development of

certain types of science over others and how that in turn influences the directions society takes. That discussion will better illuminate the homework assignment students should have begun the night before.

6. Check for understanding and review the homework assignment.

7. On the due date, collect the homework. Allow 15 minutes for a discussion of the homework topic and the input students obtained from their parents. Discuss the examples students used in their papers.

Evaluation:

Judge the homework papers for how accurately students followed directions and for how clearly they demonstrated the directive nature of society on the scientific example they selected.

Extension/Enrichment:

Have students work in small groups to brainstorm a list of how "today's problems reflect yesterday's successes." What kinds of problems could be created by today's technological successes?

THE CONSUMER HIT PARADE

In the October 6, 1987, issue of *Newsweek*, Robert J. Samuelson described the ten products or services that he believed had changed post-war American society most profoundly, resulting in a "society of greater individual choice and mobility without many of history's wants and discomforts."

Samuelson's list included the following ten items:

- Television: "TV has surely changed politics; it brought the Vietnam War into living rooms. It's also expanded national culture..."
- Jet Travel: "It has shrunk the country."
- The Pill: "Along with working women and better appliances—subverted old sex roles."
- Air Conditioning: "It made the sun belt possible."
- Automatic washers and dryers: "They revolutionized housework."
- Antibiotics: "Drastically reduced the threat to life of commonplace injuries and infections."
- Health Insurance: "It made health care an entitlement."
- Long Distance: "It too has shrunk America."
- Social Security and Pensions: They made retirement "an expected part of life."
- Interstate Highways: "They've shaped suburbia by attracting offices, malls, and industrial parks, determining where we live, work, and shop."

Samuelson's list did not include computers. He described computers as one of the products "that mainly serve business" and therefore "don't count."

We often forget just how much society has changed. The consumer culture's emphasis on the "new" tends to keep us from focusing on the impact of change.

TEN INVENTIONS THAT HAVE CHANGED OUR LIVES

Directions: Skim over the questions below. Then read "The Consumer Hit Parade." Answer the questions and be prepared to explain the reasoning behind your answers.

1. Place each of Samuelson's "Consumer Hits" into one of these categories:

Science	Technology	Society

2. Explain why you agree or disagree with Samuelson's decision to omit computers from the list.

3. What items missing from Samuelson's list do you feel should be included?

4. Which items do you think he should have omitted?

5. For each "Consumer Hit," identify one scientific discovery that laid the groundwork for the development of that item.

1)

2)

3)

4)

5)

6)

7)

8)

9)

10)

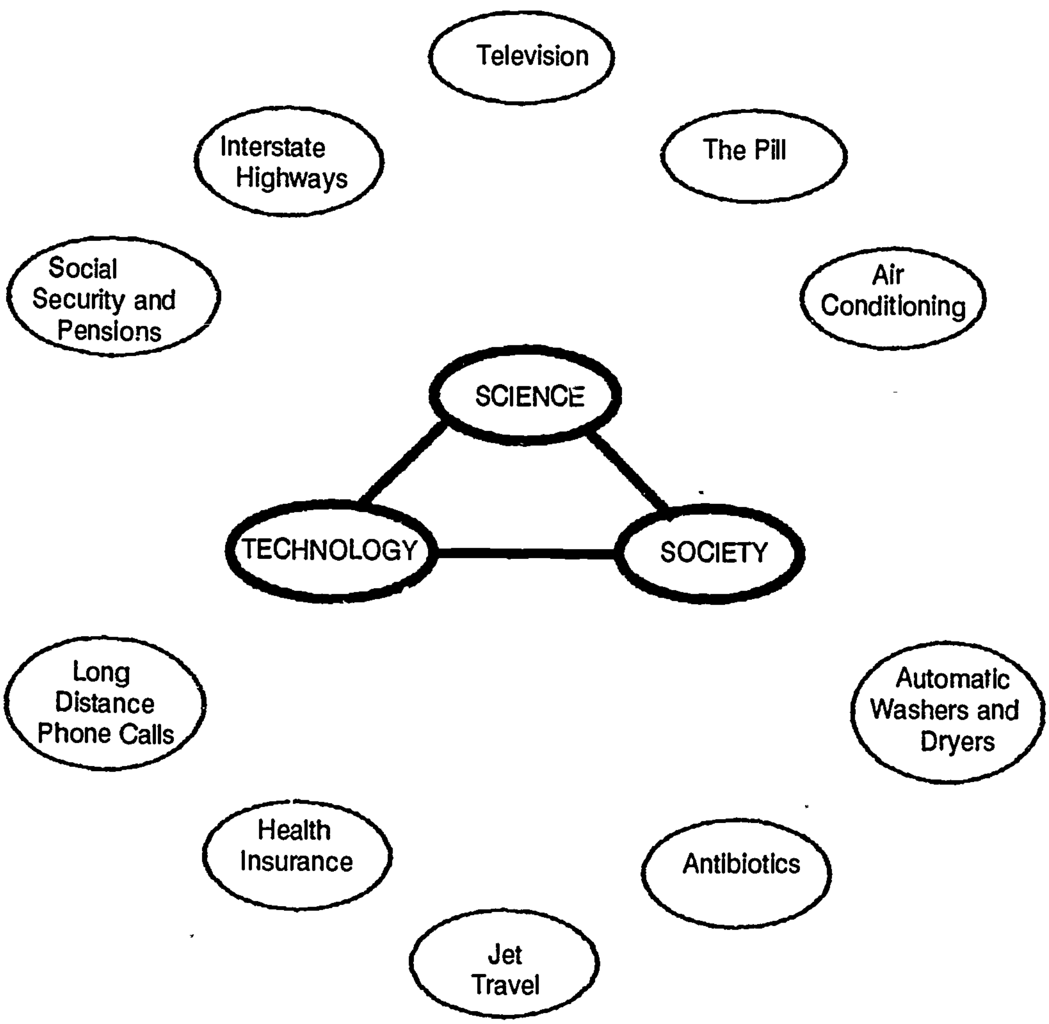
6. Pick one of the items and list one positive and one negative effect that item has had on society. Be prepared to explain your examples.

THE WEB OF SCIENCE, TECHNOLOGY, AND SOCIETY

Was categorizing items as science, technology, or society difficult? All of the "consumer hits" are connected to more than one category.

1. Draw a line from each consumer item to the categories you feel are directly connected to it.

2. With a different type of line or a different color pen, connect all of the consumer items that you feel are related or have mutual interactions.



11. BUMPER STICKER POSITION STATEMENTS

Introduction:

This activity is designed to help students identify technological issues and express their opinions on those issues. This is a good introductory exercise for a science, technology, and society unit.

Objectives: Students will be able to:

1. Identify current technology issues.

2. Express a point of view on a technological issue.

3. Explore the implications of their viewpoints.

Subject/Grade Level: Any secondary science or social studies class

Time Required: 1 class period

Materials and Preparation: For each student, you will need two or three bumper-sticker-sized strips of poster paper and crayons. You will also need a variety of current newspapers and newsmagazines.

Procedures:

1. Lead students in a brainstorm to list contemporary technological issues. Post all students' suggestions on the chalkboard.

2. Have students design and write their own bumper stickers dealing with contemporary issues with technological implications. Examples: "Recycle Yourself: Sign A Kidney Donor Card" (Transplants), "H_2O: If You Can Read This, Thank Your Science Teacher" (Importance of Science and Education), "I Took A Stand To Save The Land" (Land Use). Let students look in newspapers and magazines for ideas.

3. Have students write letters to bumper sticker companies explaining why their proposed product addresses an important view on a current issue. You may allow some research time for this portion of the activity if you wish.

4. Have students present their work to the class. Discuss the issues and allow students to formulate their own views.

Evaluation:

Evaluate the students' work on the basis of (1) creativity and (2) how well students justified their positions.

Extension/Enrichment:

Have students create a bulletin board display of their bumper stickers, preferably where students from other classes can view it.

Source: Adapted from *Turning the Tide: Technology Infusion Project* (Harrisburg, PA: Pennsylvania Department of Education, 1984), pp. 12-13. Reprinted by permission of the Pennsylvania Department of Education.

4. MODEL LESSONS ON STS ISSUES

12. POPULATION CONTROL: WHERE DO YOU STAND?

Introduction:

Birth control technologies now make it possible to control family size voluntarily. Yet, the development of such technologies does not mean that they will, in fact, be available to all people or be used by all those who have access to them.

In this lesson, students examine alternative approaches to controlling population, some enlarging the freedom of individuals and others greatly restricting individual freedoms. They identify the technologies employed in each. Finally, they suggest the steps they feel are necessary—including development of additional technologies—to curb population growth.

Objectives: Students will be able to:

1. Articulate relationships between population control programs and amount of individual and societal freedoms.

2. Identify technologies employed in various alternatives related to population growth.

3. Categorize alternatives related to population growth according to steps that enlarge both individual and societal freedoms, steps in which an individual gives up freedoms for the betterment of society, and steps that greatly limit the freedom of individuals.

4. Determine which steps are most urgent and which will be necessary in the future if growth rates continue.

5. Recognize that individual choices and actions can influence population growth.

Subject/Grade Level: Biology/grade 10; environmental studies/grades 9-10; world geography/grade 10; current events/grades 10-12

Time Required: 1-2 class periods

Materials and Preparation: Make enough sets of the cards for the card sort activity so that each group of four or five students has a set.

Procedures:

1. Begin with a discussion of population control. Is it necessary now? How do students view population growth—as a problem or a crisis? What technologies are involved in population control?

2. Introduce the following categories for steps in population control:

   a. Population control steps that enlarge individual freedoms and the freedom of society.

   b. Population control steps in which the individual gives up freedoms for the betterment of society.

   c. Population control steps that greatly limit individual freedom (i.e., totalitarian controls).

   Poll student responses for examples of population control steps in each category.

Source: Adapted from *Teaching About Population Issues* (Denver, CO: Center for Teaching International Relations, 1983). Reprinted by permission of the publisher. Activity developed by Jacquelyn Johnson.

3. Divide the class into groups of four to five and assign the card sort activity. Students should read the alternatives and categorize each one into one of the three categories outlined above. They should also identify the reasons for their choices and be prepared to defend why they placed each population control step in a particular category. Encourage students to develop their own cards for this activity also.

4. Allow time for groups to compare their results with one another. Class results should resemble the following:

Group a: education programs; equality for women; social security; ability to choose sex of unborn child; abortion.

Group b: postponement of marriage; incentives and rewards; birth control.

Group c: penalties for large families; licenses to have children; sterilization of parents.

5. Share the above categorization with the class. Poll the students for agreement and disagreement with this categorization. Ask students to share their alternative "write-in" population steps with the rest of the class.

6. Have students write on the back of each card any technology used in that alternative. Do any of the categories (a,b, or c) seem to involve a higher level of technology? Why or why not?

7. Next, instruct groups to categorize the alternatives according to those they feel are necessary now to curb population growth and those that will be necessary in the future if present growth rates continue.

8. Ask students which alternatives they themselves would be willing to adopt. Have they changed their opinions related to family size as a result of these activities? If so, in what way?

Evaluation:

Ask students to write a brief paragraph telling which alternative they prefer and explaining their reasons.

Extension/Enrichment:

Students might research actual population control programs in various nations. Which seem to be most/least effective? To which do people object most strongly? Which are most/least expensive? Which involve the most technology?

Resources:

Jacobson, Willard J., *Population Education: A Knowledge Base* (New York: Teachers College Press, 1979).

Population Information Program, Johns Hopkins University, Hampton House, 624 North Broadway, Baltimore, MD 21205.

Population Reference Bureau, 2213 M Street, NW, Washington, DC 20037.

United Nations Fund for Population Activities, 1120 19th Street, NW, Washington, DC 20036.

CARDS FOR CARD SORT

EDUCATIONAL PROGRAMS Making people aware of the population growth problem might help to solve it.	ABORTIONS If safe, legal abortions were available on demand, population growth might be limited.	BIRTH CONTROL Make birth control means available to anyone who wants it. The effect will be to curb population growth.
STERILIZATION After two children, one or both parents will be sterilized to halt population growth.	EQUALITY Equalizing opportunities for women will provide them with other roles to fulfill, and they will have fewer children.	POSTPONEMENT OF MARRIAGE Raise the age of consent so people would marry later in life, thus reducing the number of childbearing years.
SEVERE PENALITIES FOR LARGE FAMILIES People will be fined or heavily taxed for any children beyond the legal limit of two.	INCENTIVES AND REWARDS FOR SMALL FAMILIES A reward system will be set up for people who limit their family size. They would pay less taxes.	CHOOSING THE SEX OF AN UNBORN CHILD People often continue to have children until they get the boy or girl they want. Families could choose the sex of their children, thereby limiting family size.
SOCIAL SECURITY IN OLD AGE If people were financially cared for in old age, they wouldn't need large families and families would choose to limit their size.	LICENSES TO HAVE CHILDREN People must meet certain qualifications to get a legal license to have children.	

13. GROUNDWATER RIGHTS

Introduction:

Groundwater is that part of underground water that is below the water table. Groundwater is in the zone of saturation within which all the pore spaces of rock materials are filled with water. Approximately 50 percent of all Americans obtain all or part of their drinking water from groundwater sources. The United States has approximately 15 quadrillion gallons of water stored in its groundwater systems within one-half mile of the surface. Such agricultural uses as irrigation (67 percent) and water for rural households and livestock (6 percent) account for 73 percent of American groundwater usage.

In the past 80 years, the nation's population has increased by approximately 200 percent. The consumption of water on a per capita basis has increased 500 to 800 percent. About 2,000 gallons of water are used per day for each man, woman, and child.

Four doctrines govern the consumption of groundwater. In this activity, students study the four doctrines and apply the most appropriate doctrine to a case study. Some background knowledge regarding groundwater and water use in general is needed to use the lesson successfully.

Objectives: Students will be able to:

1. Explain that our supply of groundwater, although quite large, is exhaustible.

2. List the four doctrines of groundwater rights.

3. Analyze each of the four doctrines to determine which most appropriately fits a case study.

4. Appreciate the role of such principles as the four doctrines in making decisions on science-related issues.

Subject/Grade Level: Earth science/grade 8; general science/grade 9; biology/grade 10; environmental studies/grades 9-10; ecology/grade 10; civics/grade 9; government/grade 12

Time Required: 1-2 class periods

Materials and Preparation: Review the four doctrines of groundwater rights so you can discuss them with the class. Make copies of Handouts 13-1 and 13-2 for all students.

Procedures:

1. Pass out copies of Handout 13-1 and discuss the groundwater doctrines with the class.

2. Then hand out copies of the case study (Handout 13-2) and review the facts with the class.

3. Divide the class into three groups. One smaller group will play the role of the judge. The second group will represent the factory owner, and the third group will represent the landowners.

Source: Adapted from *Groundwater: A Vital Resource*, compiled by Cedar Creek Learning Center (Knoxville, TN: Tennessee Valley Authority, n.d.). Reprinted by permission of the Tennessee Valley Authority, Environmental/Energy Education Program.

4. The factory owner and landowners groups should meet separately to determine their plans of action. Each group should select one person to represent the position of the group. Opposing groups should develop questions to ask each other. While these two groups are meeting, the judges should review the four doctrines of groundwater rights and prepare questions for both groups. Some possible questions are:

- How long have you been located in this area?
- How much water do you normally use each day?
- For what purpose is the water used?
- Does your water use benefit the community in any way?

5. Allow about ten minutes for preparation. Then allow five minutes for each group to present its case and another five minutes per group for questions. All members of the groups can participate in asking and answering questions.

6. After both sides have made their presentations, the judges should discuss the case and decide who should have the groundwater rights.

7. After the judges have made their decision, review the four doctrines and have the students determine if the judges selected the doctrine that is most appropriate in the situation.

Evaluation:

Students can be asked to determine which Groundwater Doctrine is most appropriate for this case and defend their decisions in a paragraph. Evaluation can be made on how well the students defend their decisions.

Extension/Enrichment:

1. Have students write scenarios involving groundwater rights. Each student could trade scenarios with a partner and determine which doctrine applies to the partner's scenario.

2. Interested students might make a poster or bulletin board illustrating where groundwater is found.

THE FOUR DOCTRINES OF GROUNDWATER RIGHTS

1. **Riparian or Common-Law Doctrine**—The person who owns the land that lies on top of a water source has absolute ownership of the underlying groundwaters whenever he/she chooses to use it, with no limit on the amount used.

2. **Reasonable Use Doctrine**—This rule is very similar to the riparian rule but restricts the right to use the water to a use that is reasonable. A landowner's rights would not be limited except when the available supply is not enough to meet the immediate demands.

3. **Appropriation Doctrine**—The rule is "first come, first served." The ones that were there and used the water first have the strongest rights to the supply of water when it is limited. It could mean that new wells could be prohibited in areas that are developed with all the possible buildings and homes.

4. **Correlative Rights Doctrine**—All landowners have the same rights to the groundwater that they need to supply their lands that lie on top of the water supply. If too many are trying to use the available water supply, the courts may have to decide how to divide the available supply.

Overriding Rights—In some special cases, other rules may apply:

1. Federal right to water for a land reservation.

2. Indian rights for Indian reservations.

3. Pueblo rights to water supplies in former Spanish territories.

4. Federal rights to water for national security purposes.

A CASE STUDY

A chemical factory has been located in an area for 50 years. When it first moved into the area, it bought all the land within a wide area. As years passed, some of the area was sold to real estate developers, who sold houses to individual landowners. The factory has always pumped the thousands of gallons it uses daily from underground wells. There is no municipal water available. As the number of homes in the area increased, the number of family-owned wells also increased. Landowners are now being forced to dig deeper and deeper to find water, and many wells are being abandoned as they "dry out." The landowners feel it is the fault of the chemical factory, which pumps such an enormous amount of water out of the ground each day. The matter has now been taken to court.

Your class will be divided into three groups. One will represent the landowners, one the factory, and one the judges. The judges will use the Four Doctrines of Groundwater Rights, deciding which rule applies and who has the groundwater rights.

14. FOOD ADDITIVES

Introduction:

When we buy food at the grocery store or a restaurant, we assume that it is completely safe to eat. For the most part, it is. Nonetheless, concerns have been voiced about food additives—substances added in processing to color food, preserve it, or sweeten it. Some additives have been banned from food because they were found to cause cancer in laboratory animals or because they have caused other health-related problems. Other additives appear to be harmless.

In this lesson, students learn more about food additives, their purposes, and guidelines that must be followed to ensure food safety. Students analyze labels from a variety of foods and determine what additives are included in each of the foods. Through this examination, students determine whether the addition of food additives has increased the price of the food product. Finally, students decide whether food additives should be included in particular foods.

Objectives: Students will be able to:

1. Explain that food additives are added to foods to enhance the color and taste or to preserve the food.

2. Understand that some food additives are safe and others can be harmful.

3. Examine labels on food products to determine what food additives are present in each.

4. Classify food additives according to purpose and harmful effects.

5. Value the work of researchers who have discovered problems related to additives.

Subject/Grade Level: Biology/grade 10; chemistry/grade 11; physics/grade 12; environmental studies/ grades 9-10; economics/grade 12; current events/grades 10-12

Time Required: 1 class period

Materials and Preparation: Make copies of Handout 14-1 for all students. About one week prior to this lesson, ask students to begin collecting labels from a variety of foods. Encourage the students to avoid bringing in food labels from the same kinds of foods (for example, three kinds of cereals). You may want to have the school's dietitian or home economics teacher available to answer questions.

Procedures:

1. About one week prior to teaching this lesson, students should be asked to collect food labels from a variety of food products. Remind the students a few days before the activity in case some student have forgotten the assignment.

2. Introduce the activity with an overview of food additives. This can be taken from the student reading.

3. Distribute copies of Handout 14-1. Have students read this material individually or ask volunteer readers to read it aloud.

Source: Adapted from *ChemCom: Chemistry in the Community*, (Dubuque, IA: Kendall/Hunt, 1988).

4. Go over the information in the chart. Ask students to give examples of foods with each type of additive. For example, nutrients are added to most breads. The enriched flour in bread often contains niacin and iron.

5. Review the nitrite controversy. Ask students to brainstorm a list of questions that should be researched to help solve this dilemma. Also ask students what they can do personally until the nitrite dilemma is solved.

6. Divide the class into groups of three to four students. Ask students to select from all the food labels in the group, five additives that are not found naturally in foods. The group should list the food additives in a chart similar to this example:

	Food Product in Which Additive Was Found	Purpose of Additive	Other Information About Additive
1. Additive #1			
2. Additive #2			
3. Additive #3, etc....			

7. Next, ask groups to compare similar kinds of foods, such as three cereals or three soups. Do the products in each category contain the same food additives? Do some contain fewer food additives?

8. Bring the class back together and ask each group to report on the kinds of additives it found. A class list of food additives can be made on the chalkboard, with hash marks used whenever the same food additive is mentioned.

9. Conclude the activity with the following questions (having the dietitian or home economics teacher available for this discussion would be helpful):

- Why are food additives used?
- Which food additives that you found do you think should be added to food?
- Is it possible to buy the same kind of food product without additives? Give examples.
- Are there differences in prices between foods with additives and the same foods without additives?
- What must a person allergic to certain food additives do to avoid those additives?
- How extensive should testing of food additives be? Should the consumer be willing to pay higher food prices to ensure that proper testing is done?
- Should food additives be prohibited, since all food additives are unnatural additions to our foods?
- Both the use of food additives and laws protecting the quality of foods have increased since the early 1900s. What societal changes might explain these trends?

Evaluation:

Give each student one label. Ask each to indicate the food additives used, their purpose, and whether the student would or would not consume those additives.

Extension/Enrichment:

Have students look in newspapers or magazines for articles on food additives that are particularly controversial. All articles should be kept in a class file. Students can also be assigned research projects on various controversial food additives. Interested students might stage a debate on the topic of food additives.

FOOD ADDITIVE

We read a typical food label and find the following information:

> Sugar, bleached flour (enriched with niacin, iron, thiamine, and riboflavin), semisweet chocolate, animal and/or vegetable shortening, dextrose, wheat starch, monocalcium phosphate, baking soda, egg white, modified corn starch, salt, nonfat milk, cellulose gum, soy lecithin, xanthan gum, mono- and diglycerides, BHA, BHT.

Quite a collection of ingredients! You probably recognize a few of the ingredients listed—the carbohydrates (sugar, dextrose, starch), vitamins (thiamine, riboflavin), the minerals (iron and monocalcium phosphate), and possibly a few others. But you probably do not recognize many of the ingredients. A large number of substances are added to processed food products—substances intended to enhance the production, nutrition, processing, storage, appeal, or packaging of foods.

Food additives can be classified as either intentional additives or contaminants. Contaminants find their way into foods accidentally, Typical ones are trace pesticides from plants, antibiotics used to treat animals, or even trace amounts of substances from food-processing equipment or from packaging materials.

Intentional food additives are substances purposefully added to food products to enhance certain properties. Many intentional additives serve valuable purposes, such as increasing nutritional value or retarding food spoilage. Other intentional additives improve the consistency of prepared foods. Still other improve appearance and taste. Intentional food additives have been used since ancient times. For example, salt has been used for centuries to preserve foods. As people have moved greater distances from farms, greater reliance has been placed on food preservation additives. The table below summarizes the major food additive categories.

Food Additives

Additive type	Purpose	Examples
Nutrients	Improve nutritive value	Vitamins and minerals; iodine in iodized salt, B vitamins in enriched flour
Flavoring agents	Add or enhance flavor	Salt, monosodium glutamate (MSG), spices
Preservatives, antimyotic agents (growth inhibitors)	Prevent spoilage, microbal growth	Propionic acid, sorbic acid, benzoic acid, and salt retard mold growth on cheese, bread; sodium nitrite in meats adds to flavor, maintains pink color, and prevents growth of *Clostridium botulinum*
Antioxidants	Prevent fat rancidity	BHA and BHT react with free radicals to prevent oxidation of unsaturated fats

Food Additives, continued

Additive type	Purpose	Examples
Coloring agents	Increase visual appeal	Carotene—natural yellow color added to butter and margarine; converted to vitamin A in the body
Leavening agents	Make foods light in texture	Baking powder and baking soda produce CO_2, which expands food as it cooks
Bleaches	Whiten foods such as flour and cheese; hasten maturing of cheese	SO_2 bleaches, disinfects, and preserves dried foods; seems safe in foods except for persons allergic to it
Emulsifiers	Give texture, smoothness, other desired consistencies; stabilize oil-water mixtures	Cellulose gums, dextrins in whipped cream, cake mixes, mayonnaise
Anticaking agents	Keep foods free flowing	Sodium ferrocyanide added to salt to prevent caking
Humectants	Retain moisture	Glycerin
Sweeteners	Impart sweet taste	Sugar (sucrose), dextrin, fructose, saccharin, aspartame, sorbitol, mannitol

No additive discussion would be complete without some attention to nitrites. Sodium nitrite ($NaNO_2$) is used as a color stabilizer and spoilage inhibitor in meats. Nitrites are particularly effective in inhibiting the growth of *Clostridium botulinum*, which produces botulin toxin. Botulin toxin is so potent a poison that only one gram, suitably distributed worldwide, could kill the entire population of this planet!

Only recently have we discovered that the chemistry of nitrites leads to potential difficulties. In contact with hydrochloric acid (HCl) in the stomach, nitrites are converted to nitrous acid (HNO_2):

$NaNO_2$	+	HCl	→	HNO_2	+	NaCl
Sodium nitrite		Hydrochloric acid		Nitrous acid		Sodium chloride

Under certain conditions, the resulting nitrous acid can react with secondary amines. These are nitrogen compounds derived from NH_3 in which the nitrogen has two carbon groups attached, denoted below by the letter R. These secondary amines are formed in the breakdown of protein to amino acids during digestion. The reaction forms nitrosamines, which are among the most potent carcinogens (cancer-causing agents) known:

NHO_2	+	R–N–H (with R below N)	→	R–N–N=O (with R below first N)	+	H_2O
Nitrous acid		Secondary amine		A nitrosamine		Water

Our food in the United States is protected by laws. The basis of these is the Federal Food, Drug and Cosmetic Act of 1938. It was amended many times, including in 1954 (the Miller Pesticide Amendment), in 1958 (the Food Additives Amendment), and in 1960 (the Color Additives Amendment). In 1966 the Fair Packaging and Labeling Act was passed.

The Food Additives Amendment requires extensive information on proposed additives and their safety. This amendment addressed the growing concern over the presence of carcinogens in our food. The Delaney Clause in the amendment states that "no additive shall be deemed safe if it is found to induce cancer when ingested by man or animal." There is concern today that the Delaney Clause went too far because it would apply equally to the strongest and the weakest carcinogens. But the law stands.

It is worth noting that early in 1977 the cost of comprehensive toxicological testing for a single compound was $500,000 and required 3-10 years of research time. The protection we desire is expensive; we pay for it in increased food costs.

When the additive amendment was passed, many substances were exempted because they were known not to be hazardous. Those substances are not legally defined as additives, and make up the "Generally Recognized As Safe" (GRAS) list. This list is periodically reviewed to incorporate new findings. It includes items such as salt, sugar, vinegar, vitamins, and some minerals.

Various government agencies are concerned with ensuring that these laws are enforced. On the international level, organizations such as the United Nations Food and Agricultural Organization (FAO) and the World Health Organization (WHO) work to increase our worldwide food resources and upgrade world health.

In the United States processed foods are required by law to be labeled with their contents listed in decreasing order of abundance, the most plentiful first. However, such labels may not directly provide complete ingredient information.

Some food labels are required to provide only the name of the food—such as mayonnaise. The original act of 1938 gave approximately 300 common foods, including mayonnaise, what it called standards of identity. The law defined their basic ingredients, so these did not have to be listed on the label.

There are many reasons that persons with specific conditions must avoid certain food additives. Diabetics must restrict their intake of sugar. Persons with high blood pressure must avoid salt. Some persons are allergic to some food additives. There are many other reasons that some persons must avoid certain food additives. If any of these apply to you, you know it is essential that you read food labels.

15. ENVIRONMENTAL IMPACT STATEMENTS

Introduction:

The Environmental Policy Act of 1969 officially established the practice of evaluating the effects of proposed changes on the environment. An Environmental Impact Statement (EIS) is a detailed examination of a project that may significantly affect the quality of the environment (such as mining in a national forest). Environmental changes bring benefits as well as problems. The purpose of preparing an EIS is to weigh the value of a project against the damage that may result. Damage can include spoiling the scenery, killing animals on the endangered list, or any other negative result. The evaluation of a project is usually done by such professionals as ecologists, engineers, social scientists, and planners. After examining a completed EIS, governmental officials decide whether to allow the project to be carried out.

In this lesson, students learn the purpose of Environmental Impact Statements and the steps in preparing them. They prepare an EIS themselves based on a historical case study.

Objectives: Students will be able to:

1. Explain the purpose of an environmental impact statement.

2. List the steps in preparing an environmental impact statements.

3. Use the format of a model environmental impact statement to prepare an impact statement for a historical situation.

4. Use an environmental impact statement to make recommendations.

5. Value the role of scientists and social scientists in protecting the environment.

Subject/Grade Level: Environmental studies/grades 9-10; biology/grade 10; ecology/grade 10; current events/grades 9-12; U.S. history/grade 11

Time Required: 1-2 class periods

Materials and Preparation: Make copies of Handouts 15-1 and 15-2 for all students

Procedures:

1. Ask students if they know what an Environmental Impact Statement is. Can they guess the purpose of this statement from its title? Encourage them to speculate on the purpose of the EIS. Then share the information from the lesson introduction with students.

2. Give each student a copy of Handout 15-1, which lists the steps involved in preparing an Environmental Impact Statement. Go over these steps, making sure students understand the order of the steps as well as the purpose of each. Discuss whether preparing an EIS would be easy or difficult, time-consuming or quickly accomplished.

3. Ask students to brainstorm a list of situations in which assessing environmental impact might be important to local citizens. Some examples might be building a new highway, a toxic waste treatment facility, or a dam on a river. Copies of local newspapers could be helpful in generating ideas.

4. Ask students to list historical technological developments that had large environmental impacts. Some examples might be development of the cotton gin, steam engine, and nuclear weapons. If scientists of the era had done an EIS, how might things be different today?

5. Distribute Handout 15-2, which presents a case study on the automobile. Have students use the information provided to prepare an environmental impact statement on development of the automobile. This assignment can be completed in class or as homework.

6. Have students work in small groups to compare their impact statements. Each group should report to the class on their collective findings and recommendations.

Evaluation:

Have students respond to the following questions, orally or in writing:

1. What is the purpose of an Environmental Impact Statement?

2. What types of information are collected in writing an EIS?

3. What conclusions did you reach about the environmental impact of the automobile?

Extension/Enrichment:

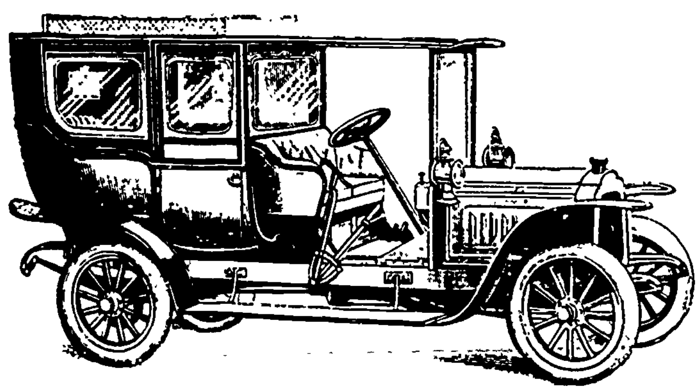
Have students apply the model presented in the lesson to situations reported in the newspaper or to historical situations covered during the year.

STEPS IN WRITING AN ENVIRONMENTAL IMPACT STATEMENT

1. State the objective of the project being considered.
2. List the technology necessary to accomplish the objective.
3. Propose one or more alternative ways of achieving the objective.
4. Describe the characteristics of the existing environment (before the proposed project).
5. List the costs and benefits for each alternative way of meeting the objective.
6. Predict the environmental impact of each alternative.
7. List the separate actions involved in the project and determine their effects upon various parts of the environment.
8. Prepare a summary and list of recommendations.

ENVIRONMENTAL IMPACT OF THE AUTOMOBILE

Directions: At the time the automobile was invented, no one wrote an EIS to determine whether the automobile should be built. Read the information below. Then, using the process of developing an EIS, determine whether the invention of the automobile did have an impact on the environment. A list of the data you will need follows the reading.



The November 7, 1938 issue of *Newsweek* contained an article titled "America Remade in 40 Years: The Automobile." This article talked about the vast changes in American life brought about by the automobile. Noting that "The average American family would as soon be without teeth as without its car," the article listed numerous changes to "human habits and social relations." Some of these changes were:

- Development of a huge new industry—manufacturing of cars. This industry depended on many other industries, including the steel and rubber industries. Millions of jobs were created by these industries.
- Miles of highways were built across the nation. This construction also created new jobs.
- One-room schoolhouses were greatly reduced because children could be bused to larger schools farther away. This allowed "thousands of children to enjoy a longer school term, more specialized instruction, and better physical equipment."
- Housewives had opportunities to buy a wider variety of goods and to enjoy cultural activities, such as literary societies.
- The distinction between farm families and city dwellers was blurred, as farm families gained access to the resources of the city.
- Tractors allowed farmers to increase the number of acres farmed. Trucks allowed certain kinds of perishable goods to be taken to markets not previously open to these farm goods.
- Medical services were more accessible. Not only could doctors get to more people, but more people could get to hospitals.
- Availability of cars to the police and fire departments increased safety. Losses due to fires were cut nearly in half between 1926 and 1936.

I. Description

1. Describe the present and past use of the automobile.
2. Describe the change in the American way of life that occurred before 1938 because of the invention of the automobile.
3. Describe the changes that have occurred since 1938.
4. Describe how the automobile affects your life.

II. Environmental Impacts

1. Discuss impacts that may have occurred to wildlife, air quality, noise, safety, or quality of life.
2. Discuss how these impacts could be minimized.
3. Discuss the economic impact of the automobile.

III. Alternatives

1. What are some of the alternatives that could be implemented to help alleviate the environmental impact of the automobile?

IV. Short-Term Use vs. Long-Term Productivity

1. What is the impact to the environment caused by the automobile?
2. What are the economic costs and benefits for present generations?
3. What will be the economic costs and benefits for future generations?

V. Summary of Major Findings, Conclusions, and Recommendations

After considering the many aspects of the invention of the automobile, write a summary of your conclusions and recommendations.

16. WHAT WOULD YOU DO IF ...?

Introduction:

Technology affects our lives in many ways. The automobile has made life easier for most people, but this technology is not without its negative trade-offs. In this lesson, students work in groups to role play a family situation showing how transportation needs might be met if automobile trips were limited to six per week.

Objectives: Students should be able to:

1. Describe how the results of technology have affected individuals' lives.

2. Identify costs and benefits of using a particular technology.

3. Generate several alternative solutions to a problem.

4. Recognize that individuals may have to sacrifice some conveniences for the good of the community.

Subject/Grade Level: Life science/grade 7; physical or general science/grade 9; environmental studies/grades 9-10; biology/grade 10; ecology/grade 10; civics/grade 9: government/grade 12

Time Required: 1-2 class periods

Materials and Preparation: For each group of four students, you will need to prepare the following: one copy of Handout C-1 or C-2 and one copy each of Handouts C-3 and C-4. Prepare a set of dilemma cards for optional use.

Procedure:

1. With the class, discuss briefly some of the benefits and problems of driving a car in an urban environment. Emphasize the trade-offs involved. Below are some points that should be covered:

Benefits:
Increased mobility
Fun of driving
Personal freedom
Wider choice in location of home and work (can live farther from work)

Problems:
Pollution, ugly brown cloud
Health problems caused by pollution
Traffic congestion
Parking problems
Cost of gasoline, parking

2. Explain that in this activity, students will work in groups of four. Each group member will assume the role of a family member. Each family is to reach a decision on car use; they can reach the decision by any method they choose. Teams must finish the decision-making 15 minutes before class is over and be prepared to tell about their decisions.

Source: Adapted from *Topics in Applied Science* (Lakewood, CO: Jefferson County Public Schools, 1982), pp.146-151. Reprinted by permission of the publisher.

3. Assign half the teams to be Greens, the other half to be Clarks. Note: two groups may interact (a Green family and a Clark family) to carpool, but let students originate this idea. Also, families may use public transportation.

4. Give each group a copy of either Handout 16-1 or 16-2 and copies of Handouts 16-3 and 16-4. Direct them to begin working. If teams seem to be handling the task well and need more challenge, give them dilemma cards to consider. One dilemma per team should be sufficient.

5. Call the class together. Ask a person from each group to explain how the team solved the transportation problems. Have them tell

- How the six trips are used.
- How each transportation need of family members is met.
- How the decision was reached.

6. If no teams use the carpool or public transportation, have teams regroup and try using these alternatives.

7. Conclude the lesson by discussing different solutions to the same problem. Can the class come to consensus on the best possible solution for each family?

Evaluation:

The questions on the student instruction sheet can be discussed orally or in writing as an evaluative tool. Group interaction and participation can also be evaluated.

Enrichment/Extension:

Continue discussion about the use of various kinds of technology, using the following questions:

- If the pollution problem became severe, should the government be allowed to restrict use of the automobile?
- What other technologies provide both benefits and costs?
- If the problems outweigh the benefits in the use of these technologies, who should decide whether the technology should continue to be used?

THE CLARK FAMILY

You are a family of four living in the Sunny Vista housing development west of the city. It is one mile to the nearest grocery store and five miles to the nearest shopping center complex. There is a movie theater in that shopping center.

Parent #1

You work at an insurance firm 15 miles north of your home. You usually get to the office at 9 a.m. and return home at 6 p.m. You play tennis on Thursday night at an indoor tennis court five miles east of your house. You are gone on that night from 7 to 9 p.m. On Sunday you are a volunteer at the hospital from 8 a.m. until noon.

Parent #2

You are a salesperson in the city 10 miles from home. You leave home at 8 a.m. and return home at 5:30 p.m. You usually take customers out to dinner one night each week, although you can usually decide which night. You also play tennis on Thursday night from 7 to 9 at the indoor tennis court. On Saturday morning from 9 to 11:30 a.m. you bowl in a league at the bowling alley eight miles south of your house.

High school student

You are a student at the local high school, 1 1/2 miles away. You have a second-hand car that you can drive to school. You are on the basketball team and the gymnastics team. You are gone from home from 7:30 a.m. to 5:30 p.m. for school and athletics. Athletic games are scheduled Friday nights from 6:30 until 8:30. You like to go out on dates twice a week and drive.

Junior high student

You go to school two miles from your home. You usually ride the bus to school and home again, except on Tuesday and Thursday when you stay and work on the school newspaper. You are through on those days at 5 p.m. You usually get together with your friends on the weekend.

THE GREEN FAMILY

You are a family of four living in the Sunny Vista housing development west of the city. It is one mile to the nearest grocery store and five miles to the nearest shopping center complex. There is a movie theater in that shopping center.

Parent #1

You work at a hardware store nine miles south of home. You work from 9 a.m. to 6 p.m. Monday through Friday. You swim at the "Y" three nights each week. On Saturday you like to go hiking in the mountains 10 miles west of home.

Parent #2

You are a lawyer with the firm of Brown, Green and Smith. Your office is in the city. You can set your own hours except when you are trying a case. On Tuesday night from 6 to 9 p.m., you teach a class at the community college. On Sundays you usually spend part of the day at the library (where it's quiet), preparing cases.

High school student

You are a cheerleader at the school 1 1/2 miles from your home. You ride the bus to school except on Tuesday and Thursday, when you practice cheers until 5 p.m. You have been dating three or four people from time to time.

Junior high student

The school you attend is two miles from home. Although you ride the bus to school, your participation in volleyball and student council prevents you from riding the bus home. You get home at 6 p.m. every night. You have many friends, whom you see as often as possible.

FAMILY TRANSPORTATION ROLE PLAY INSTRUCTIONS

Due to an alarming increase in the number of air pollution alerts and a great shortage of gasoline in the state, the governor has put controls on the number of trips a family can take in its car. The governor (who has been given emergency powers) has limited automobile trips to a total of six per week, per family. This must include all trips to work, to school, for shopping, and all else. Even if the family has more than one car, it can make only six automobile trips.

This sudden cutback in transportation has required most families to rethink their transportation needs, plan ahead, and cooperate with each other like never before.

Group Assignment

Your group is to become one family, either the Clarks or the Greens, in the town of Sunny Vista. You must solve your family's weekly transportation problem.

Follow these steps:

1. Read the description of the family assigned to you.

2. Each group member should assume the role of one character in the family.

3. Together work out a plan through which everyone in the family can meet his/her obligations, have a share of recreation and fun, and stay within the six automobile trips allowed.

Group Skills

In this activity, concentrate on the group skill, "Everyone may criticize ideas but no one may criticize persons." Use of this skill improves the interaction of all groups, including families.

You might begin with each family member making a list of the trips he/she has to make. Refer to the map of Sunny Vista when planning your trips.

Later, your teacher may give your family a dilemma card. The dilemma card will describe one of those emergencies that so often happens (such as the dog gets sick and has to be taken to the vet). Dilemmas must be handled within the limit of six trips, too. If you get into a dilemma, you will need to replan your trips.

As a family, decide how you use your six car trips per week. List them.

Car trip 1

Car trip 2

Car trip 3

Car trip 4

Car trip 5

Car trip 6

With the Class

Be ready to explain to the class

1. The six trips your family will take in the car.
2. How each family member will get to his/her appointments not included in the six trips.
3. What the dilemma was and how you handled it.

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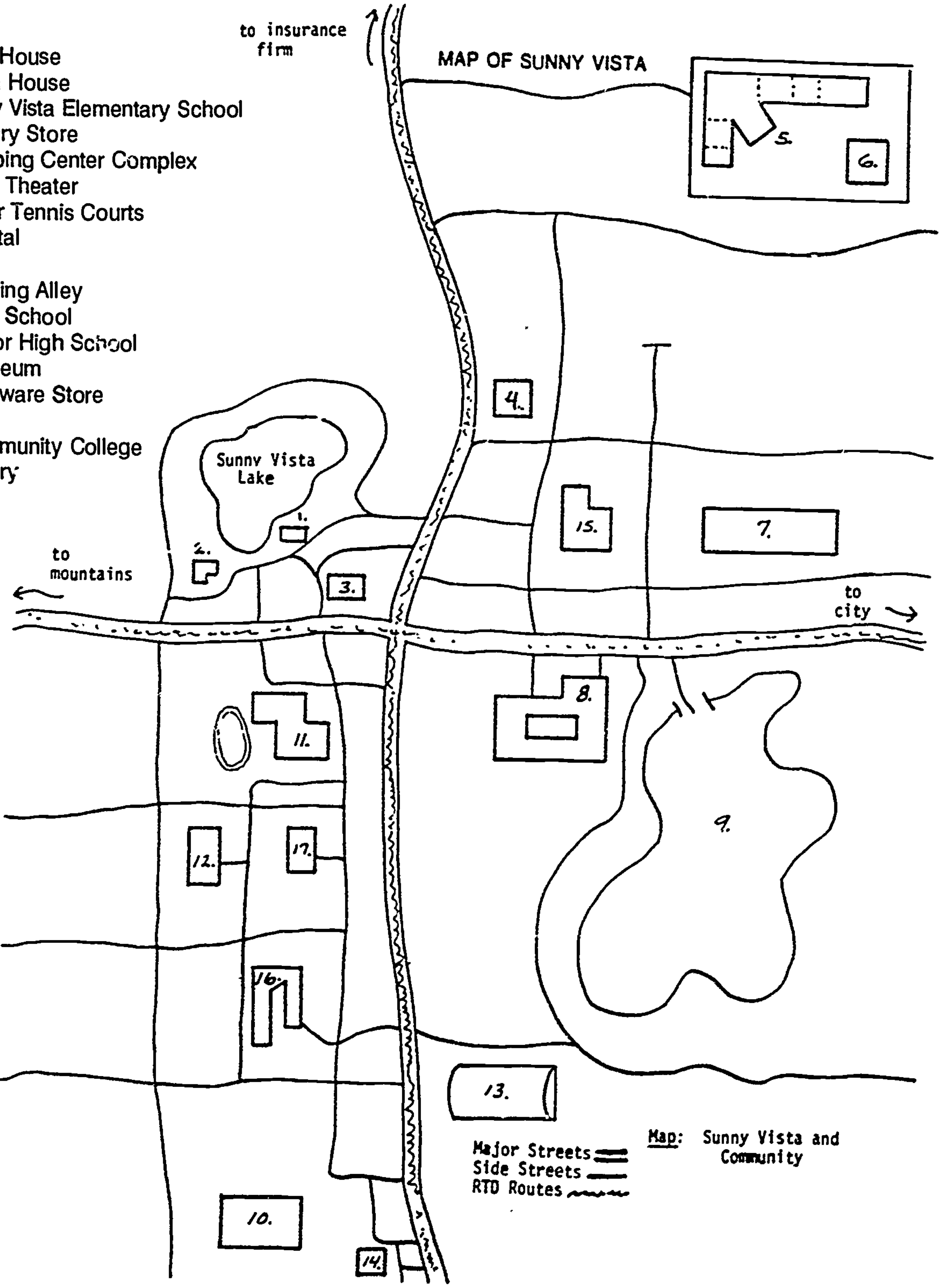
MAP OF SUNNY VISTA

Key:
1. Clark House
2. Green House
3. Sunny Vista Elementary School
4. Grocery Store
5. Shopping Center Complex
6. Movie Theater
7. Indoor Tennis Courts
8. Hospital
9. Zoo
10. Bowling Alley
11. High School
12. Junior High School
13. Coliseum
14. Hardware Store
15. Y
16. Community College
17. Library



DILEMMA CARDS

For parent (lawyer)—Green Family

Your associate needs help in preparing a case for trial tomorrow. You need to meet your associate at the library for 30 minutes tonight.

For parent—Clark family

Your hot water heater just sprang a leak today at 4 p.m. You can get the parts to fix it yourself at the hardware store. There are two stores with parts: the one at the shopping center complex and the one south of your house (see map).

For either family

Grandparents just phoned from Columbus, Ohio, to say they will be arriving at the airport in three hours for a surprise visit.

For high school student—either family

Heart is coming for a rock concert this Saturday night at the Coliseum. Tickets are still available.

For parent—either family

The junior high school office just phoned and said your junior high school student has been taken to the emergency clinic with an injured foot, sustained when a solar collector was accidentally dropped.

For junior high student—either family

Your best friend is having a party at his/her house on Friday night. Your friend lives three miles away.

17. COLLECTING POINTS OF (pH)IEW

Introduction:

Surveys are used by sociologists, political scientists, the news media, and politicians to assess public attitudes about a variety of issues. They can be used to assess needs for new programs, policies, or services; determine public awareness; evaluate the quality of existing programs, policies, or services; involve citizens in the process of program and policy development; and educate the public about programs, policies, or issues.

In this lesson students gain experience in developing and selecting questions, sampling, and summarizing and analyzing data. They use these survey skills to learn more about the problem of acid rain, although the model presented could be applied to any socially relevant issue.

Objectives: Students should be able to:

1. Define acid rain.

2. Explain why acid rain is a problem.

3. Use a questionnaire to gather information about acid rain.

4. Measure the degree of public interest regarding the issue of acid rain.

5. Identify and choose people to be questioned in order to gather needed information.

6. Compile, tabulate, and analyze survey results.

7. Interpret information gathered in a questionnaire.

8. Appreciate the value of surveys in gathering data about STS issues.

Subject/Grade Level: Earth science/grade 8; physical science/grade 9; general science/grade 9; ecology/grade 10; environmental studies/grades 9-10; chemistry/grade 11; current events/grades 9-12

Time Required: 4+ class periods

Materials and Preparation: Make copies of Handout 17-1 for all students. For each group of four or five students, gather the following materials: 4 strips of pH paper; 1 cup of rainwater, melted snow, or local stream water; 1 cup of lemon juice; 1 cup of tap water; 1 teaspoon of baking soda; 1 copy of Handout 17-2; and several sheets of newsprint. You may have copies of Handout 17-3 available to guide students' development of surveys (optional). If time permits, let students collect the water samples.

Procedures:

1. Distribute Handout 17-1. Assign students to read it in class or as homework.

2. Divide the class into groups of four to five students. Tell them they are going to conduct an experiment to determine the pH of the precipitation (or lake/stream water) in your area. Distribute the group materials (except the newsprint) and allow time for students to complete the worksheet.

Source: Adapted from "Collecting Points of (pH)iew: An Acid Precipitation Sur(pH)ey," from *Acid Rain in Minnesota: Teachers Resource Guide* (St. Paul, MN: The Acid Rain Foundation, Inc., 1985). Reprinted by permission of the publisher.

3. Discuss students' findings, as well as what they learned about the acid rain problem from the reading.

4. Turn the discussion to what the public knows about acid rain, asking such questions as:

- What do you think people know about acid rain?
- Where do you think people obtain information about acid rain?
- What are some ways we could find answers to these kinds of questions?
- Is public perception about acid rain worth caring about? Will anybody care about the results?
- What is the purpose of a questionnaire about acid rain? What are we interested in learning?
- What kind(s) of information do we need to fulfill the purpose of the questionnaire?

5. Have the class return to their small groups. Ask each group to develop a few questions about acid precipitation. Handout 17-3 contains some examples of questions and response formats. On large sheets of newsprint, have students write their questions. When they are finished, one person in the group should post these lists on the wall. A second person should be prepared to give a brief report to the class on their group's questions. After all groups have reported, make some decisions about the questions:

- Draw lines through questions that are repetitive, are not necessary, or do not fulfill the purpose of the questionnaire.
- Circle items that absolutely must be asked.
- Draw boxes around items that should be asked, but which require more clarity to avoid confusion.

6. Transfer the questions from newsprint to standard sheets of paper and have copies ready for the class the next time you meet. You may want to clarify ambiguous or confusing questions. Ask these questions to guide a discussion of the survey:

- Are all of the questions clear?
- Do we have enough questions or too many questions? What ones are we going to eliminate?
- How are people supposed to respond to the questions? Completion? Agree-Disagree? Should we also ask the intensity of agreement-disagreement?
- How will people know what the purpose is? Should the questionnaire contain a brief statement describing its purpose? What should it say?
- What additional information is needed on the form? Date? Age? Sex? Instructions?
- How are we going to assure confidentiality?

7. Now, ask some questions about the sample:

- How many surveys should we do?
- Who should we survey? Our class? School? Community? Should the sample include different age groups? Which ones? Should the group be balanced, i.e., same number of adults and students?
- When is the survey to be completed?

8. Now, ask some questions about the distribution and collection of the survey:

- How are we going to distribute and use the questionnaire?
- Who is going to complete the survey? The respondent or the person doing the survey?
- If we are going to use the survey as an interview, what do you need to say to introduce yourselves?

- How will we get forms back?

9. Make a final copy of the questionnaire and give copies to students for distribution. They should find other students or adults who will complete the questionnaire for them. They should bring the completed questionnaires back to class within three days, with the results tabulated.

10. Divide the class into small groups and have them compare and summarize the results of their surveys. Then, post the tabulations of results from the survey so all students can see them.

For some of the questions, you may want students to calculate percentages. Percentages are calculated as follows: Divide the number in each category by the total number, then multiply by 100 to obtain the percentage. For example, the number of adults who feel that other countries have done more than we have about acid rain is 20. The total number of adults is 50. To determine the percentage, divide 20 by 50 and multiply by 100, that is:

20 divided by 50 x 100 = 40 or 40%

11. Ask these kinds of questions to guide a discussion of the survey results:

- Did people you surveyed ask you any questions about acid raid? What were they?
- Were the survey questions clear? What is your evidence?
- Do the people surveyed have a clear understanding of the issues associated with acid rain? What is your evidence?
- How do people tend to view acid rain? What is your evidence?
- How representative is our data? How could it be improved?
- What are some of the similarities and differences you observe?
- Do people seem to be interested in acid rain? What is your evidence?
- What do you make of the evidence? What are all the possible interpretations?
- How could we be more certain of conclusions we reached from the data?

Evaluation:

Any of the following techniques could be used to evaluate student learning:

- Ask students to write a newspaper headline they would use in an article about their findings.
- Have students write a topic sentence for a paragraph in which they use the survey data.
- Ask students to complete these statements;

  If I were to conduct an acid precipitation survey ten years from now, I would find...
  Acid rain is...
  When it comes to acid precipitation,...
  The most frustrating thing in conducting a survey is...

Enrichment/Extension:

1. If the survey results warrant, an article about the findings could be prepared and submitted to either the school or local community newspaper.

2. Have students do more research on the issue of acid rain in the United States and other countries, focusing particularly on the need for nations to work together to solve this problem.

3. Other students might design a survey to gather information on additional STS issues.

Resources:

The Acid Rain Foundation, Inc., 1630 Blackhawk Hills, Saint Paul, MN 55122; provides information/ education materials, such as a resource directory, curriculum guide, and information packets.

American Biology Teacher 45(April-May 1983), special edition on acid rain.

Bibliography for 1985-1986 National High School Debate Topic: Water Policy (Bethesda, MD: American Water Works Association, 1985).

Bybee, Rodger, "The Acid Rain Debate," *Science Teacher*, Volume 51(April 1984), pp. 50-55.

Environmental Information Handbook (New York: Simon and Schuster, 1984).

Facts on File (New York: Facts on File, Inc., 1987). A weekly digest and index of news, compiled from major national and international newspapers.

Pollution (Boca Raton, FL: Social Issues Resources Series, Inc., 1986).

Taking Sides: Clashing Views on Controversial Environmental Issues (Guilford, CT: Dushkin Publishing Group, 1984).

ACID RAIN

Bear, deer, fox, and beaver still roam the woods in the mountainous areas of New York's Adirondacks, the largest state park in the continental U.S. Raptorial birds still soar on the thermal updrafts. Sparkling blue lakes, once famous for fat native trout, dot the area. But something's wrong. The wood frog's chirp has been stilled. Stands of beech, spruce, and tamarack show signs of disease. And in more than 200 of the shimmering lakes, the trout are gone. Osprey, loon, and kingfisher no longer frequent these lakes. The otter, unable to find crayfish, has long since gone elsewhere.

Of all these foreboding signs, it is the disappearance of fish that has become the symbol of a growing environmental tragedy.

When the fish started dying in the 1920s, lodge owners and anglers suspected natural causes. They blamed declining fish counts on savage winter storms and beaver dams. Many decades later, Scandinavian research revealed that death and disease are carried to the Adirondack region in the winds. The culprit: a phenomenon technically known as **acid precipitation**. This insidious pollution falls to earth in such forms as rain, snow, ice, hail, and even fog. It is commonly called **acid rain.**

Acid rain's corrosive hand touches more than lake life. Forests and other vegetation are vulnerable to acid rain attack. It etches its devastation on certain vegetable crops, on painted surfaces of human-made objects, and on the metal or concrete facades of buildings. It may even affect human health.

Acid rain has long been known in this part of the world. The effects of acid rain were first noted in the U.S. in the Adirondacks decades ago. Now we're finding acid rain in all parts of the country, from southern California to northern Maine; from Colorado to Florida. Acid rain is a growing threat to wildlife, crops, and human health.

What Is Acid Rain?

Uncontaminated rain is slightly acidic (pH 5.6). Because of air pollution, rain in most of this country is much more acidic than normal. The acidity of a liquid, soil, or other substance is measured on a pH scale that ranges from 0 (very acid) to 14 (very alkaline or basic). A value of 7 is neutral. Distilled water is one of the few neutral substances. The pH scale is designed so every one-unit drop in pH represents a 10-fold increase in acidity. For example, pH 6 is 10 times more acid than a pH 7; pH 5 is 100 times more acid than pH 7. Precipitation having a pH less than 5.6—the theoretical pH of natural rainwater—is considered to be abnormally acidic. Rain in the Adirondacks averages about 4.2. The lowest reading ever was made in Wheeling, West Virginia, when a storm dropped rain measuring 1.5. By comparison, vinegar has a pH of 3.0.

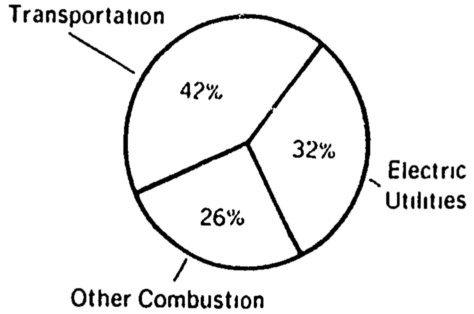
Where Does Acid Rain Come From?

Acid rain in formed from two kinds of pollutants, **sulfur dioxide** (SO_2) and **nitrogen oxides** (NO_x), which are emitted primarily from utility and smelter smokestacks and from the tailpipes of cars and trucks. Sometimes these pollutants react with oxygen in the air, become heavy aerosols, and fall to earth in a dry form. More often, they are ejected high into the atmosphere—usually from tall smokestacks—hitch rides on prevailing winds and travel for days, moving hundreds or thousands of miles from their source. In the course of their journey, they combine with moisture in clouds and are converted to acids. The sulfur dioxide becomes a mild solution of sulfuric acid, and the nitrogen oxides form nitric acid. These acids are cleansed from the air by rain, snow, and other forms of precipitation, and fall to the earth beneath.

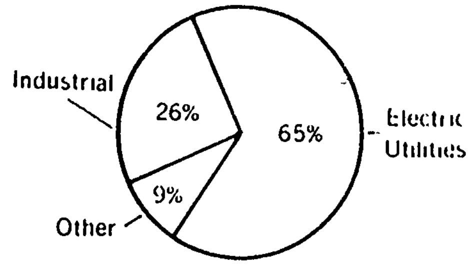
Source: Adapted from *Acid Rain—What It Is* (Washington, DC: National Wildlife Federation, 1984). Reprinted by permission of the publisher.

In the West, nitrogen oxides, streaming from utility stacks and the tailpipes of cars and trucks, combine with moisture to form nitric acid as the main component of acid precipitation. In the East, the big problem is sulfuric acid produced by sulfur dioxide emissions from the tall stacks of power plants. The biggest offenders are power plants in the Ohio River Valley, but emissions also come from other areas, such as the Great Lakes industrial sector. The consensus among experts is that the burning of fossil fuels is the root of the acid rain problem.

Sources of NO_x and SO_2



Nitrogen Emissions
Totaled 24.5 million tons/yr.



Sulfur Dioxide Emissions
Totaled 29.7 million tons/yr.

Where Is Acid Rain A Problem?

Thirty-one states in the Eastern U.S. and several provinces in southeastern Canada are drenched with precipitation that averages 20 to 30 times more acid than normal rain. A National Wildlife Federation study found 15 of these states to be "extremely vulnerable"—both in terms of environmental impacts and building materials damage—to this acidic downpour.

About 70 percent of the sulfuric acid reaching the Adirondacks originates outside the mid-Atlantic area. Scientists using satellites have tracked the drift of polluted air masses from oil- and coal-burning power plants in the Ohio River Valley to the Adirondacks and to southeastern Canada, especially the provinces of Ontario and Nova Scotia.

The Adirondacks also absorb some acid rain formed from pollutants originating in areas like Sudbury, Ontario. These emissions come from tall smokestacks built by utilities and smelters over the past 20 years to alleviate local air pollution problems. These stacks, some more than 2000 feet tall, do help clear the air locally. But Newton's law still applies: what goes up must—and does—come down, somewhere.

By a cruel quirk of fate, many of the acids formed by sulfur dioxide and nitrogen oxides come down in places poorly equipped, geologically, to cope with them. In some areas, the soil can neutralize some the the acids in the rain. But soils like those in the Adirondacks are too thin and too low in alkaline components to neutralize or counter the effects of deposited acids. In these situations, the precipitation that runs off the land into mountain lakes can be highly acidic. The receiving lakes also lack the ability to buffer the acids. Thus unchecked, the acids act inexorably to alter the chemistry of the waters.

Upstate New York is not the only vulnerable area to receive acid precipitation. Acid rainfall has been reported all over the country. The sensitive Boundary Waters Wilderness Area of Minnesota is receiving an acid onslaught. Isolated spots in Washington and British Columbia are measuring precipitation at pH levels below 5.6. Rainfall in portions of the Southwest and central Colorado periodically reaches acidity levels 20 to 40 times that of "pure" rain. Areas of southern California are not exempt from an acid rainbath. Recently, Los Angeles recorded acid fog at pH 3. Vinegar!

It has been estimated that 60,000 miles of streams and 9,400 lakes in the eastern half of the U.S. are acid altered or at risk.

Acid Rain Is Killing Lakes

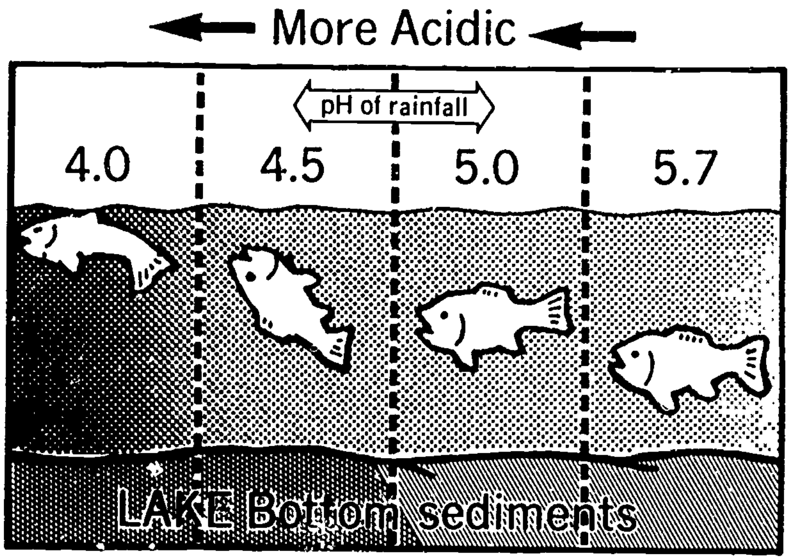
Acid rain packs a powerful wallop, leaving few parts of an ecosystem untouched. Its destructive effects are best documented for aquatic systems like lakes and rivers and the life found in them. Lakes and rivers underlain with granite, rather than neutralizing limestone, are the least able to offer resistance to repeated acid drenchings. Acid precipitation can lower the pH of these waters and also leach aluminum and other toxic metals from soils and bottom sediments.

The double punch combination of high acidity (low pH) and high levels of aluminum is deadly to fish and other aquatic life. It is so deadly that more than 200 lakes and ponds in the Adirondacks and 140 lakes in Ontario are fishless. Some 2,600 lakes in Minnesota are in jeopardy of experiencing the same fate, their waters bordering on the fish-critical pH of 5.5. The National Academy of Sciences has projected that the number of acidified lakes in the U.S. will more than double by 1990, unless pollutants that cause acid rain are significantly reduced.

Because of the closely woven web of life, death has a domino effect. In an aquatic system that is altered by acid rain, fish are usually among the last organisms to suffer the destructive effects of the acid. Unfortunately, by the time the fish are gone, a whole freshwater community may have been altered irreversibly.

A healthy freshwater lake has a pH around 8, slightly alkaline. But continued input of acid rain, plus the sudden influx of acid from melting snow each spring, gradually deplete the lake of its natural agents that tend to neutralize the acid. The pH begins to fall.

At pH 6.0 no freshwater shrimp can be found. As the pH falls to 5.5, bottom-dwelling bacterial decomposers begin to die. Leaf litter and other organic debris begin to collect on the lake bottom, and plankton—the base of the foodchain—starts to disappear. Toxic metals, such as aluminum, mercury, and lead, are released from lake bottom sediments or leached from surrounding soils. Aluminum, which can damage fish gills, and the lowered pH can mean the beginning of the end for many fish. By the time the pH has fallen to 4.5, all fish, most of the frogs, and many of the insects have died. The lake may still be clear and blue, but the vibrant community of living organisms it once contained is now just a memory.



In addition to lowering the pH of freshwater lakes and rivers, acid rain can leach aluminum and other toxic metals from soils and bottom sediments.

Acid Rain Affects Vegetation

Acid rain is also harmful to vegetation. Though the detrimental effects are not completely understood, this much is known: from above, foliage is attacked; from below, roots are starved and sometimes poisoned. The aerial assault damages the protective waxy surfaces of leaves, allowing acidic poisons to diffuse into the leaves. Transpiration and gas exchange are interrupted; the plant can no longer "breathe." As a consequence, photosynthesis and seed germination are inhibited. An overall result: plant productivity and crop yields can decrease.

The few field studies of the effects of acid rain on vegetation that have been conducted reveal these facts: Bush beans, radishes, and soybeans may be damaged. Yields of beets, carrots, and broccoli may be reduced. Soft fruits, including tomatoes, may be spoiled, and apples may be spotted. While yields of spinach and lettuce appear to be unaffected by acid rain, the foliage of these vegetables can be so damaged that they are unmarketable. We are just beginning to estimate damages to crops. According to Dr. Thomas D. Crocker of the University of Wyoming, "Acid rain has already reduced the nation's agricultural revenue by $1 billion (1978 estimate), while its total economic effect in the eastern third of the U.S. may be as much as $5 billion."

In forested areas, spruce, pine, aspen, and birch trees are among the species most stressed by acid rain. Here again acid rain packs a double punch. Leaves, with their protective layer damaged, become more vulnerable to drought and disease. Weakened root systems, poisoned by the uptake of toxic aluminum leached from soils, and the injured leaves cause the tree to slowly begin dying. Dieback starts with reduced foliage and eventually leads to the death of the tree.

Acid rain also affects important soil-dwelling organisms. Certain bacteria, which have the capacity to enrich the soil by forming nitrogen, are killed by the increasing soil acidity. Other microorganisms that thrive on organic litter and humus are also killed by high acidity. As a result, the soil is robbed of sources of materials important to continued plant growth.

Acid Rain: A Threat to People

Humans, too, may not be immune to the effects of acid rain. As a result of acid precipitation, people may be exposed to higher levels of toxic lead, copper, aluminum, and cadmium in their drinking water. Acids strip these metals from watershed soils, like sediments, or from pipes delivering water to homes.

The owner of an Adirondack lake resort told a Congressional committee that, after his children repeatedly complained about the bad taste of his lodge's drinking water, he had the water tested. Scientists found the water to be acidic and to contain 5 times the recommended safe level for lead and 10 times this level for copper.

Acidified lakes may also induce toxic mercury contamination of aquatic life.

Economic Losses are Staggering

Acid rain is already costing us incredible sums. Stopping the pollution at its source will also cost money. But corrective measures will be cheaper than the sustained economic losses caused by acid rain. For 200 fishless lakes in the Adirondacks, loss of angling revenue each year is placed at $1.5 million. In the Eastern U.S., acid precipitation destroys $13 billion worth of materials yearly (according to at least one estimate). Damage to forests could reach $1.75 billion annually, and crop damage in the Ohio River basin alone could mount to $8.3 billion over the next 20 years. Health costs have been pegged at $40 million for Minnesota alone.

Several sources contend that control costs would be comparatively modest. For example, Data Resources, Inc. recently estimated that all environmental rules (with air quality programs forming only a small part) would reduce the Gross National Product by only 0.7 percent by 1987, would actually stimulate employment and business investments, and would increase average annual consumer prices by only 0.4 percent per year.

In its 1981 report to Congress, the National Commission on Air Quality pegged the total 1978 costs for air pollution control at $16.6 billion, but estima[illegible]fits at $21.4 to $51.2 billion.

The National Commission on Air Quality has [illegible]d that a 7 million ton per year (or 35 percent) reduction in SO_2 emissions in the Eastern U.S. would cost $2.2 billion. This translates to an average utility rate increase of only 1.8 percent by 1990. With free interstate trading of emission reduction credits, which spreads the costs out among more sources, a 10 million ton reduction in SO_2 emissions can be achieved at an average increase in Eastern U.S. utility rates of only 1.4 percent (at a total annual cost of $2.4 billion according to a 1981 contract report by ICF, Inc.). While it is true that some Midwestern states would receive higher than average increases (up to a maximum of about 7.5 percent), these same states generate most of the emissions responsible for acid rain in the East. And, even with hefty rate increases, the Midwestern states would still pay less for electricity than New England and the mid-Atlantic region.

Solution: Control the Pollutants That Cause Acidity

Because many of the chemical steps in the conversion of sulfur dioxide and nitrogen oxides to acid are not fully understood, industry spokespeople and the Reagan Administration have called for more research into the problem. They have also urged measures such as lake liming, which is the dumping of calcium compounds in lakes to neutralize the acid. Liming is a short-lived and costly corrective measure that can only be applied to a fraction of affected lakes. It is treating the symptoms, not the illness. Moreover, it restores only lakes. Damage to soils, crops, forests, wildlife, building materials, and human health remain uncorrected.

Certainly, more research is needed and should be supported by industry and federal and state governments. Still, research alone will not stop acid rain. The goal must be to emit less SO_2 and NO_x into the air so that fewer acids form in moisture-laden atmospheres to rain down on vulnerable ecosystems.

The most cost-effective (and the only reliable) solution to the problem of acid rain is to control the offending pollutants at their source. A position statement on acid rain control, developed by the National Wildlife Federation, has been endorsed by over 100 scientists active in acid rain research. Though noting the uncertainties, these researchers agree that "what is already known about the acid rain phenomenon justifies and requires immediate legislative steps to begin abating emissions of human-generated acid rain precursors."

TESTING OUR WATER

1. Using a sample of rainwater or snow (use lake or stream water if no rainwater or melted snow is available), test the pH with a strip of pH paper.

   What is the pH of your water sample? ________

2. Using a clean cup with a sample of tap water, measure the pH of the tap water.

   What is the pH of tap water? __________

3. Next measure the pH of lemon juice. __________

4. Mix the baking soda in the tap water.

   What is the pH of this solution?________

5. Mark the pH of each liquid on the pH scale.

ACIDIC	NEUTRAL	BASIC

0 2 4 6 7 8 10 12 14

SAMPLE QUESTIONS

AGREE-DISAGREE

If you STRONGLY AGREE (SA) with the statement, circle number 1.
If you AGREE (A) with the statement, circle number 2.
If you have NO OPINION (NO) about the statement, circle number 3.
If you DISAGREE (D) with the statement, circle number 4.
If you STRONGLY DISAGREE (SD) with the statement, circle number 5.

Be sure to circle only one number for each statement.

	SA	A	N	D	SD
1. More must be learned about acid rain before it can be regulated.	1	2	3	4	5
2. Acid rain is a present and severe danger.	1	2	3	4	5
3. Failure to act promptly on acid rain will soon result in untold and irreparable damage to forests, agriculture, fish, wildlife, and ' uildings/statuary of the state.	1	2	3	4	5
4. States should be allowed to bring legal proceedings against polluters from outside their state.	1	2	3	4	5
5. Those receiving acid precipitation pollution should have as much to say about the issue as the producers of this pollution.	1	2	3	4	5
6. The biggest concern about acid rain is regional air pollution rather than local air contaminants.	1	2	3	4	5

CIRCLE ONE

7. I agree/disagree that the causes of acid precipitation are well known.
8. I agree/disagree that acid precipitation producers should be required to meet national standards.
9. We should have less/about the same/more regulation of emissions from coal-fired power plants (or automobiles and trucks).

RANK-ORDER

10. Rank order the potential acid rain impacts from most important (1) to least important (7).

____Health ____Economic ____Buildings ____Forest

____Soil ____Statuary ____Wildlife

COMPLETION

11. How have you learned about problems and issues related to acid rain? ____________________

12. Do you talk about acid rain with your friends?

_______a. Yes _______b. No

13. How often have you tried to influence a person about an issue associated with acid rain?

_______a. Five or six times _______c. Once or twice

_______b. Three or four times _______d. Never

14. How often do you watch television programs about public affairs and the news?

_______a. Almost daily _______d. A few times a year

_______b. Two or three times a week _______e. Never

_______c. Three or four times a week

15. How much do you know about acid rain? ____

OPINIONS

16. a. When it comes to acid rain, do you think we can trust the government in Washington to do what is right? ____

b. With respect to acid rain, would you say that the government in Washington is generally run for the benefit of a few big interests or that it is run for the benefit of most of the people?

____

c. Do you think we can trust the state government to do what is right about acid rain?

____

d. Do you think you can trust industry to do what is right about acid rain? ____________

____

e. Do you think you can trust the car-buying public to do what is right about acid rain? ______

____

18. THE BIOLOGICAL EFFECTS OF A NUCLEAR EXPLOSION

Introduction:

The threat of nuclear war and quality of life are interrelated issues that affect students. The devastating biological effects of a nuclear explosion are one important aspect of the nuclear issue.

This lesson deals with those biological effects. It is based on study of Hiroshima and Nagasaki victims and survivors. It allows students the opportunity to think about the seriousness of such an explosion, to share their feelings, and to ask clarifying questions about this critically important issue.

Objectives: Students will be able to:

1. List the effects of radiation on the ten major physiological systems of the body.

2. Analyze personal responses to statements from survivors of a nuclear explosion.

3. Respect the efforts of individuals whose personal experiences have prompted them to seek solutions to global problems.

Subject/Grade Level: General science/grade 9; biology/grade 10; chemistry/grade 11; physics/grade 12

Time Required: 1-2 class periods

Materials and Preparation: Make copies of Handouts 18-1, 18-2, and 18-3 for all students. Prepare a sheet of newsprint or posting paper with the ten major systems listed so group recorders can use this as a model when preparing their sheets;

System	Damage Caused by Radiation
1. Skin	
2. Skeletal	
3. Muscular	
4. Respiratory	
5. Circulatory	
6. Digestive	
7. Reproductive	
8. Urinary	
9. Nervous	
10. Endocrine (Hormonal)	

You will need a supply of posting paper, markers, and tape for the group activity.

Procedures:

1. Give each student a copy of Handout 18-1. Allow time for them to read the material.

2. Explain to the class that in this activity, groups of students will participate in a timed race to see which team can determine the various biological effects of radiation on the ten major physiological systems of the body. Students will write their responses on the newsprint or posting paper and tape their completed lists on the wall for evaluation.

Source: Adapted from *Crossroads—Quality of Life in a Nuclear World*, by Dan French and Connie Phillips (Boston, MA.: Jobs with Peace, 1983). Reprinted by permission of Jobs with Peace Educational Task Force, 76 Summer Street, Boston, MA 02110.

3. Assign students to groups of three or four and distribute supplies. Give students a maximum of 15 minutes to complete the task. The group with the most correct responses at the end of this time is the winner.

4. Each group should select a recorder to write the responses of the group. The recorder should prepare the group's paper with the headings shown in the model above.

5. Call the class together and review with the students the correct responses in each column. Correct answers are provided.

System	Damage Caused by Radiation	
Skin	burns fever loss of cell reproduction	loss of hair sores sweating
Skeletal	destruction of blood cell formation in the marrow	increased incidence of infection
Muscular	muscle damage	
Respiratory	destruction of lung tissue	increased permeability, leading to flooding of the lungs
Circulatory	anemia heart failure	hypoxia (or loss of oxygen to the body) leukemia
Digestive	dehydration diarrhea loss of appetite	loss of cell reproduction vomiting
Rep.oductive	loss of female fertility and male potency	
Urinary	kidney damage	
Nervous	apathy blindness burns	cell damage headaches
Endocrine (or hormonal)	thyroid cancer	

6. Debrief this part of the lesson with these questions:

- The very young and the very old are especially susceptible to radiation damage. Why do you think this is so?
- White blood cells are important to the body in fighting bacteria and foreign particles. Like red blood cells, they are made in the bone marrow. Why does radiation lower a person's resistance to infection?
- Is there anything else that has such effects on the human body?
- How do you feel about this part of the lesson?

7. Next, give each student a copy of Handout 18-2. Ask volunteers to read these quotations aloud to the class.

8. After all the quotations have been read, write the heading "Reaction" on the chalkboard. Ask students to say the first thing they thought about after hearing the quotations. Write all the reactions down. Then read through the list of reactions. Summarize with the following questions:

- Can anyone summarize the general reaction to these quotations?
- What do you think it felt like to survive the bomb and not know what had happened to you?
- If you were a Hiroshima survivor, how do you think you would feel about nuclear arms?

9. Distribute copies of Handout 18-3, which describes activities of people who survived the bombings and are contributing to world peace. Discuss these people with the class, using the following questions:

- What reaction do you have about these excerpts?
- How are these two *hibakusha* taking action and contributing to world peace?

Evaluation:

Have students create large drawings of the human body showing the damage to the ten physiological systems. Beneath their charts, students should write a paragraph describing why they respect the contributions of Busuke Shimoe and Hatsuko Tominaga.

Extension/Enrichment:

1. Advanced students might investigate the use of radiation to treat cancers. How is its effectiveness related to what they learned in this lesson?

2. Encourage students to read some of the many books written by and about the survivors of Hiroshima and Nagasaki. One that is very readable is *Hiroshima*, by John Hershey.

3. Have students create a bulletin board display devoted to individuals who have reacted to a very negative experience by working to solve the problem that created the experience. The individuals mentioned on Handout 18-3 might be included, along with the founders of such organizations as Mothers Against Drunk Driving.

Resources:

Ball, Howard, "Downwind From the Bomb," *New York Times Magazine* (February 9, 1986), pp. 32+.

Lifton, Robert Jay, "Toward a Nuclear-age Ethos," *Bulletin of the Atomic Scientists* (August 1985), pp. 168+.

Morrison, David C., "Energy Department's Weapons Conglomerate," *Bulletin of the Atomic Scientists* (April 1985), pp. 32+.

Nuclear Arms Control—Background and Issues (Washington, DC: National Academy Press, 1985).

Pond, Elizabeth, "Nuclear Weapons," *Christian Science Monitor* (June 21, 1982), pp. 12-13.

THE PHYSIOLOGICAL EFFECTS OF RADIATION

The descriptions below come from real events. Survivors of the 1945 Hiroshima and Nagasaki bombings have told their stories in words and pictures. Some years later, the U.S. tested nuclear weapons over the Marshall Islands in the South Pacific. Many natives of the islands and U.S. military personnel recounted what happened to them after the bombs dropped.

Persons exposed to large amounts of radiation suffer intense sweating, fever, damage to their stomachs, intestines, nerves, and muscles. They become dehydrated and apathetic. If a person inhales plutonium (a radioactive element in a nuclear bomb), the alveoli (or air sacs) of the lungs become permeable to blood and tissue fluids so the person has the sensation of drowning. Hypoxia (or loss of oxygen), heart failure, kidney damage, thyroid cancer, and leukemia may result later on.

Within 20 miles of the blast, people will suffer third-degree burns in their eyes as well as over their bodies. If they inhale, ingest, or absorb through their skin radioactive particles, they will experience radiation sickness. Cells that normally divide often—such as those of the skin and the lining of the stomach and intestines--are damaged. Radiation penetrates the bone marrow, where blood cells are made. Symptoms of radiation sickness include: anorexia (loss of appetite), nausea, headaches, vomiting, diarrhea, anemia (too few red blood cells), loss of hair, skin sores, increased susceptibility to infections, and loss of reproductive capacity. Radiation stays in the thyroid, nerves, lungs, stomach, liver, kidneys, intestines, bones, muscles, skin, ovaries, and testicles.

Remember, radioactivity cannot be seen, smelled, tasted, or felt and it stays in the air, food, and water for a long time as fallout.

VOICES OF HIROSHIMA VICTIMS

"How many seconds or minutes had passed I could not tell, but, regaining consciousness, I found myself lying on the ground covered with pieces of wood. When I stood up in a frantic effort to look around, there was darkness. Terribly frightened, I thought I was alone in a world of death, and groped for any light. My fear was so great I did not think anyone would truly understand. When I came to my senses, I found my clothes in shreds, and I was without my wooden sandals."

"A mother, driven half-mad while looking for her child, was calling his name. At last she found him. His head looked like a boiled octopus. His eyes were half-closed, and his mouth was white, swollen, and pursed."

"A woman who looked like an expectant mother was dead. At her side, a girl of about three years of age brought some water in an empty can she had found. She was trying to let her mother drink from it."

"While taking my severely wounded wife out to the riverbank by the side of the hill of Nakahiro-machi, I was horrified, indeed, at the sight of a stark naked man standing in the rain with his eyeball in his palm. He looked to be in great pain, but there was nothing I could do for him."

"I just could not understand why our surroundings had changed so greatly in one instant...I thought it might have been something which had nothing to do with the war—the collapse of the earth, which it was said would take place at the end of the world, and which I had read about as a child."

"The street was cluttered with parts of houses that had slid into it, and with fallen telephone poles and wires. From every second or third house came the voices of people buried and abandoned, who invariably screamed, with formal politeness, 'Tasukete kure! Help, if you please!' The priests recognized several ruins from which these cries came as the homes of friends, but because of the fire it was too late to help."

"They held their arms bent (forward)...and their skin—not only on their hands but on their faces and bodies, too—hung down—If there had been only one or two such people...perhaps I would not have had such a strong impression. But wherever I walked, I met these people...Many of them died along the road. I can still picture them in my mind—like walking ghosts. They didn't look like people of this world."

"My face was so distorted and changed that people couldn't tell who I was. After a while I could call others' names but they couldn't recognize me. Suddenly, I wondered what had happened to my mother and sister. My mother was then forty-five, and my sister five years old. When the darkness began to fade, I found that there was nothing around me. My house, the next door neighbor's house, and the next had all vanished. I was standing amid the ruins of my house. No one was around. It was quiet, very quiet—an eerie moment."

Source: Excerpted from *Unforgettable Fire: Pictures Drawn by Atomic Bomb Survivors*, Japan Broadcasting Association (New York: Pantheon, n.d.). Reprinted by permission of Pantheon Books, a division of Random House, Inc.

HIBAKUSHA – A-BOMB SURVIVORS

The bombings of Hiroshima and Nagasaki caused a tragic loss of lives. But many survivors of Hiroshima and Nagasaki live on today and make important and positive contributions to the world. *Hibakusha* is the Japanese word for one who survived the dropping of the atomic bomb. Below are descriptions of recent activities of two *hibakusha*.

Busuke Shimoe (born 1903):

Mr. Shimoe's wife and daughter were killed by the A-bomb. Mr. Shimoe himself was severely burned. Mr. Shimoe has been active in a campaign to ensure that A-bombs will never be used again and to seek relief for victims. He has traveled to many small villages, seeking signatures and collecting funds for the campaign. He has also supported the United Nations Special Session on Disarmament.

Hatsuko Tominaga (born 1914):

Ms. Tominaga has an eye affliction called "atomic cataract." It not only obscures her vision, but causes sharp pain. Her left breast was removed because of a tumor. Every Sunday, Ms. Tominaga attends church and then goes to the Atomic Bomb Dome at the Atomic Bomb Museum. There she hands out pamphlets to visitors. Near the end of the Vietnam War, many Japanese people feared that the United States would use nuclear weapons again. Ms. Tominaga led street demonstrations to ban the use of nuclear weapons.

19. ENERGY SOURCES

Introduction:

Energy consumption and production are important issues. Unless alternative sources of energy are found to replace those nonrenewable energy sources we are using at very rapid rates, we will indeed have an energy crisis.

In this lesson, students look at a variety of energy resources, determining the capabilities of each, as well as the constraints on the use of each. They decide which resource or resources would satisfy the needs of their immediate community, considering environmental impact in making their choices.

Objectives: Students will be able to:

1. Explain that all energy comes from either fossil fuels or solar, nuclear, or geothermal sources.

2. Define renewable and nonrenewable energy sources.

3. Describe the capabilities, constraints, and environmental impact of various energy sources.

4. Analyze a graph showing energy consumption in the United States.

5. Participate in selecting the most effective energy source or sources.

6. Value the contribution each individual can make in helping conserve nonrenewable energy.

Subject/Grade Level: Physical science/grades 8-9; general science/grade 9; environmental studies/grades 9-10; physics/grade 12; U.S. history/grade 11

Time Required: 1-2 class periods

Materials and Preparation: Make copies of Handout 19-1 for all students. Also make eight copies of Handout 19-2 and three copies of the information sources.

Procedures:

1. Have the class brainstorm a list of energy sources. List all of the suggested forms of energy on the chalkboard. Review this list and eliminate any incorrect responses.

2. Distribute copies of Handout 19-1. Allow students a few minutes to review the chart. Discuss the chart with the students, defining the following terms:

- Fossil fuels
- Solar energy
- Nuclear energy
- Geothermal energy
- Other energy sources (such as wind or hydroelectric)
- Renewable energy sources
- Nonrenewable energy sources

Source: Adapted from *Wind, Water, Fire, and Earth: Energy Lessons for the Physical Sciences* (Washington, DC: National Science Teachers Association, 1986). Reprinted by permission of the publisher.

3. Divide the class into eight groups, giving each group four information sources, as shown below:

Group 1: 1, 4, 7, and 14
Group 2: 2, 6, 11, and 16
Group 3: 3, 5, 10, and 15
Group 4: 8, 9, 12, and 13
Group 5: 1, 6, 10, and 11
Group 6: 2, 9, 15, and 16
Group 7: 3, 4, 12, and 14
Group 8: 5, 7, 8, and 13

Also give each group one copy of Handout 19-2.

4. Have the groups review the information sources and complete the worksheet questions about the four forms of energy they reviewed. Each group should select a recorder to complete the worksheet and a reporter to present information to the entire class.

5. As groups review their four information sources, ask each to select the one energy source they think would be most feasible for the area in which you live. When the reporter is presenting information, he/she should briefly review the four energy sources the group studied and reveal the energy source the group chose as the one most feasible for the area in which students live. List the sources selected by the groups on the chalkboard. Beside each, list some of its capabilities and constraints.

6. After all groups have reported, review the energy sources on the class list. Have the class identify whether each energy source listed is a fossil fuel, a form of solar energy, nuclear energy, geothermal energy, or other form of energy. Also identify if each is a renewable or nonrenewable form of energy. Then have the class discuss the pros and cons of each of the listed energy sources.

7. Have students select the energy source or sources from the list that would best serve the needs of their community. If the energy sources selected have a significant environmental impact, let students determine how this environmental impact could be reduced.

8. Conclude the activity with the following questions:

- Why is it important to be concerned with whether an energy source is renewable or nonrenewable?
- What can one individual do to help conserve nonrenewable energy sources?
- How can students encourage use of renewable forms of energy?
- Since the United States uses more energy than it produces, should government regulate the amount of energy each household, business, or industry uses? Why or why not?
- Should the government spend money to encourage the development of renewable forms of energy? Why or why not?
- What are some of the risks involved with continued energy consumption?

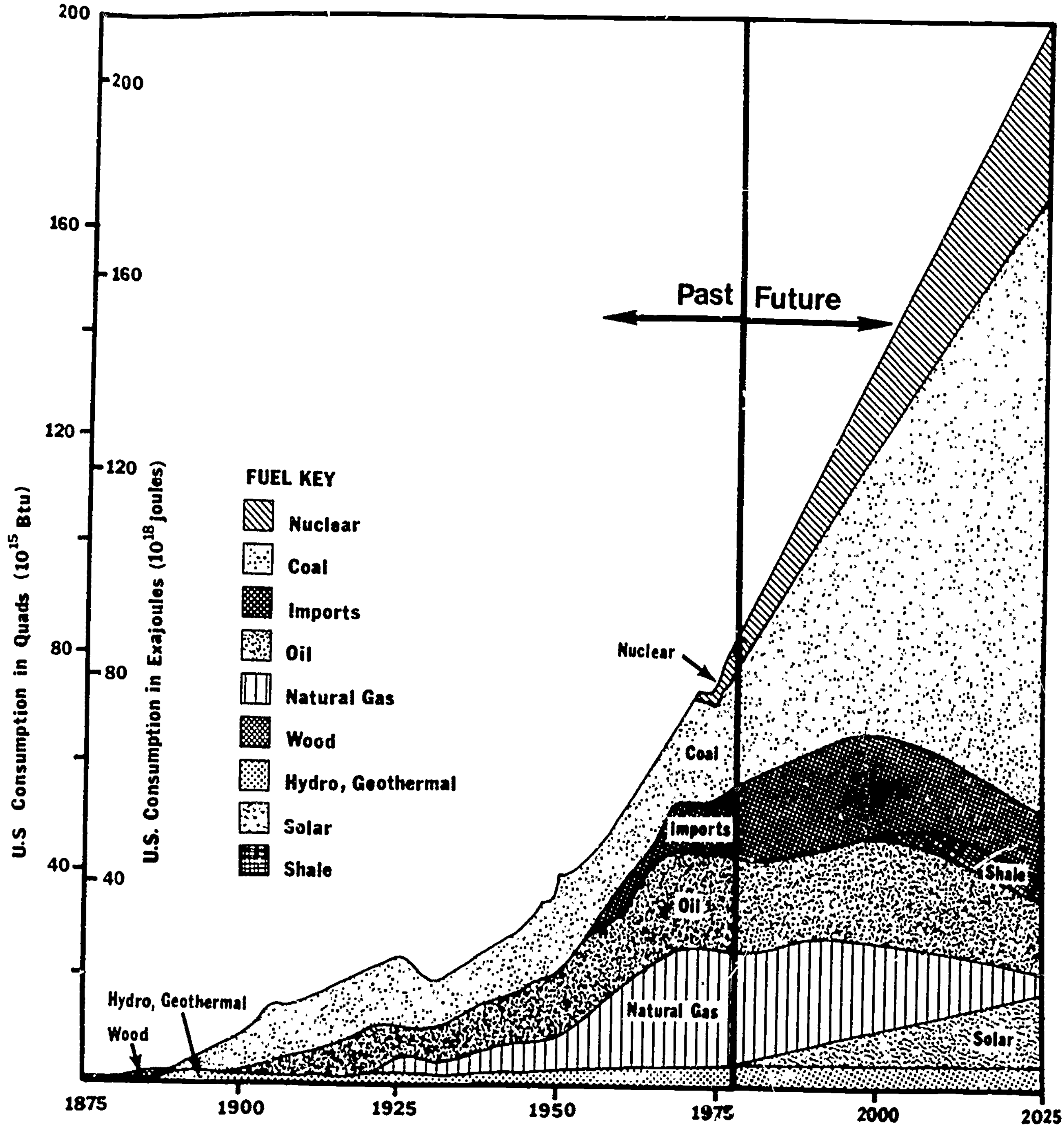
Evaluation:

Group interaction, class discussion, and contributions to the discussion on energy conservation can be evaluated. Students might also make a classification chart on the various energy sources.

Extension/Enrichment:

Have students survey the area in which they live to determine what types of energy sources are most prevalent. Students can also contact city and state officials to ascertain if conversion to any alternative forms of energy is being planned. A visit to a local power-generating station would also be instructive.

THE ENERGY HISTORY OF THE UNITED STATES



This graph shows a concise energy history of the United States. Examine it carefully. Note: Quad is short for quadrillion or 10^{15} Btu. One quad is equal to: 170 million barrels of crude oil; 7 billion gallons of crude oil; 43 million tons of bituminous coal; 1 trillion cubic feet of natural gas; 293 billion kilowatt hours of electricity; 393 billion horsepower.

ENERGY ASSESSMENT WORKSHEET

1. Information Sheet ____ Energy Source ______________

   A. What are the two major capabilities of this energy source?

   B. What are the two major constraints of this energy source?

   C. What are two major environmental impacts of this energy source?

   D. How widespread is the current use of this energy source?

   E. Is this energy source renewable or nonrenewable?

2. Information Sheet ____ Energy Source ______________

   A. What are the two major capabilities of this energy source?

   B. What are the two major constraints of this energy source?

   C. What are two major environmental impacts of this energy source?

   D. How widespread is the current use of this energy source?

   E. Is this energy source renewable or nonrenewable?

3. Information Sheet ____ Energy Source ______________

   A. What are the two major capabilities of this energy source?

   B. What are the two major constraints of this energy source?

   C. What are two major environmental impacts of this energy source?

   D. How widespread is the current use of this energy source?

   E. Is this energy source renewable or nonrenewable?

4. Information Sheet ____ Energy Source ______________

   A. What are the two major capabilities of this energy source?

   B. What are the two major constraints of this energy source?

   C. What are two major environmental impacts of this energy source?

   D. How widespread is the current use of this energy source?

   E. Is this energy source renewable or nonrenewable?

INFORMATION SOURCES

1. Petroleum

Production and Conversion: Oil, the fossil remains of ancient organic material, is trapped within the earth in several forms and may be recovered by drilling, pumping, and in some cases, mining. The crude product then can be refined to produce high-energy liquid fuels such as gasoline, diesel oil, fuel oil, kerosene, and others.

Energy Supply Capabilities: Oil products are highly flexible and transportable. Oil powers transportation and can be burned to provide heat, light, and electricity. Other important, nonenergy uses include petroleum chemical feedstocks and lubricating oils.

Resource Constraints: Our dependence on oil, especially for transportation but also in every sector of society, is much higher than remaining supplies can support for long. In the U.S. and much of the Western world, oil imports are essential to oil consumption rates and patterns. Much imported oil comes from countries that are not politically sympathetic to the West. Therefore, supply disruptions and price instability make oil an unreliable source.

Environmental Impact: Moderate air pollution; low water pollution; moderate land use impact.

2. Coal

Production and Conversion: Coal, composed of the remains of once-living plants, is found in seams beneath the surface of the earth and is produced by underground or strip mining. Coal can be burned to release large amounts of heat. It can also be converted to gaseous and liquid fuels.

Energy Supply Capabilities: As a solid, coal can be burned to produce heat and electricity either in centralized power stations or locally. Coal can be converted to liquids, replacing oil for transportation and feedstocks, or to gases, for industrial and personal energy needs.

Resource Constraints: Although coal is nonrenewable, the resource base is very large. The constraining factors fall into other categories: severe pollution problems, high occupational risks, negative social impacts.

Environmental Impact: High air pollution (sulfur, particulates, acid rain); moderate water pollution (acid mine drainage, thermal pollution); high land use impact (mining, transportation).

3. Natural Gas

Production and Conversion: Natural gas, formed by the same processes that formed oil and coal, exists primarily as methane, and in small amounts as propane and butane. Natural gas is often found with oil and can be extracted at those sites. Because of its mobility, it can be located, drilled, and collected separately from gas wells.

Energy Supply Capabilities: Natural gas is a highly flexible fuel that provides heat and electricity. It is especially important for some manufacturing needs, residential and commercial cooking, and in liquid state, as fuel in isolated areas.

Resource Constraints: Demand for natural gas is much higher than remaining supplies can sustain for long. World supplies will be exhausted in less than 150 years at present consumption rates. Because of price differentials and pricing policies, supply interruptions also have been a problem in the past.

Environmental Impact: Low air pollution; low water pollution; moderate land use impact.

4. Biomass (Plants)

Production and Conversion: Radiant energy from the sun is converted into chemical energy in vegetation by photosynthesis. Biomass, a term that includes all kinds of plant material, can be grown, harvested, and burned as a fuel.

Energy Supply Capabilities: Biomass has about one-half the energy content per unit mass of the high energy coals. Biomass can be burned to produce energy for heating and electrical generation. It also can yield liquids that can be combined with gasoline as fuel for transportation.

Resource Constraints: Land for growing enough plants to produce large amounts of energy is limited. Biomass crops often compete indirectly with food crops for growing space. Large plantings of single species crops (monocultures) are particularly susceptible to epidemics and insect infestations.

Environmental Impact: Low air pollution; low water pollution; moderate land use impact.

5. Biomass (Organic Waste)

Production and Conversion: Uban waste, municipal sewage sludge, industrial waste, and agricultural and forestry residues can be used for fuel. The organic components of waste can be burned as fuel, or the waste can be biologically converted to liquid and gaseous fuels.

Energy Supply Capabilities: Organic waste can be burned to produce electricity i. large, central generating stations. Thermal and biological processes can produce liquids and gases for heating, electricity, industrial uses, etc.

Resource Constraints: Converting organic waste to fuel is economically attractive because it makes efficient use of often "valueless" material and because landfill sites are costly and often scarce. Recycling glass, metal, and other valuable products also increases the attractiveness of organic waste conversion. Manure and crop residues may be more useful a· fertilizers and soil builders.

Environmental Impact: Low air pollution; low water pollution; low land use impact.

6. Photovoltaics

Production and Conversion: Radiant energy from the sun can be directly converted to electricity by the photovoltaic effect of solar cells. The movement of electrons in a wafer of silicon makes an electric current. Large arrays or panels of these cells have been used in remote areas of the world and to power spacecraft. However, the installation of photovoltaic arrays for commercial, residential, and industrial use is increasing rapidly.

Energy Supply Capabilities: Electricity produced by photovoltaics is as useful as electricity from any other source. In some cases it may be more economical because peak availability of sunlight coincides with peak hours of the summer cooling load.

Resource Constraints: The availability of sunlight is the most important supply factor. Weather and tall buildings can both interrupt the supply factor. Storage can be a problem, although most small installations sell extra power to a local utility, thereby using the utility grid itself as storage.

Environmental Impact: Low air pollution; low water pollution; moderate land use impact.

7. Solar Thermal Conversion

Production and Conversion: Radiant energy from the sun can be converted to high quality electricity either by focusing large arrays of mirrors (heliostats) on a central tower (receiver) or by collecting the heat at distributed receivers and transmitting it to a power plant.

Energy Supply Capabilities: In the central receiver system (the power tower), solar energy can be concentrated by a factor as high as 1000 times to produce supersaturated steam at 482°C to 538°C. This steam is used in turbines to generate electricity. Distributed receiver systems do not produce temperatures in this range, but they can operate on indirect sunlight. In both cases, electricity is produced, and peak power output should coincide roughly with peak demand.

Resource Constraints: The central receiver system requires full sunlight, but the distributed receiver system can operate on indirect sunlight or in hazy conditions. The requisite temperature for a specific purpose will determine which system is most useful in a specific application.

Environmental Impact: Low air pollution; low water pollution; moderate land use impact.

8. Ocean Thermal Energy Conversion (OTEC)

Production and Conversion: Radiant energy from the sun is stored in the earth's oceans. This solar energy can be used to operate a heat engine. For example, a working fluid such as ammonia can be evaporated using the heat of the warm surface water. The ammonia steam would be used to produce electrical power. The gaseous ammonia then would be cooled by low temperature water from the ocean depths and would be converted back to a liquid for the next cycle of the heat engine.

Energy Supply Capabilities: OTEC does not depend directly on availability of sunlight—solar energy is already stored in the oceans. OTEC electricity could be transmitted to shore or could be used at the site of generation for energy-intensive manufacturing (for example, aluminum refining).

Energy Supply Capabilities: Resource constraints in OTEC technology are almost nonexistent: the energy resources are huge and constantly renewed. However, the geographical constraints of site location, saltwater corrosion, plant growth, and the threat of hurricanes and ocean storms limit the technology for producing ocean energy.

Resource Constraints: Low air pollution; moderate water pollution; low land use impact.

9. Active Solar Heating and Cooling

Production and Conversion: Solar energy is harvested by flat plate collectors arrayed on rooftops or near buildings. The heat energy is carried by a medium such as water or air to the point of use or into storage.

Energy Supply Capabilities: Active solar heating systems can easily supply most of the energy needed for a home's space heat and hot water. Solar cooling requires higher temperatures, but with the addition of concentrators or in combination with a heat pump, active solar cooling systems are feasible.

Resource Constraints: Weather and tall buildings can block local access to the solar resource, but adequate solar energy is available in most of the U.S. for home heating and cooling.

Environmental Impact: Low air pollution; low water pollution; low land use impact.

10. Passive Solar Heating

Production and Conversion: In a passive solar heating system, sunlight is admitted through a window or similar device and stored in some form of mass (such as water, concrete, brick, or stone) and then reradiated as heat.

Energy Supply Capabilities: Passive solar can be used for space and water heating. It can also cool buildings by ventilation and evaporation devices. Passive solar heating systems are used only in buildings, and for the most part in new buildings. Because of the special design features that must be used to collect the solar energy, these buildings are highly self-sufficient.

Resource Constraints: The availability of solar energy—dependent on weather and surrounding buildings—is the only resource constraint. Technologically, passive solar is most easily and economically incorporated into new buildings because of the necessary siting and design features. However, retrofits are often possible and economical.

Environmental Impact: Low air pollution; low water pollution; low land use impact.

11. Windpower

Production and Conversion: Wind energy is a form of solar energy that results from uneven heating of the earth's surface. The energy reradiated from the surface causes great masses of air to move, making wind. Local wind patterns result from topography and weather as well as from global winds. Wind-generated electricity is the major new use of an old technology, windmills. Both large, centralized systems using networks of wind turbine generators, and small, decentralized applications for homes and small businesses are being pursued.

Energy Supply Capabilities: Large, centralized, wind-driven electrical generation systems produce electricity. Small-scale, decentralized wind systems can be used for electrical generation, battery storage, and a wide variety of mechanical applications such as pumping water, grinding, and compressing gases and liquids.

Resource Constraints: Most wind generation systems are limited by the availability of energy-producing wind speeds. Winds traveling from 8 to 60 miles per hour and faster can be tapped, but greatest efficiency is gained from constant, moderate winds. Unless the centralized electric power grid is used, storage and transmission of the electricity can be difficult.

Environment Impact: Low air pollution; low water pollution; moderate land use impact.

12. Hydroelectric Conversion

Production and Conversion: Flowing water is currently used to generate electrical power and in some instances in direct mechanical applications such as grinding grain. The technology is an old and proven one based upon the hydrologic cycle which is driven by the sun. Water evaporates from the earth's surface and redistributes through precipitation. The water flowing from higher elevations can be used to turn turbines and water wheels as it flows down to sea level.

Energy Supply Capabilities: Hydropower currently produces about 11 percent of this country's electricity. Most of the supply is generated in large, centralized sites and distributed through traditional transmission networks. New research and development efforts cover small, decentralized, low-water-flow systems for local community applications.

Resource Constraints: Most suitable sites for large-scale electric generation are now in use. The lack of suitable sites, transmission losses, and environmental protection will limit further development of massive hydropower installations like the Hoover Dam. Efforts to use new low-pressure turbines in small, decentralized applications may allow us to derive more electrical and mechanical energy from flowing water sources. As is true of all solar sources, hydropower sites are affected by the weather—in this case, by drought.

Environmental Impact: Low air pollution; moderate water pollution (flow change); high land use impact (flooding, ecosystem effects).

13. Conventional Fission Reactors

Production and Conversion: Uranium ore is mined, concentrated, and refined to produce an enriched uranium that is used as fuel in a nuclear power plant. There, a controlled nuclear fission reaction releases large amounts of heat that produce steam to drive turbines and generate electricity.

Energy Supply Capabilities: Conventional reactors are used to generate electricity in much the same manner as large, centralized fossil-fuel-powered systems. The electricity generated can be used in exactly the same way and with the same efficiency as electricity generated by existing fossil fuel systems.

Resource Constraints: Uranium ore supplies in the U.S. are fairly large, but not unlimited. Eventually, these supplies will be depleted. Constraints fall into other categories: radioactive waste disposal, public concern over health and safety, poor economic performance.

Environmental Impact: Low air pollution; medium water pollution (thermal pollution); medium (mining) to high (waste storage) land use impact..

14. Breeder Fission Reactors

Production and Conversion: Breeder reactors are similar to conventional reactors with two notable exceptions: they can use a more commonly occurring isotope of uranium; and they can produce more fuel than they use in the fission process. Therefore, breeders can produce not only high energy steam, but also enough fuel to power a second reactor (after 8 to 21 years of operation).

Energy Supply Capabilities: Breeder reactors generate electricity and could be hooked into the centralized transmission and distribution system in the same manner as fossil fuel plants and conventional nuclear reactors. The electricity generated can be used for the same ends and with the same efficiency as currently existing systems.

Resource Constraints: Breeder reactors are fueled by a nonrenewable resource. Although they generate more fuel, eventually fuel supplies will be depleted. The generation of plutonium 239 in the breeder reactor cycle presents a unique resource constraint. This new human-made element, a prime reactor fuel, is also the basic ingredient of a nuclear bomb. Its creation and transportation usher in a new set of resource constraints that are largely social in nature.

Environmental Impact: Low air pollution; low water pollution; medium (mining) and high (waste storage) land use impact.

15. Nuclear Fusion Reactors

Production and Conversion: When two light nuclei combine or fuse to form a heavier nucleus, energy is released. This simple fact describes the process of nuclear fusion, which promises huge amounts of energy from very small amounts of fuel. Sustaining the tremendous temperatures, pressures, and densities required for the fusion reaction to take place and producing more power than is needed to activate the process are two technical challenges that have not been met.

Energy Supply Capabilities: Fusion reactors will generate electricity in a traditional, centralized system.

Resource Constraints: While fusion reactors would use naturally occurring elements that are not renewable, very small masses of fuel would produce great amounts of energy. Each ton of deuterium could produce 10 million times more energy than a ton of coal. Therefore, deuterium from the oceans could be used to generate high-quality energy for millions of years.

Environmental Impact: Low air pollution; low water pollution; low land use. Waste disposal impacts are unknown at this time.

16. Geothermal Energy

Production and Conversion: Geothermal energy is the product of energy released by the radioactive decay of elements in the earth's core. Heat from this decay is conducted through the earth's crust. This heat is concentrated in hot spots near the edges of the continental plates. Where water is present as well, the heat—as steam or boiling water—can be tapped for electric generation and heating.

Energy Supply Capabilities: Steam and boiling water heated by geothermal energy can be used for heating, cooling, and electrical power generation. The quality of energy produced varies with the source. If a site produces high-energy steam, then it can be coupled with a turbine to generate electricity. If a site produces hot water, it can be used for heating and cooling.

Resource Constraints: Geothermal resources are limited by geography. The majority of domestic sources seem to be located in the mountain and western states; a few sites are scattered over the rest of the U.S. Although these resources are site-specific, groundwater replenishment and the long-term supply of heat from the earth's core guarantee a long-lived supply.

Environmental Impact: Moderate air pollution; moderate water pollution; moderate land use impact.

20. ENERGY SOURCES IN THE GOOD OLD DAYS

Introduction:

Petroleum use can be traced back almost 5000 years. Ancient Middle Eastern civilizations collected petroleum seepage and used it to waterproof ships and canals and to pave roads. By 1000 A.D., Arabs processed petroleum to obtain kerosene for lighting. Eleventh-century Chinese extracted oil from wells more than a half-mile deep. Marco Polo described oil fields he observed in travels through Persia in the 13th century. The first oil well in the United States was drilled in 1869 in Titusville, Pennsylvania. Since then, our way of life has been greatly altered because of petroleum products and the energy that petroleum has provided.

This lesson is designed to help students realize just how much life has changed during the more recent history of petroleum use. This is accomplished by having students interview older individuals who remember what life was like prior to the popular use of petroleum products and energy produced from petroleum.

Objectives: Students will be able to:

1. Describe what life was like prior to the use of petroleum as an energy source.
2. List ways in which petroleum has been used as an energy source.
3. Interview an older person to determine what energy sources petroleum replaced.
4. Summarize the data from the survey.
5. Value the comforts that petroleum provides in our lives.

Subject/Grade Level: Physical or general science/grade 9; environmental studies/grades 9-10; chemistry/grade 11; physics/grade 12; U.S. history/grade 11

Time Required: 1-1/2 class periods

Materials and Preparation: Make copies of Handout 20-1 for all students. During the lesson, each student is to interview one person who is at least 70 years old. If you think making arrangements to do so will be difficult for students, you may wish to call a senior center or retirement home to seek volunteer interviewees.

Procedures:

1. Begin the lesson by discussing the information provided in the **Introduction**. Ask students to brainstorm the various kinds of energy that are currently being used.

2. Tell students that earlier in this century, petroleum was used far less that it is now. The purpose of this survey is to determine the kinds of energy that were used when their grandparents or other older persons were younger.

3. Distribute a copy of the interview to each student. Go over the questions with the class.

Source: Adapted from *ChemCom: Chemistry in the Community* (Dubuque, IA: Kendall/Hunt, 1988).

4. Divide the class into pairs of students. Let students take turns interviewing their partners. Circulate around the room to determine if students are have any difficulty with the questions.

5. On the day the interviews are due, tabulate the results for each question on the chalkboard.

6. After all the questions have been tabulated, ask students the following questions:

- What are the main differences between earlier years and the present day regarding:

  a. Home heating
  b. Lighting
  c. Public transportation
  d. Cooking
  e. Food packaging
  f. Clothes washing

- Would a return to the "Good Old Days" be desirable? Why or why not?
- What would we do if current energy sources were used up? Would we need to return to a lifestyle similar to the "Good Old Days"?
- What can each of us do to help current energy sources last longer?

Evaluation:

Have each student make a chart showing current uses of petroleum and the early American analogs. They should also write sentences describing the changes extensive use of petroleum has made in our society.

Extension/Enrichment:

Let students develop other interview instruments that can be used to gather information about current energy consumption and current energy sources that people in your area use.

ENERGY USE INTERVIEW

1. How would you describe where you lived as a child?

   Urban area   Suburban area   Rural area

2. What was the main source of heat in your home at that time?

   ____

3. How was this source of heat supplied?

   It was delivered to our home.   We obtained the fuel ourselves.

4. What was the main source of lighting in your home?

   ____

5. What source of energy was used to provide this lighting?

   ____

6. What was the main source of public transportation?

   ____

7. What energy source was used to provide energy for public transportation?

   ____

8. What was the main source of private transportation?

   ____

9. What energy source was used to provide energy for this private transportation?

   ____

10. What kind of fuel was used for cooking? ______________________________

11. If you bought food rather than growing it, how was it packaged?

    ____

12. How were clothes washed? ______________________________

13. What kind of soap was used? ______________________________

14. How did this compare to today's soaps and detergents?

    ____

15. What were the main fabrics used for clothes?

____

16. Were clothes easier or harder to care for than they are today? Please explain.

____

17. How did you get to school?

____

18. What did families do in the evening without television?

____

21. LIFE WITHOUT PETROLEUM

Introduction:

In the past, our nation had abundant supplies of inexpensive energy. Until about 1850, wood, water, wind, and animal power satisfied all of our slowly growing energy needs. Wood, the predominant energy source, was readily available due to the conversion of forests to farmland. Wood served as an energy source for heating, cooking, and lighting. Water, wind, and animal power provided transportation and "fueled" our machinery and industrial processes.

Today, petroleum is the most prevalent energy source. It powers our automobiles, trucks, buses, and airplanes. Petroleum products are used to develop wearing apparel and most of the modern conveniences we enjoy. Petroleum products come from oil, a nonrenewable resource.

In this lesson, students look at U.S. energy consumption from 1850 to 1980, determining why use of various energy sources has changed. Students also read an excerpt by a well-known science writer, who speculates about what life will be like without petroleum as an energy source.

Objectives: Students will be able to:

1. Understand that wood and oil are both nonrenewable energy sources.

2. Explain why the demand for oil is increasing.

3. Analyze a graph to determine current and past energy sources.

4. Speculate how life would change without petroleum as an energy source.

5. Appreciate the need to conserve energy.

Subject/Grade Level: Any secondary science course; U.S. history/grades 8, 11; current events/grades 7-12

Time Required: 1 class period

Materials and Preparation: Make copies of Handouts 21-1 and 21-2 for all students.

Procedures:

1. Introduce the activity by presenting a copy of Handout 21-1 to each student. Allow time for students to study this graph.

2. Discuss the graph and accompanying questions.

3. Once students understand that changing demands for and supplies of various energy sources have played a large role in determining our country's history, tell students they will have a chance to speculate on what the future would be like without petroleum—one of the energy sources upon which we depend most.

4. Distribute copies of Handout 21-2. Allow students a few minutes to read this excerpt or have a volunteer read it aloud.

Source: Adapted from *ChemCom: Chemistry in the Community* (Dubuque, IA: Kendall/Hunt, 1988).

5. After students have read the excerpt, ask students to write short descriptions of how their daily lives would change in a world without petroleum. Tell students to include in their descriptions the changes that would be the most difficult to adapt to and those that would be easiest, giving reasons for their selections.

6. After students have completed the writing task, collect their papers for evaluation and conclude the activity with the following questions:

- What actions could be taken to keep this hypothetical situation from actually happening?
- What government action could prevent this hypothetical situation from happening?
- Who should take the responsibility for ensuring that this situation does not occur?
- Based on the graph we looked at earlier, does it seem possible that other sources of energy will replace oil as the energy source we depend on most?

Evaluation:

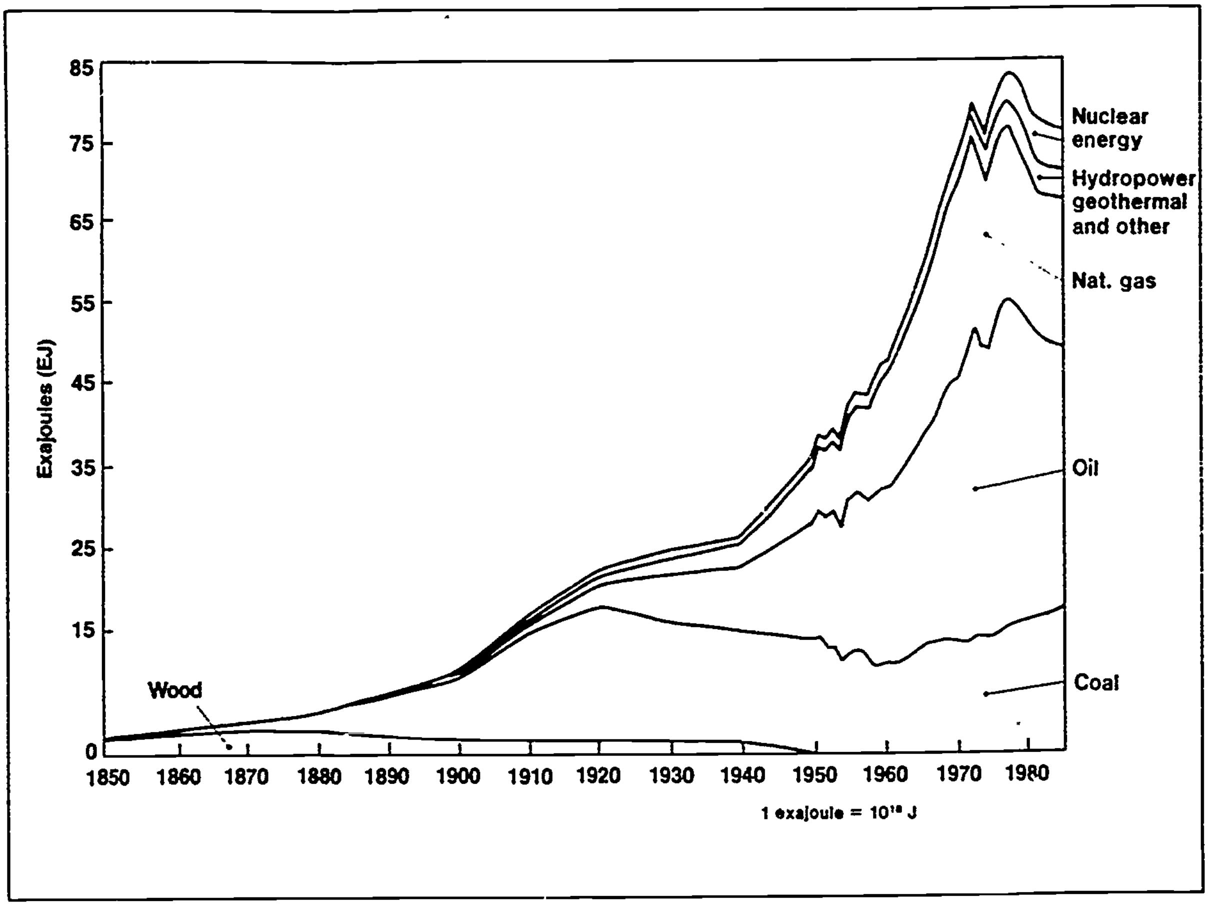
The papers written about a future without petroleum as an energy source can be evaluated to determine if students understand that without prudent conservation efforts, petroleum could suffer the same fate as wood. To assess students' understanding of the graph, ask them to write a one-paragraph summary of what the graph shows.

Extension/Enrichment:

1. Have interested students expand on their papers about life without petroleum by presenting skits or plays showing how daily life would be affected if petroleum were no longer available.

2. Groups of students might select other energy sources shown on the graph and research the advantages and disadvantages of increased use of these sources. Could these sources replace oil, or would a new source be needed?

U.S. ENERGY CONSUMPTION BY FUEL TYPE, 1850-1980



1. Since 1850, has our overall use of energy remained constant, increased at a fixed rate, or accelerated (grown at an increasing rate)? Describe at least two factors that might explain this trend.

2. Did overall energy use decrease at any time over the past 130 years? If so, when did this occur? Why?

3. Over what time period did wood supply more than 50 percent of our overall energy needs? What was the chief form of transportation during this period?

4. What factors might explain the declining use of wood after this period? What energy source was the next to rise in importance?

5. Compared to other energy sources, only a small quantity of petroleum was used prior to 1910. What do you think was its main use at that time? Oil became increasingly important about the same time that the use of coal reached its peak. When did this occur? What can explain the growing use of petroleum after this date?

6. What is the most recent energy source to enter the picture? What is the major use of this energy source?

LIFE WITHOUT OIL

What would life be like without petroleum for fuel? *Time* magazine asked Isaac Asimov to describe such a world. Asimov chose the year 1997 as a target date. By 1997 you will be a part of the public responsible for helping make decisions and dealing with their consequences.

Here is an excerpt from Asimov's story.

...Anyone older than 10 can remember automobiles. They dwindled. At first the price of gasoline climbed—way up. Finally only the well-to-do drove, and that was too clear an indication that they were filthy rich, so any automobile that dared show itself on a city street was overturned and burned. Rationing was introduced to "equalize sacrifice," but every three months the ration was reduced. The cars just vanished and became part of the metal resource.

There are many advantages, if you want to look for them. Our 1997 newspapers continually point them out. The air is cleaner and there seem to be fewer colds. Against most predictions, the crime rate has dropped. With the police car too expensive (and too easy a target), policemen are back on their beats. More important, the streets are full. Legs are king in the cities of 1997, and people walk far into the night. Even the parks are full, and there is mutual protection in crowds...

As for the winter—well, it is inconvenient to be cold, with most of what furnace fuel is allowed hoarded for the dawn; but sweaters are popular indoor wear and showers are not an everyday luxury. Lukewarm sponge baths will do, and if the air is not always very fragrant in the human vicinity, the automobile fumes are gone...

Source: "The Nightmare Life Without Fuel," *Time* (April 25, 1977), p. 33. Reprinted by permission from *Time*.

22. LAND USE

Introduction:

Decisions affecting the character and use of a particular area of land are made daily, often with very little information or consideration of the alternatives. Small groups of individuals, such as a city council or county commissioners, often make such decisions. Yet land use issues are seldom clear-cut; they are complex and often involve trade-offs. For this reason, open hearings have been established to enable local or state leaders to determine what citizens' views on these matters are.

This lesson provides students an opportunity to look at a land-use issue. Through a role play, students determine how a land-use decision would affect each individual involved, look at pros and cons of the proposed use of the land, and decide what use would benefit the majority of citizens involved.

Objectives: Students will be able to:

1. List a variety of purposes for which land can be used.

2. Explain why land-use issues can be very controversial.

3. Analyze a land-use issue and determine the effect of various alternatives.

4. Synthesize the information presented on a land-use issue and come to consensus on the best solution.

5. Appreciate analysis and consensus building as methods of decision-making.

6. Value individual citizen input in decisions that have a community impact.

Time Required: 2-3 class periods

Subject/Grade Level: Life science/grade 7; earth science/grade 8; general science/grade 9; environmental studies/grades 9-10; biology/grade 10

Materials and Preparation: Make copies of Handouts 22-1 and 22-2 for all students. Make one set of the role cards. Prior to using the lesson, you may wish to review the roles and determine the group assignments accordingly.

Procedures:

1. Open the lesson with a brief discussion of the need for individual citizens to participate in community decision-making, particularly on issues that could affect the economics of individuals and the community, as well as the environment. Continue by telling students that many issues affect a community. One such issue that often causes a great deal of controversy is land use. People have different ideas about the best use for a piece of land. All of the people affected by how a piece of land will be used have a right to help determine the best use for the land.

2. Give each student a copy of Handout 22-1. Have each student read the case study or assign one or more volunteers to read the case study aloud.

3. Ask students to help brainstorm a list of ways in which Mrs. Howard's pasture might be used. Write this list on the chalkboard. Don't eliminate any suggestions—all are valuable.

4. Next, see if there are ways items on this list can be combined. For example, suggested ways of using the land might be categorized as recreational, industrial, commercial, residential, etc.

5. Divide the class into seven groups. Tell each group to select one person to act as group spokesperson. Give each group a role card. Have groups review their roles and discuss the use of the land that each is proposing.

6. To help groups evaluate their proposals, give each group Handout 22-2 to complete. The questions on this worksheet will stimulate thinking about the proposal and will suggest points that can be presented to the city council for consideration.

7. Allow groups time to prepare a presentation that the group spokesperson will make to the city council. This presentation should be designed to convince the city council that a particular proposal is the best one for Angel Harbor.

8. Prior to the presentations of the proposals, select one student from each group to act as a city council member. Students who are not group spokespersons or city council members will represent the citizens of Angel Harbor and can ask questions of the spokespersons.

9. As the spokespersons present their proposals, the city council members should listen to the arguments and the questions raised by the citizens of Angel Harbor.

10. After all the spokespersons have reported and the citizens have asked any questions they have, summarize the input from the groups. You might make a chart on the chalkboard and list responses to the following questions:

- What is the science or technology involved with each proposal?
- What is the social issue involved with each proposal?
- Which of the proposed uses of the land would create the most controversy? Why?
- Which of the proposed uses of the land would be most beneficial to the residents of Angel Harbor?
- Which of the proposed uses of the land would be least beneficial to the residents of Angel Harbor?
- Which of the proposed uses of the land would affect taxes?
- Which of the proposed uses of the land would affect people's lifestyles? How?
- Which of the proposed uses of the land would create new jobs?
- Which of the proposed uses of the land would leave people without jobs?
- Is this piece of land suited to each proposed use? In what way?
- How will each proposed use affect the ecology of this area?
- What are the pros and cons of each proposal?

11. After these questions have been discussed, ask the members of the city council to deliberate for a few minutes and determine the one proposal that seems to be best for the residents of Angel Harbor. After deliberation, have the city council members announce their decision, giving reasons for their selection.

12. Discuss the decision with the class. Take a poll or use a show of hands to determine how many students agree with the decision of the city council. Ask students if they think this method of decision-making is fair. Would this be a good way for cities to make important decisions, such as land-use decisions?

13. Conclude by asking students what they learned from participating in this kind of activity. Also ask students to comment on why it is important for citizens to become involved in community decision-making.

Evaluation:

This activity should elicit good participation from all students. You will need to circulate around the room during group discussion to determine if students are contributing. At the end of the activity, you may ask students to indicate, in writing, whether they agree with the final outcome and how they justify their agreement or disagreement.

Extension/Enrichment:

1. Have students explore their neighborhoods to find proposed zoning changes or requests for variance. Good places to look include on vacant lots or large parcels of empty land, on buildings in older neighborhoods that are undergoing changes, or in areas where new construction is starting.

Tell students to examine the signs for the following information:

- What is being requested—a zoning change or a variance.
- When the hearing will be held.
- What city or county agency is holding the hearing.

Students might contact someone living next to or near this land to find out his or her opinion about the proposed change and then report their findings to the class.

2. Plan a field trip to a meeting of a city or county planning commission so students can see firsthand the work that is done in determining uses for community lands.

MRS. HOWARD'S PASTURE

Angel Harbor is a bustling community of 48,000 people. Its primary industries are fishing, lumbering, and the manufacture of fishing equipment and furniture. Angel Harbor is located on the ocean. The Angel River, a small river fed by mountain springs, flows through the center of the city on its way to the ocean. The river provides water for farms outside of the city. Angel Harbor has numerous parks and recreation facilities along the river.

Eleanor Howard has lived in Angel Harbor all her life. Her big house sits along the river on the edge of town. She has about 200 acres of land around her home, which she uses as pasture for her herd of horses. Recently, Mrs. Howard deeded 30 acres of riverfront pasture land to the community, with the requirement that the city council determine a use for the land that would be most beneficial for the majority of the community.

The city council encouraged the entire community to present proposals for the use of the land. The council received seven proposals. The council must now decide which proposal is the best one for the community. A town meeting has been scheduled. At this meeting, the seven proposals will be discussed by citizens and the city council.

Directions:

1. Your group will represent one of the people presenting a proposal to the council. First read your role. Then develop a presentation that will convince the city council and the community that your plan is the best one.

2. Select one member of the group to be the spokesperson. He or she will argue your group's position at the town meeting.

3. The teacher will pick one person from each group to serve as a member of the city council. The rest of the group members will represent citizens of Angel Harbor and should listen to the arguments made by each of the seven spokespersons and ask questions. The questions should help the city council decide which proposal really is the best one for the people of Angel Harbor.

LAND-USE WORKSHEET

As your group discusses the land-use proposal that it has been assigned, answer the following questions. This information will be helpful when your group spokesperson reports to the city council.

1. What is the science or technology involved with your proposal? ______________________

   ____

2. What is the social issue involved with your proposal? ______________________

   ____

3. Would this proposal be controversial? If yes, in what way? ______________________

   ____

4. How would this proposal benefit the residents of Angel Harbor? ______________________

   ____

5. Will this proposal create new jobs or leave people without jobs? ______________________

6. Describe the impact this proposal would have on the community of Angel Harbor. ____________

   ____

7. Would this be a positive or negative impact? ______________________

   ____

8. How would this proposal change the ecology of the area? ______________________

   ____

ROLE CARDS

1. Peter Blair

I represent a group of individuals who would like to build an amusement park for Angel Harbor. We feel this type of entertainment would be beneficial to the city. It would provide a place for adults and children to enjoy themselves, particularly on the weekends and evenings during the summer months. An amusement park would also be a tourist attraction. The people who would come to enjoy the amusement park would also eat at local restaurants and buy gasoline and other products from local merchants, thus adding to our economy.

The amusement park would add approximately 20 jobs for local residents. Because the land in question is on the edge of Angel Harbor, the music and lights of the amusement park would not be a nuisance to the residents of the community. There would be no cost to the city. The investment group would pay for the entire development.

2. Fay English

The land donated to the city by Mrs. Howard is priceless. This land is home to many kinds of animals. White-tail deer are frequently seen drinking from the river in the early morning and late evening. Several varieties of ducks and geese spend the winter in this area. We have beaver and muskrat on the river banks. And the river is teeming with all kinds of fish.

It would be in the best interest of the citizens of Angel Harbor to maintain this land in its natural state, a wildlife preserve. We could build a parking facility near the highway and trails to and from the river. This would allow people to study the wildlife in this area while safeguarding the habitat for these local species. The cost to the city would be approximately $5,000 for the parking area and $2,500 for the trail and trail markers. I am certain that many of the service organizations in our city would see this as a worthwhile community project and would donate both time and money to the development of a wildlife preserve.

3. Bob Evans

We need moderate-priced housing in Angel Harbor. High-paid professionals can choose from many new and older homes, but many workers and retired persons cannot spend $80,000 to $100,000 for a home. My company, Evans Brothers Homes, would like to purchase the land donated to Angel Harbor by Mrs. Howard. We would offer fair market price for the land. In turn, we would build single-family condominiums on the land. We would sell each unit for $58,000 to $67,000, depending on the number of bedrooms and other options desired by the buyer.

We anticipate that 60 condos could be built on this land. This development would be attractive and would add to the tax base for our community and school system.

4. Evelyn Cooper

What this city needs is a good family restaurant. We have many fast-food restaurants, and we have gourmet restaurants. But we need a restaurant that caters to families with big appetites and not too much money. What better place to build a restaurant than in a pleasant country setting?

I would like to purchase this land from the city. On the land I would build my restaurant. It would be built close to the river so that access on and off the main road would not cause congestion. I anticipate that my new restaurant would create jobs for 15 Angel Harbor residents.

5. Bill Dunn

Angel Harbor's citizens take pride in their community, its growth, and its welfare. We are careful to keep our city clean and attractive for the residents, as well as visitors. However, our fair city will soon experience a garbage disposal problem if alternatives are not found. As city sanitation manager, I have studied Angel Harbor's solid waste treatment methods. If Angel Harbor continues to dispose of its solid waste at the municipal landfill, the landfill will be completely filled in seven years.

I am proposing a recycling center where the community can recycle such materials as paper, glass, aluminum cans, and other metal products. This center would not need the entire 30 acres of land and could be built near the main road. The initial cost to the city would be $60,000, but it would extend the life of the landfill by 25 years and would earn $25,000 each year. The city council would need to make recycling mandatory for everyone in order to make my plan work.

6. Calvin Bristow

I am the girl's and boy's basketball and baseball coach at Angel Harbor Junior High School. I believe the children and adults of Angel Harbor need a better place for their recreational sports. The facilities available at the schools are adequate for school sports, but many adult and student softball and soccer leagues need fields on which to play and practice. I propose that the city build two baseball fields, four softball fields, and four soccer fields, along with stands for spectators, a concession area, dressing facilities for males and females, and a parking area to serve the entire complex. The complex would cost $30,000 to build. Through donations and community projects to raise funds, however, the city should not have to spend more than $15,000. Physical education should be a priority of both adults and children. I wholeheartedly encourage your consideration of my proposal.

7. Maureen Vincent

As a safety engineer hired by the city of Angel Harbor, I recommend that the Howard land be used to build a new fire station. This city has a good history of fire protection. It is also experiencing a great deal of growth, particularly to the north of the city, toward Mrs. Howard's land. Right now, the homes on the north end of town depend on the Russell Street Fire Station, which is eight miles away. This may not seem like a great distance, but when your home is burning, seconds count.

I encourage the city council to annex this land and use it to build a new fire station. The cost of $1.3 million dollars would need to be raised through a tax increase, but this will be money well spent.

23. THE ARTIFICIAL HEART: A TECHNOLOGICAL ALTERNATIVE

Introduction:

Technology has increased life expectancy significantly and has improved the quality of human life in many ways. Such medical technologies as transplanted organs and artificial kidney machines save hundreds of lives annually. Yet medical technology can also keep people alive even though they are brain-dead and unable to enjoy the "benefits" of prolonged life.

In this lesson, students address some of the questions raised by medical advances: Who has the right to make life-and-death decisions? Who should pay for medical care and research? Students read about the first recipient of the artificial heart. They then work in small groups to role play a committee that must decide whether to use an artificial heart with another patient.

Objectives: Students should be able to:

1. Describe the operation of the artificial heart.

2. List advantages and disadvantages of using the artificial heart.

3. Evaluate whether the artificial heart should be used in a particular situation.

4. Respect diverse opinions on the use of new medical technologies.

Subject/Grade Level: General science/grade 9; biology/grade 10; current events/grades 9-12

Time Required: 3 class periods

Materials and Preparation: Prepare copies of Handout 23-1 for all students. You may also want to have available a photo, drawing, or model of an artificial heart as well as other articles on the artificial heart, other artificial organs, and organ transplants. For each group of five students, you will need one copy of Handout 23-2 and one set of role cards.

Procedure:

1. If one is available, display a photo, drawing, or model of an artificial heart. Discuss how the artificial heart works, comparing its operation with that of the human heart.

2. Distribute copies of Handout 23-1 and allow time for students to read it. (Note: This could also be assigned as homework for the previous night.)

3. After students have read the information about Barney Clark, discuss with them the question raised in the reading: Was this a step in the research process that should have been taken?

4. Tell students they will be working in groups of five to decide whether another patient should receive an artificial heart. Group the students and distribute a copy of Handout 23-2 to each group. Go over the instructions.

5. Pass out a set of the role cards to each group and let group members distribute the roles among themselves. Have students attempt to reach a decision about whether Smith should receive the artificial heart. Urge students to list both the costs and benefits of using the technology. In listing costs, they will need to consider risks.

6. Each group should select a group moderator to lead the discussion and a recorder to take notes and report back to the class.

7. Let each group report on their discussion and decision.

8. Finally, as a class activity, discuss the following questions:
   - What are the risks and benefits of Smith's potential surgery?
   - Would this be unethical experimentation? Why or why not?
   - Should humans be used as experimental subjects?
   - If the government cannot pay the cost for this kind of medical technology, who should pay?

Evaluation:

Have each student develop an opinion paper on the technology and use of the artificial heart.

Extension/Enrichment:

Students could do further research to learn more about the technology involved in designing and implanting the artificial heart.

Resources:

Biomedical Ethics: Opposing Viewpoints (St. Paul, MN: Greenhaven Press, 1987).

Dunn, P.D., *Appropriate Technology: Technology With a Human Face* (New York: Schocken Books, 1979).

Weiss, Ann E., *Bioethics: Dilemmas in Modern Medicine* (Hillside, NJ: Enslow Publishers, 1985).

BIOETHICS AND HUMAN EXPERIMENTATION

On December 1, 1982, a dentist from Des Moines, Washington, became the first human being to have an artificial heart implanted in his chest. The dentist's name was Barney Clark, and the operation was performed at the University of Utah Medical Center.

Dr. Clark's new heart, constructed of plastic and held together with strips of Velcro, was linked to two tubes, also made of plastic. The six-foot-long tubes exited from Dr. Clark's body just under his ribs. At the other end, each was connected to an electric pump. As the pump operated, air pressure inside the tubes increased and decreased regularly. Each pressure change produced a heartbeat.

In all, that artificial heart beat more than 12 million times, keeping Dr. Clark alive for four months. He died on March 23, 1983, a victim of kidney failure, breathing problems, complete loss of blood pressure, and various other ailments. Possibly, he was also a victim of unethical human experimentation.

For the artificial heart was an experiment. Called the Jarvik-7 after its inventor, Dr. Robert Jarvik, its implantation in Dr. Clark's chest was just one step in a long-term scientific research project. Was it a step that should have been taken?

Before the operation, many people thought it should. Dr. Clark and his family did. His doctors, Jarvik and the surgeon who performed the operation, William DeVries, agreed. So did the hospital's Institutional Review Board (IRB), a 16-member committee of doctors, nurses, pharmacists, lawyers, philosophers, and laypeople. An IRB must approve any medical experiment on a human being before it can take place.

After Dr. Clark's death, however, attitudes changed. During 1983, the Utah hospital's IRB was asked to give permission for other artificial heart operations. For over a year, all requests were turned down. Not until June 1984 did the IRB decide to allow a second artificial heart implant.

Before that operation could be carried out in Utah, however, Dr. DeVries moved to a hospital in Louisville, Kentucky. There, late in 1984, he implanted an artificial heart into the chest of a middle-aged man named William Schroeder. Several months later, Schroeder was still alive. Other artificial heart implants followed. Also in 1984, in another daring procedure, doctors in California transplanted the heart of a baboon into a newborn infant. The child, known to the public only as "Baby Fae," survived three weeks with the animal heart. The new operations helped fuel the national debate over the ethics of such experimentation.

Source: *Bioethics: Dilemmas in Modern Medicine*, by Ann E. Weiss (Hillside, NJ: Enslow Publishers, 1985), pp. 33-34. Used by permission of the publisher.

A MEDICAL DILEMMA: ROLE PLAY INSTRUCTIONS

Carol Smith, a 48-year-old mother of two, is seriously ill. After suffering three major heart attacks, she is nearing death. One alternative available to her is an artificial heart transplant. Prior to her heart attacks, Ms. Smith was in fair health. Although the cost of the heart transplant is $25,000, government funds for medical research are available to cover this expense.

Each member of your group will be assigned a role—either that of Carol Smith or a person who might serve on an Institutional Review Board to decide whether Smith should have the operation. Read your role card. Then discuss with the other members of your group whether Smith should have the operation. In discussing the operation, point out the costs and benefits. Be sure to cover the risks involved.

Would your group vote for or against using the artificial heart?

ROLE CARDS

Role 1: Carol Smith

I love my family very much and do not want to die. After I suffered my third heart attack, my doctor referred me to a specialist, Dr. Malcomb, who has done four heart transplants. Three of these patients have died, but the fourth has survived 11 months with an artificial heart. I really want this artificial heart. It is my only hope for survival.

Role 2: Dr. Albert Malcomb

Ms. Smith would be a good candidate for an artificial heart. Although three of my four patients have died, the fourth, Sarah Willis, is making a nice recovery and may be able to go home for a short visit soon. Carol Smith is a fairly healthy woman, not overweight, and a non-smoker. Her chances for survival through the surgical process are 80 percent. And she has a 50-50 chance of living one or more years following surgery.

Role 3: Carl Andrews, Hospital Administrator

The board of directors, following lengthy discussion, has agreed to allow Dr. Malcomb to perform an artificial heart transplant on Carol Smith. Several of the board members argued that this type of surgery has not been successful enough to warrant co ·nuation. They further argued that continued experimentation should occur on animals rather than humans. The majority of the board members, however, are firm in their position that each patient should be given a fair chance for continued survival.

Role 4: Nancy Greenly, U.S. Senator and Chairman of the Medical Ethics Committee

The Medical Ethics Committee evaluates the effectiveness of medical technology and organ transplants, including artificial heart transplants. This committee is responsible for securing federal funds for research and funds to subsidize medical costs for organ transplant patients. The annual fund for research exceeds 1.4 billion dollars, and medical costs average 4.7 million dollars. Recently, the medical technology involved with the artificial heart has come under much scrutiny. A bill before Congress would eliminate research and medical coverage for artificial heart transplants. Strong lobbying may result in passage of this bill, which would eliminate financial help to patients such as Carol Smith.

Role 5: Wayne Harris, Citizens Against Human Experimentation

I represent a group of concerned citizens who disagree with ongoing experimentation with humans. Particularly, the implantation of artificial hearts in humans should be discontinued until scientists are able to perfect the heart and achieve more successful results with animals. To date, only three recipients of artificial hearts are still alive. And the prognosis of these three patients is not good. Is extending the life of an individual two to twelve months ethically a good decision, especially if the person suffers a stroke or other side effect?

24. THE BENEFITS OF TECHNOLOGY: CONQUERING DISEASES

Introduction:

Through technological inventions and scientific discoveries, many diseases that have plagued humans since very early history are now being controlled; one disease, smallpox, has been eliminated entirely. The cost of finding effective cures or vaccines has been great.

In this lesson, students examine three major diseases from an historical perspective. They look at the scientific, technological, and social impact of each disease, as well as the role of scientists and technologists in controlling the diseases. Finally, students use the information gathered to look at a fairly new disease, AIDS, examining health concerns, economic and social concerns, and prevention.

Objectives: Students will be able to:

1. Explain how diseases are transmitted and how changes in transportation technology have affected the spread of disease.

2. Describe the social impact of diseases on the world.

3. Explain why development of cures and vaccines is very costly.

4. Determine the social, scientific, and technological impact of a particular disease.

5. Determine who should be responsible for the cost of research and treatment involved with a disease.

6. Value the role of technology in helping scientists conquer diseases.

Subject/Grade Level: Biology/grade 10; chemistry/grade 11; world history/grade 10; current events/ grades 10-12

Time Required: 2-3 class periods

Materials and Preparation: Make copies of Handouts 24-1, 24-4, and 24-5 for all students. Make enough copies of Handouts 24-2, 24-3, and 24-4 for one-third of the class. Prior to doing this lesson with your students, it would be wise to read through each case study (Handouts 24-2, 24-3, 24-4, and 24-5) and anticipate the questions it might elicit from students. In addition, you may wish to preplan how you will group students for the exercise.

Procedures:

1. Explain to students that they will be working in groups to analyze a specific disease. Distribute Handout 24-1 and go over the questions students will answer in their groups.

2. Divide the class into three groups. Each group will be working with a different case study. If groups seem too large and unmanageable, divide the class into six groups. Each of the three case studies will then be studied by two groups. Distribute one case study to each group (or two groups).

3. Groups may want to select one person to be responsible for reading the case study to the entire group, or the groups may want to allow time prior to the discussion for each student in the group to read the case study. However this is done, each group should have one person responsible for leading the discussion on each worksheet question. Before answers are written, groups should reach concensus on their answer. Each student should complete his/her own worksheet.

4. Next, each group should select one person to give an overview of the disease that was discussed. This will help other groups learn more about the two diseases not assigned to them. The group reporter may want to use these questions to organize the presentation:

- What disease did the case study explore?
- How serious was/is the disease?
- Who was affected by the disease?
- How was/is the disease being controlled?
- How long did it take from the time the disease was identified until the disease was controlled?
- What are some important points about this disease?

5. Following the presentations, summarize this part of the activity with a discussion of the following questions:

- What are some ways in which science and technology have helped identify and control such diseases as smallpox, influenza, and poliomyelitis? (Make a class list on the chalkboard.)
- What are some of the ways in which science and technology have increased the risk of catching a serious disease? (Make a class list on the chalkboard.)
- What impact has each of these three diseases had on society?

  Smallpox Influenza Poliomyelitis

- Why do you think treatment of diseases in America moved from a reliance on "Providence" to a reliance on advanced technology?
- Why did it take so long to find a cure for smallpox and vaccines for influenza and poliomyelitis?
- Besides cures or vaccines for diseases, what are some of the benefits to society that medical research has provided? (Make a class list on the chalkboard.)
- What are some of the risks and controversies involved with medical research?

Save the information that has been listed on the chalkboard. It will be helpful during the second part of this activity.

6. At the beginning of the next class period, review briefly the three diseases that were the focus of the first part of this lesson. Particularly go over the impact of each disease on science, technology, and society.

7. Next have students return to their small groups. Give each student a copy of the AIDS case study and discuss it. Handout 24-6 can be used to help stimulate discussion of this case study.

8. After students have discussed the AIDS case study and completed the worksheet, call the class together and conclude the activity with a discussion of the following questions:

- How is the AIDS epidemic similar to the smallpox, influenza, and poliomyelitis epidemics? (Make a list of similarities on the chalkboard.)
- Is the AIDS epidemic different from the poliomyelitis, smallpox, and influenza epidemics? Explain your answer.
- What controversies surround the AIDS epidemic?
- It took many years to develop a cure for smallpox and find vaccines for polio and influenza. Is it reasonable to think we should wait about the same length of time to find a cure or vaccine for AIDS? Why or why not?

- The progress in medicine comes from much scientific and technological research. This research is very costly. Who should pay for medical research?
- Treating persons who have AIDS is also very expensive. Who should pay for this treatment?
- If persons cannot afford to pay for treatment for AIDS or any other disease, who should decide who will receive treatment and who will not?

Evaluation:

Participation in the group and class discussion is an important evaluation tool for this lesson. Students' abilities to determine the impact of the diseases and to use the data to make and support decisions about financial questions are keys.

Extension/Enrichment:

Students may want to do further research about a variety of diseases. In particular, students might look at how diseases have shaped the history of the world and the United States.

You might want to invite doctors, researchers, or other medical personnel to address questions related to research on AIDS and the social, economic, and personal consequences surrounding AIDS.

GROUP WORKSHEET: CONQUERING DISEASES

Which disease is your group discussing? ____________________

As your group discusses the disease it was assigned, complete your own worksheet. Do not write an answer to any question until your group has reached agreement.

1. How did science and technology help identify this disease?

2. In what way did science and technology contribute to the promotion or spread of this disease?

3. Why were doctors cautious about collecting evidence about this disease before trying to find a way to treat the disease?

4. How do you think methods of investigation to find a cure for a disease have changed in the past 100 years? in the past 20 years?

5. How long did it take to find a cure for this disease?

6. Did this disease affect only the poor? Why or why not?

7. Did your group's case study indicate that treatment was provided for all regardless of whether they could afford treatment or not?

8. Who do you think paid for the research to find the cure or vaccine for your disease?

SMALLPOX CASE STUDY

In mid-October 1976, a team of doctors and health workers spent 24 hours guarding four homes in the African capital of Mogadishu, Somalia. Inside the homes were the last representatives of an army that had killed more people than all the wars in history. The enemy was very tiny—only 250 millimicrons across—and numbered in the billions. When these last microscopic warriors died, smallpox was eliminated from the face of the earth.

This was a feat of monumental proportion. No other disease, not even the bubonic plague, had such an impact on the course of human events. For example, history records that one of China's greatest emperors was chosen because he alone among his siblings had already had smallpox. Smallpox is also credited with assisting the introduction of Buddhism to Japan. Even scars on the mummified head of Ramses the Fifth of Egypt indicate that this powerful ruler died of smallpox over 3,000 year ago.

Early in the Christian era, smallpox was introduced to the Western world, brought home by the Crusaders who had traveled throughout Asia Minor. Because of increased exploration and ventures into new countries and lands, from the Middle Ages onward, one death in every ten is said to have been caused by the smallpox virus. Thus, in 1520, this virus was the most potent weapon the Spanish conquistadors carried with them to the New World.

Smallpox was responsible in part for the colonizing of Massachusetts. In 1620, Miles Standish, commenting on the effect of smallpox in killing off hostile Indian tribes, wrote that "neither malaria, nor yellow fever, nor the plague, but smallpox was the blessing in disguise that gave our emigrant ancestors an opportunity to found the state." It was not long, however, before this new disease turned on the settlers. For more than two centuries, smallpox was responsible for more deaths than any other cause.

It was not until the end of the 1800s that Edward Jenner discovered the principle of vaccination with cowpox—a mild form of smallpox. This came after many years of unsuccessful attempts to isolate the virus and to vaccinate with the virus from other smallpox victims.

The disease, much like other viral diseases, had its classic symptoms. About 10 to 12 days after the virus entered a human body, the infected person became sick with a high fever and aching sensations much like influenza. After two to four days, a rash developed on the face. The rash then spread to the rest of the body within one or two days. Small, red, pimplelike bumps filled with clear serum appeared. By the fifth day, this fluid became pus. By the 10th day, scabs began to form. Although these scabs fell off in about three weeks, a disfiguring scar was often left. Some victims were left blind. Many more died.

The smallpox virus had one quality that made eradication possible. The virus must have a human to infect. Other major diseases (e.g., polio, diptheria, cholera, tetanus, malaria, rabies, bubonic plague, and hepatitis, as well as thousands of other contagious illnesses) can survive in animals, birds, insects, or the environment, waiting to strike humans when the time is right.

Source: Adapted from "Putting an End to Smallpox," by Richard Knox, *Boston Globe* (October 6, 1976), pp. A-1, A-4. Used by permission of the publisher.

POLIOMYELITIS CASE STUDY

Poliomyelitis (polio) was first described in 1789 by Michael Underwood in a book on childhood diseases. By the late 1800s, polio epidemics began hitting the United States and Sweden. In 1916, there were 30,000 cases in the United States; thousands died.

By the 1930s, researchers had learned that polio is caused by a virus and had succeeded in transmitting the disease to monkeys. Through their work, scientists were hoping to show that infection came about when the polio virus entered the body through the nose. Ultimately, however, it was found that the polio virus most commonly is spread via direct contact or from food or water contaminated from human feces, and enters the body through the mouth and throat.

Two attempts were made in the 1930s to develop a polio vaccine patterned on Pasteur's method for making rabies vaccine 50 years earlier. But in 1935, in trials with both killed and live virus versions, the vaccines were found to be unsafe. Meanwhile, by the late 1930s, polio had killed tens of thousands of children and young adults and crippled hundred of thousands more. Moreover, polio epidemics were becoming more severe and more widespread.

To make a polio vaccine, scientists first had to identify the virus that caused the disease. Then they had to find a way of growing the virus outside the body—a difficult task, since viruses will grow only on selected types of living tissue that are suitable for producing vaccines.

In 1949, Dr. John Enders succeeded in growing polio viruses in monkey kidney cells grown in test tubes. After lengthy research using this new tool, investigators found that there were three strains of polio viruses.

Ender's basic research was one of the key elements that made it possible for Drs. Jonas Salk and Albert Sabin to develop safe vaccines that could be mass-produced and administered to large populations. Mass inoculation of U.S. children with Salk's killed virus vaccine began in the 1950s. A live virus vaccine developed by Sabin was proven safe and effective in clinical trials, the largest of which were in the Soviet Union. Before long, the Sabin vaccine came to be used almost exclusively in the United States. By 1965, the number of polio cases in the United States, Canada, Australia, and New Zealand had fallen to 1,000 annually, a drop of 99 percent in 12 years.

Today, even with the vast resources of modern medical technology, once children contract paralytic polio, doctors can do little more for them than provide respiratory support. Thus, it is critical that all children and adults be vaccinated against this dread disease.

Source: Adapted from "The Centuries-Old Struggle Against Infectious Diseases," by Egon Weck, *FDA Consumer* (April 1986), pp. 18-23.

INFLUENZA CASE STUDY

Influenza (flu) is a highly infectious disease. It is easily spread by person-to-person contact. Quarantines provide little protection against the disease. The virus that causes influenza appears in three types—A, B, and C—and several sub-types. The flu virus is subject to frequent mutations. This is why it has not been possible to develop a flu vaccine that is as effective as the polio vaccines.

An influenza pandemic (an epidemic that occurs over a wide geographic area and affects a very high proportion of the population) in 1918 and 1919 spread so widely that only a few islands of the world escaped. In some communities, whole populations came down with the flu at the same time, and up to half the people died. According to medical historians, 30 influenza pandemics have occurred since 1510.

The 1918-1919 flu pandemic first appeared in April 1918 in Western France, where American troops were getting off war ships. The virus had reached England by the second week in June. By August the flu had reached Boston. In one month it spread north across the North American continent. But in Australia, where a stringent quarantine was enforced, it did not reach epidemic proportions until February 1919. Some suggest that it even spread to animals, including baboons in South Africa and hogs in the United States.

In 1940, Sir Frank Macfarlane Burnett succeeded in growing the flu virus in the chick embryos of fertilized eggs. Flu vaccines continue to be made from viruses grown this way. The viruses are harvested from the egg fluid and then inactivated. The first line of defense against influenza continues to be the vaccine, which is estimated to be 70 to 90 percent effective. By careful investigation and watch, public health authorities can catch mutations of known viral strains. Then vaccines can be produced to protect persons at high risk during flu epidemics.

An example of this was seen in the United States in 1957. On April 17 of that year, an article in the *New York Times* reported that thousands of children in Hong Kong were being treated for high fevers and influenza symptoms. American doctors suspected that this was an outbreak of a new variety of flu.

Researchers contacted Army authorities in Hong Kong and asked them to send swabbings from the throats of flu victims. Within a month after the report was spotted in the newspaper, the virus specimens arrived; in five days, a new flu virus, A2, had been isolated.

Pharmaceutical manufacturers worked quickly to produce a vaccine that would protect against the A2 flu virus in time for the start of the autumn flu season in the United States. Although in 1957 alone, nearly 19,000 Americans died from the A2 (or Asian flu), the vaccine greatly reduced the severity of the pandemic and prevented a major health catastrophe.

Today, the drug amantadine is also useful in preventing flu. No vaccines have yet totally eliminated this disease. Antibiotics can be given to treat bacterial infections that often accompany the flu during epidemics. When left untreated, however, such infections contribute substantially to the mortality of flu victims.

Source: Adapted from "The Centuries-Old Struggle Against Infectious Diseases," by Egon Weck, *FDA Consumer* (April 1986), pp. 18-23.

AIDS CASE STUDY

The Acquired Immune Deficiency Syndrome, or AIDS, was first reported in the United States in mid-1981. Since that time, the Public Health Service has received reports of more than 15,000 cases, about 52 percent of which have resulted in death. An estimated 500,000 to 1 million people have been infected by the virus that causes AIDS but have no symptoms of the illness.

AIDS is characterized by a defect in natural immunity against disease. People who have AIDS are vulnerable to serious illnesses, which would not be a threat to anyone whose immune system was functioning normally. These illnesses are referred to as "opportunistic" infections or diseases.

Researchers have discovered the virus that causes AIDS. Different groups of researchers have given different names to the virus, but all appear to be the same virus. The virus is called human T-lymphotropic virus, type III (HTLV-III). Infection with this virus does not always lead to AIDS. Preliminary results of studies show that most infected persons remain in good health; others may develop illnesses varying in severity from mild to extremely serious.

AIDS is spread by sexual contact, needle sharing, or, less commonly, through transfused blood. The risk of infection with the virus is increased by having multiple sexual partners, either homosexual or heterosexual, and sharing needles among those using illicit drugs. The occurrence of the syndrome in hemophilia patients and persons receiving transfusions provides evidence for transmission through blood. Screening tests have now virtually eliminated the risk of exposure due to blood transfusion. AIDS may be transmitted from infected mother to infant.

Most individuals infected with the AIDS virus have no symptoms and feel well. Some develop such symptoms as tiredness, fever, loss of appetite and weight, diarrhea, night sweats, and swollen glands (lymph notes) – usually in the neck, armpits, or groin. Since there are no clearcut symptoms, however, the diagnosis of AIDS depends on the presence of opportunistic diseases, such as Pneumoncystis carinii pneumonia (PCP), a parasitic infection of the lungs, and a type of cancer known as Kaposi's sarcoma (KS). KS usually occurs anywhere on the surface of the skin or in the mouth. In early stages, KS may look like a blue-violet bruise or brownish spot. The spot or spots persist and may grow larger. KS may spread to, or appear in, other organs of the body. PCP has symptoms similar to any other form of severe pneumonia, especially cough, fever, and difficulty breathing.

Although there is no single test for diagnosing AIDS, there is now a test for antibodies (substances produced in the blood to fight disease organisms) to the virus that causes AIDS. The presence of HTLV-III antibodies means that a person has been infected with that virus. It does not tell whether the person is still infected.

AIDS is difficult to catch, even among people at highest risk for the disease. The risk of transmitting AIDS from daily contact at work, school, or at home is very slight. In virtually all cases, direct sexual contact or the sharing of IV (intravenous) drug needles has led to the disease.

Researchers and scientists are working diligently to find a cure for AIDS. Currently, there is no vaccine for AIDS. There is good evidence to show that individuals can reduce their risk of contracting AIDS through education about the illness. The Public Health Service also recommends the following steps to help prevent the spread of AIDS.

Source: Reprinted by permission from *The AIDS Crisis: Conflicting Social Values*, a book from the *Ideas In Conflict* series, by Gary E. McCuen (Hudson, WI: GEM Publications, 1986). For more information, contact GEM Publications, 502 Second Street, Hudson, WI 54016.

- Do not have sexual intercourse with AIDS patients, with members of high risk groups, or with people who have tested positive for the AIDS virus.
- Do not use IV drugs. If you do, do not share needles.
- Do not have sex with people who use IV drugs.
- Women who are sex partners of risk group members or who use IV drugs should consider the risk to their babies before pregnancy.
- Do not have sex with multiple partners, including prostitutes (who may also be IV drug abusers). The more partners you have, the greater your chances of catching AIDS.
- People at risk for AIDS should not donate blood, organs, or sperm.
- The use of condoms is highly recommended for all individuals if the risk for AIDS is unknown.

Less than three years elapsed between the time AIDS was first recognized as a probably viral disease until highly sensitive tests for the AIDS antibody were developed. During this three-year period, researchers also identified the modes of transmission and developed a heat treatment that has been somewhat effective in destroying the AIDS virus. This heat treatment will be helpful for screening blood donors and will reduce the risk for hemophilia patients.

A vaccine to control the AIDS epidemic appears to be many years away. Thus, the continued spread of AIDS will place greater strains on the health care systems, particularly in areas of the country where the AIDS virus is most prevalent. In San Francisco, for example, it is estimated that the total lifetime cost of inpatient hospital treatment is $25,000 to $32,000 per patient. The Center for Disease Control has estimated that nationally the cost per patient could be as high as $143,000, or $1.25 billion annually just for inpatient care.

As many as one-third of all AIDS patients are covered by Medicaid, which indicates that they have lost their health insurance due to their loss of employment related to illness or that they were underinsured. The problem of paying for health care for AIDS patients is a serious one. A key question in this dilemma—for AIDs patients, as well as for all Americans—is: What is the federal government's role in health care financing?

AIDS WORKSHEET

After your group has read and discussed the AIDS case study, complete this worksheet.

1. How is the AIDS epidemic similar to the smallpox, influenza, and poliomyelitis epidemics?

2. How is the AIDS epidemic different from the smallpox, influenza, and poliomyelitis epidemics?

3. What impact has the AIDS epidemic had on each of the following?
   - Science
   - Technology
   - Society

4. What should we do as individuals to protect ourselves against the AIDS virus?

5. What can we do as individuals to help persons who have the AIDS virus?

25. GENETIC SCREENING

Introduction:

Progress in medical genetics has increased our specific knowledge about genetic disorders. New screening tests help geneticists identify at-risk individuals. Depending on the nature of a disorder and its impact on the individual, genetic screening may take place at or shortly after birth, during childhood, or during adulthood. Presently, most large-scale screening programs involve disorders—such as sickle cell anemia and Tay-Sachs disease—that are transmitted from one generation to another as recessive traits. In such cases, two abnormal genes must be present to cause the disorder. A variety of biochemical tests can detect a carrier of a recessive trait. Individuals identified as carriers can be counseled to make better decisions about their reproductive options.

In this lesson, students are introduced to the idea of genetic screening and learn how it is different from other kinds of medical screening. They then apply a decision-making model to two case studies involving genetic screening.

Objectives: Students will be able to:

1. Define genetic screening.

2. Describe how genetic screening differs from screening for other health problems.

3. List some problems that can arise from genetic screening.

4. Apply a decision-making model to a case study involving genetic screening.

5. Value the contributions of scientists in making genetic screening available to carriers of disorders transmitted from one generation to another.

Subject/Grade Level: General science/grade 9; biology/grade 10; current events/grades 9-12

Time Required: 1-2 class periods

Materials and Preparation: Make copies of Handout 25-1 for all students; make enough copies of Handouts 25-2 and 25-3 for the groups to which you intend to assign each case study.

Procedure:

1. Use the **Teacher Background Information** to introduce the concept of genetic screening. Ask the following questions to determine whether students understand the major points:

- What is genetic screening?
- Why is genetic screening important?
- How is genetic screening different from other kinds of medical screening?
- What problems could arise from genetic screening?

2. Tell students that people who have had genetic screening and found that they are carriers of genetically transmitted diseases face important decisions. Pass out copies of Handout 25-1. Go over the steps in the decision-making model.

Source: Adapted from *Biomedical Technology* (Dubuque, IA: Kendall/Hunt, 1984). © 1984 by Biological Sciences Curriculum Study. Reprinted by permission of Kendall/Hunt Publishing Company.

3. Tell students they will have a chance to apply the decision-making model to two case studies involving genetic screening. Divide the students into groups of five or six. Depending on the time available, you may have each group do only one case study or do both. Distribute Handouts 25-2 and 25-3. Tell the groups to review the assigned case study(ies), discuss the facts of the case(s), and use the decision-making model to decide on a course of action. A reporter should be appointed within each group (if each group is doing both cases, a reporter should be appointed for each case).

4. After groups have reviewed their cases and determined a course of action, call the class together and let each group report.

5. After each group has reported, use the following questions to debrief the activity:

- How did the final decision of each group compare with individual recommendations? Did the group compromise or did one point of view dominate?
- Why is genetic screening important?
- Should genetic screening be a requirement before persons could get married or have children? Why or why not?
- How could this decision-making model be used with other life situations? What are some examples?

Evaluation:

Student achievement of the knowledge objectives for the lesson could be evaluated by having them prepare written responses to the questions under step 1 of the Procedures. Their ability to use the decision-making model could be assessed by using the two case studies in the **Extension/Enrichment** section as evaluation tools.

Extension/Enrichment:

1. This activity can be extended by introducing the issue of confidentiality. Provide each student with a copy of Handout 25-4. Have them read "What Is Confidentiality?" Then ask each student to choose one of the situations and write a paragraph answering the following questions for that situation:

- What is the issue?
- Who is involved in this issue?
- What are the risks involved with this issue?
- What are the alternatives available to the counselor?
- What are the costs and benefits of each alternative?
- What do you think the counselor should do? Explain your answer.

2. Have students do research on PKU and its treatment. Is this a technological success story?

Resources:

Alexander, George, "Machines That Sort Cells," *Popular Science* (November 1983), pp. 106-109.

Bender, David L., and Bruno Leone, eds., *Biomedical Ethics: Opposing Viewpoints* (St Paul, MN: Greenhaven Press, 1987).

CIBA Foundation, *Human Embryo Research: Yes or No?* (New York: Tavistock Publications, 1986).

Ingrasci, Rick, "The Brave New World of Bioengineering," *New Age Journal* (June 1983), pp. 41-47.

Weiss, Ann E., *Bioethics—Dilemmas in Modern Medicine* (Hillside, NJ: Enslow Publishers, Inc., 1985).

Teacher Background Information:

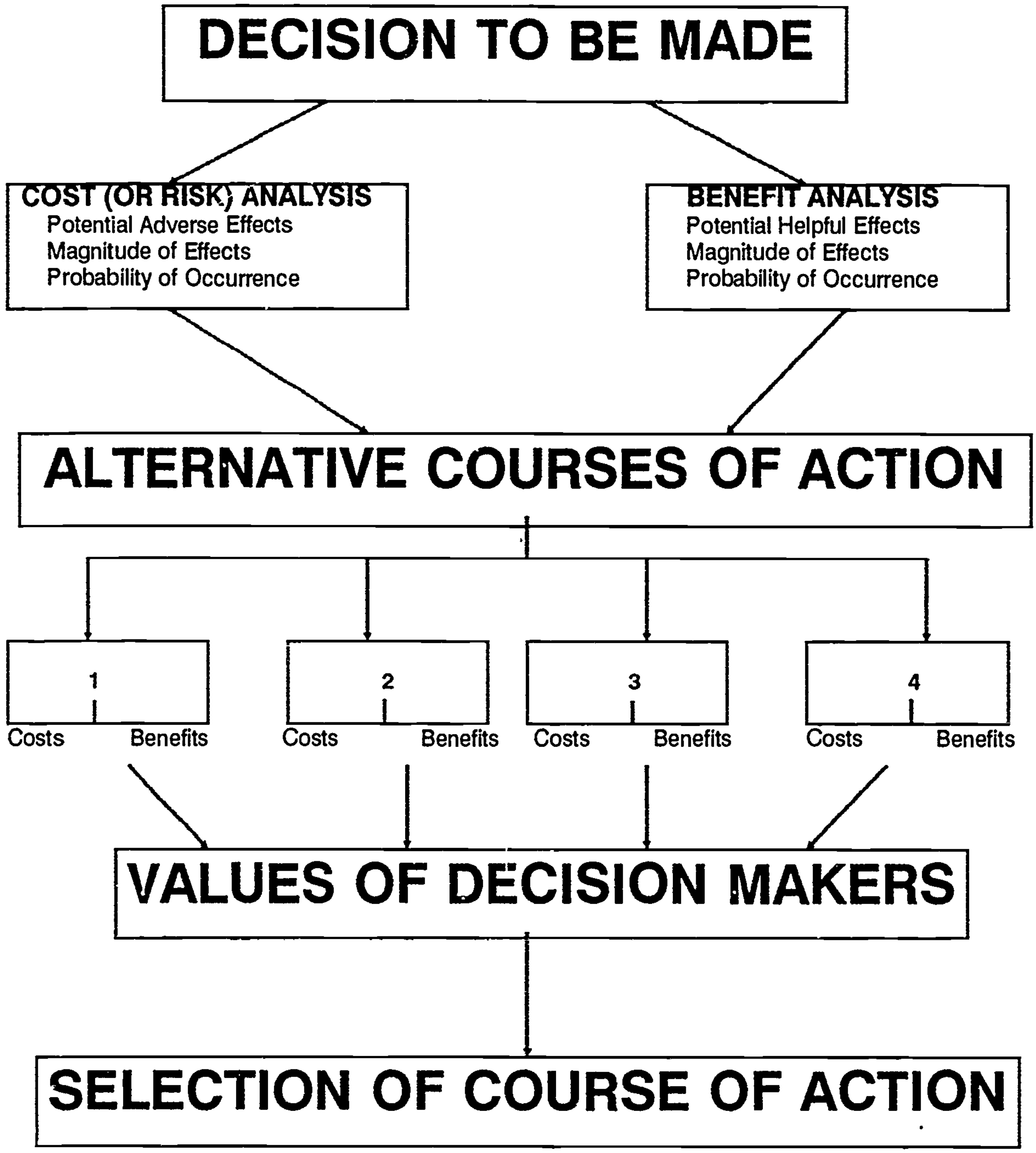
Genetic screening is the testing of people to see if they have genetic characteristics that could harm themselves or their descendants. Genetic screening may take place at or shortly after birth, during childhood, or during adulthood. Many states, for example, have laws requiring the screening of all newborns for phenylketonuria (PKU), an inherited error of metabolism that results in severe mental retardation if not treated through a strict diet. Most large screening programs involve disorders—such as sickle cell anemia and Tay-Sachs disease—that are transmitted from one generation to another as recessive traits. In such cases, two parents with the recessive trait could give a child two abnormal genes, meaning the child would have the disorder. Carrier tests are now available for more than 40 recessively inherited disorders.

Individuals can have what is called prospective counseling. Prospective counseling is done when an individual is planning to be married or a couple is planning to have a child. People who receive such counseling can make better decisions about having children. They may decide, for example, not to marry another carrier, not to have children, or to have artificial insemination by a donor who is not a carrier.

Genetic screening is different from most other types of medical screening, such as that for infectious diseases. In genetic screening, the conditions being screened for generally are rare. In addition, in nongenetic screening, the individual being screened is the individual who is be protected. In genetic screening, protection is often not for the individual being screened, but for others—prospective offspring, siblings, or other relatives. Often, decisions resulting from use of genetic screening involve two people, who may have different views on how the information should be used. Because genetic screening identifies a disorder that is part of the individual's biological make-up, the person may feel a loss of self-esteem or guilt about carrying the disorder.

Good counseling can help those individuals identified as carriers realize that their feelings of guilt or inferiority are unfounded. Some people have been unfairly labeled as a result of genetic screening programs. For example, some blacks who are carriers of the sickle cell trait—which produces no disorder—have been denied insurance and even jobs. This raises the issue of whether such information should be made available to anyone except the person being screened.

A DECISION-MAKING MODEL



CASE STUDY I

Mark Fulcher is a 23-year-old black student at a large university. The genetics unit at a local hospital conducted a sickle cell screening program on campus, and Mark was tested. The simple blood test involves the detection of sickle hemoglobin, using electrophoresis.

Hemoglobin A differs from hemoglobin S—sickle hemoglobin—by one amino acid. In HbS, valine is substituted for glutamic acid at the position of the sixth amino acid. This changes the electrical charge of the hemoglobin molecules. The change can be detected by electrophoresis. If the test shows a pattern of all HbA, the person is homozygous for normal hemoglobin and does not have the gene for HbS. If the person's blood shows HbA and HbS, the person has one gene for each hemoglobin type. Those persons are heterozygotes and have sickle cell trait. If the test shows all HbS, the person is homozygous for sickle hemoglobin—that is, he or she has two genes for sickle hemoglobin. Such persons have sickle cell anemia. Persons with sickle cell trait generally experience no ill effects.

Trait carriers can, however, pass the sickle cell gene on to their offspring. When Mark received the news that he had sickle cell trait, he made an appointment with a counselor at the genetics unit.

Mark was informed that his carrier status had important implications for decisions concerning marriage and childbirth. He was told that if he married another carrier, there was a 25-percent probability with each pregnancy that the child would have sickle cell anemia. In addition, Mark learned that his younger brother and sister also were at risk for being carriers, since at least one and perhaps both of his parents were carriers.

Mark informed the counselor that he was engaged to a young black woman and that the wedding was to take place in six months. The counselor suggested that Mark inform his fiancee of his carrier status, since she should be aware of the situation and should herself be tested. It was also important, the counselor asserted, for Mark's parents to tell his brother and sister, as well as other relatives, so that they all could be tested.

Mark steadfastly refused, saying that everyone would think he was "defective." He was afraid that his fiancee would call off the wedding and that his family would hate him for revealing that they might all be "defective."

What action should the counselor take?

CASE STUDY II

Tay-Sachs disease (TSD) is most common among Jewish people who trace their ancestry to Eastern Europe. Children born with TSD are missing an enzyme called hexosaminidase A (Hex-A). The genes that are supposed to produce the enzyme do not work properly. The affected children inherit one defective gene from each parent. The parents are unaffected, because they have one gene that is functioning normally. That gene produces enough Hex-A to prevent any ill effects.

Because they lack Hex-A completely, affected children cannot break down a certain group of fats in the body. Those fats build up in the nerve cells of the brain and prevent those cells from working properly. The disease is always fatal; children born with TSD rarely live past the age of four.

A screening test can detect a person who is a carrier. A simple test can measure the level of Hex-A in the blood. Carriers will show a level of Hex-A that is in between the "normal" and affected levels.

Craig and Roberta Robinson had never been screened for Tay-Sachs. However, their first child, Kerry, had the disorder. She died when she was 22 months. Both Craig and Roberta were devastated by the experience.

Four years have passed, and Roberta would like to have another child. The counselor has told the Robinsons that the chances are one in four that another child will also have the disorder. Craig says that the risk is too high. He cannot face the possibility of suffering through the death of another child.

What should the Robinsons do?

SCREENING AND CONFIDENTIALITY

What Is Confidentiality?

Doctors have long adhered to a code of ethics that calls for confidentiality. This means that information about patients cannot be disclosed to third parties. Many states even protect confidentiality in court, when the patient objects to the doctor's revealing the information. These laws illustrate that information shared with a doctor is subject to the patient's control.

Counselors, who deal with very sensitive information, are also expected to keep information confidential. Information from genetic screening, however, can indicate that some of the relatives of the person being screened are at risk. Thus, it is argued, confidentially cannot be as strict in the case of genetic screening information.

Situation 1:

Jimmy, a four-year-old boy, has been diagnosed with hemophilia, an inherited condition in which the blood fails to clot quickly enough, causing prolonged and uncontrolled bleeding from even the smallest cut. This disease appears in males but is carried by females. Because Jimmy's mother has been diagnosed as a carrier of hemophilia, the genetics counselor is afraid that the mother's female relatives, particularly her three sisters, are also carriers of this disorder.

During counseling, Jimmy's mother refused to let the counselor contact her three sisters. Should the counselor be permitted to override this objection?

Situation 2:

Amniocentesis is a method used to diagnose genetic diseases before a child is born. Down's syndrome is one disease that can be detected in this way. Babies born with Down's syndrome are mentally retarded and often have other physical problems. The results of amniocentesis are more than 99 percent accurate.

Betty and Brian have been married for one year. Both are looking forward to raising a family. Betty is 16 weeks pregnant and has amniocentesis done. The results indicate that her unborn child will have Down's syndrome. The doctor suggests that Brian come in so the doctor can explain the disease more fully to both Betty and Brian. Betty refuses to tell Brian or let the doctor tell Brian because she is afraid Brian would want her to terminate the pregnancy. What should the doctor do?

26. THE PINE BEETLE CONTROVERSY

Introduction:

Scientific problems often have technological solutions that are plagued with risk. Such is the case with the mountain pine beetle, which has caused hundreds of thousands of dollars in damage to the national forests. Lindane, the chemical pesticide used to treat the trees, has been proven to be toxic and carcinogenic. Nonetheless, it has been effective in helping eliminate these pests. A mechanical method of removing diseased trees from the contaminated area has also proven to be effective, but this process is almost twice as costly. The controversy over using a dangerous pesticide and the economics involved in solving the problem pose difficult choices.

In this lesson, students examine the pine beetle case study, choose options, determine costs and benefits of the various options, and decide on the one plan of action that would be best for this situation.

Objectives: Students will be able to:

1. Define the following concepts: toxic, carcinogenic, pest, and pesticide.

2. Describe the damage caused by the pine beetle and the need to rid forested areas of this pest.

3. Evaluate the situation and participate in making a decision.

4. Evaluate the decision that is made.

5. Value use of a structured approach to making a decision about a serious problem

Subject/Grade Level: General science/grade 9; biology/grade 10; environmental studies/grades 9-10; chemistry/grade 11; government/grade 12; current events/grades 9-12

Time Required: 1 class period

Materials and Preparation: Make copies of Handouts 26-1 and 26-2 for all students.

Procedures:

1. Explain that students will be using a structured approach to making a decision about an important issue in today's lesson. Ask why having a structured approach—one that takes the decision-maker through a series of steps—would be useful. Would decisions made in this way be better than those made in some other way?

2. Distribute Handout 26-1. Allow time for students to read the case study. Review the facts of the case with students, focusing on the concepts of toxicity, carcinogenic, pest, and pesticide.

3. Divide the class into groups of from four to six students. Explain that the groups will be working together to identify the issue, determine alternative courses of action, investigate the pros and cons of each alternative, and come to a group decision about the best plan of action to solve the problem. As the groups work through the process, each student should complete the decision-making worksheet (Handout 26-2).

4. After each group has determined the best plan of action, the groups should come together and report on their decisions. List the various decisions on the chalkboard.

5. Debrief the activity using the following questions:
   - What was the central issue of this case study?
   - What were some of the alternative courses of action proposed by the groups?
   - Which alternatives seemed most popular? Why?
   - What compromises were made by the groups?
   - Is this process an effective one for solving problems?
   - How could this process help you with other problems you might encounter in your life?

Evaluation:

The decision-making process provides students opportunities to explore issues, weigh alternatives, and come to a decision about a problem. As long as each alternative is reasonably examined, students may make a variety of possible, and valid, decisions. The decision-making worksheet can be used as an evaluative tool to determine if students understood the decision-making process and came to a reasonable decision.

Extension/Enrichment:

Have students apply the decision-making process to another situation. This could be either a problem they personally faced or a problem they have read about in the media.

THE BEAUTY AND THE BEETLE

The residents of Fort Collins, Colorado, are worried about the nearby mountain forests. Hiking through the cool green forest is an experience many of them enjoy. In addition, many of their homes have been built to take advantage of mountain views.

The citizens are concerned because the usually lush green of the pine trees has changed to reddish-brown. The pine trees are infested with a lethal enemy—the mountain pine beetle. The beetles mature in late July or early August and invade more trees in the area. The beetle bores a tiny hole through the tree bark and lays eggs that hatch into larvae. The larvae eat the tissue inside the tree. Destruction of this cambium tissue prevents the tree from conducting water and minerals to the growing tissue. Lumber from these trees is sometimes bluish because a blue stain fungus is carried by the larvae.

Lindane (hexachlorocyclohexane) is a chemical pesticide being used by the National Forest Service to fight the mountain pine beetle in Colorado's national forest lands. The chemical is 92 percent effective in killing the beetle, if handled properly. The cost to spray each tree in 1985 was $14.00.

The effects on humans who come into contact with the pesticide are difficulty breathing, convulsions, pulmonary edema, fatty invasion of liver, dilation of the heart, and—in small children—death. The pesticide can be absorbed through the skin and be stored in the body. The Environmental Protection Agency has proven that in the long term, Lindane is carcinogenic (causes cancer). Lindane can be toxic to fish, honey bees, and other wildlife.

The mountain pine beetle can be controlled by a nonchemical method. Since the beetles mature later in the summer, they cannot fly until then. The infected trees can be cut down, the bark peeled and then removed from the area. This method is 100 percent effective in killing the beetle. The removal, chipping, and debarking of the trees is more expensive than spraying, however. In 1985, the cost per tree was $22.26.

The forest service is facing funding cuts, which could reduce the money available for dealing with the pine beetle. The forest service is also encountering opposition from environmental groups because of the use of Lindane to treat the pine beetles. Your job is to help the forest service determine the best method for ridding the forests of the pine beetle.

DECISION-MAKING WORKSHEET

1. What is the problem or issue to be addressed? ______________________

____

2. What are the alternatives?

   Alternative 1 ______________________

   ____

   Alternative 2 ______________________

   ____

   Alternative 3 ______________________

   ____

3. What are the pros and cons of each alternative?

   Alternative 1:

   Pros ______________________

   Cons ______________________

   Alternative 2:

   Pros ______________________

   Cons ______________________

   Alternative 3:

   Pros ______________________

   Cons ______________________

4. What is the best course of action to solve this issue or problem? ______________________

____

5. Explain why you think this course of action is the best.

____

____

____

____

27. PESTICIDES: A GLOBAL PROBLEM

Introduction:

Technology has increased the level of interdependence in the world. Some technological advances have had a detrimental effect on the global environment. The use of pesticides is a good example. Many pesticides banned for use in the United States because they have been proven toxic and carcinogenic are still being manufactured and sold to other countries, particularly Third World countries. These countries use the dangerous pesticides on food crops that are then exported to other countries, including the United States. The United States depends on these countries for a large portion of its fruits and vegetables. The countries growing the crops depend on the United States and other developed nations to provide the pesticides needed to produce these food crops. Meanwhile, the pesticides and foods grown with them pose environmental and health problems both here and abroad.

This lesson introduces students to the pesticide problem. Through their examination of this issue, students learn how the nations of the world are interdependent.

Objectives: Students will be able to:

1. Identify use of pesticides as a global environmental issue.

2. Explain how this issue illustrates global interdependence.

3. Analyze arguments for and against using dangerous pesticides.

4. Recognize the value of diverse viewpoints on an issue.

Subject/Grade Level: Biology/grade 10; environmental studies/grades 9-10; chemistry/grade 11; world geography/grade 7 or 10; economics/grade 12; current events/grades 7-12

Time Required: 1 class period

Materials and Preparation: Make copies of Handouts 27-1 and 27-2 for all students.

Procedures:

1. Have students brainstorm a list of major environmental problems that are a result of technological developments. (The students may identify such problems as air and water pollution, energy shortages, population growth, depletion of natural resources, nuclear waste disposal, nuclear weapons, etc.) List the problems on the chalkboard.

2. Ask students how many of the problems are global—affect all nations. How does the fact that nations share problems illustrate interdependence?

3. Distribute copies of Handout 27-1 and have volunteers read this information aloud. Ask the students:

- What environmental problems are evident in this article?
- What technological problems are evident in this article?
- How serious do you consider this problem?
- Who is most seriously affected by this problem?
- What is the major effect of this problem on the people of the world?

4. Give each student a copy of Handout 27-2. Students should complete these worksheets before discussion is continued. The worksheet allows students to look at both sides of the pesticide issue.

5. Summarize the activity with the following questions:
   - In what way does this issue illustrate global interdependence?
   - Can you think of other ways in which nations are interdependent?
   - Who is responsible for solving global environmental problems such as the problem with pesticides?
   - How can you help solve global environmental problems?

Evaluation:

The issues to be evaluated are the students' understanding of global interdependence and of the environmental problems that often result because of technological developments. Students' contributions to the discussion will help you evaluate this understanding, as will completion of the worksheet.

Extension/Enrichment:

Students may conduct research in their local community to answer two questions: (1) what pesticides are used or sold in our community? and (2) what foods available in our community are imported from Third World or developing countries? Students may simply answer these questions or may delve further into each, looking at what ingredients are used in the pesticides sold locally, what the health and environmental effects of these pesticides are, which foods available locally were grown in countries that use banned pesticides, how grocery importers work with the Food and Drug Administration, and so on.

Resources:

Boraiko, Allen A., "The Pesticide Dilemma," *National Geographic* (February 1980).

"The Development Dilemma," *Calypso Log* (March 1986), pp. 5-8.

Environmental Issues-Prospects and Problems, Editorial Research Reports (Washington, DC: Congressional Quarterly Inc., 1982).

Feeney, Andy, "Breaking the Circle of Poison," *Environmental Action* (April 1984), pp. 16-20.

Mott, Lawrie, "Bad Apples," *Amicus Journal* (Summer 1984), pp. 34-37.

Weir, David and Mark Schapiro, *Circle of Poison* (San Francisco: Institute for Food and Development Policy, 1981).

THE PESTICIDE PROBLEM

Pesticides are chemicals that control or kill pests—insects, weeds, and diseases—that destroy crops or spread diseases to humans. Pesticides are a technology—a scientific method people have developed for achieving a practical purpose. The three categories of pesticides are described below:

1. Insecticides kills insects by affecting respiration, digestion, or the nervous system. Some insecticides are sprayed on the soil; they are then taken in by the plant through its roots. When an insect eats the plant, it is poisoned. Other insecticides are sprayed directly on the plant; insects are killed either by eating the plant or by taking in the poison through their skin.

2. Herbicides are used to kill weeds. They too can be sprayed on the soil or directly on the weeds. Some herbicides damage the weed's structure, while others make it impossible for the weed to grow or to use energy from the sun. Some herbicides are selective (i.e., they kill only certain types of plants); others are nonselective (i.e., they kill many kinds of plants) and thus can actually damage the plants they are supposed to protect.

3. Fungicides usually kill by direct contact with the organisms that cause plant diseases. They are sprayed or dusted directly onto the corps.

Because of a range of serious environmental and health effects, the Environmental Protection Agency has banned or severely restricted use of a number of pesticides in the United States. Table 1 lists five such pesticides, identifying their status in the United States and the health and environmental effects they cause. These pesticides can, however, be manufactured by U.S. firms and sold to other nations. The largest market for these pesticides is in developing nations. Dangerous pesticides are purchased in developing nations because they allow growers to increase production, particularly of unblemished produce for export.

Continued manufacture and sale of these extremely toxic pesticides pose health problems for at least four groups: (1) workers who manufacture and transport the pesticides, (2) users in Third World countries, (3) people living near where the pesticides are used in Third World countries, and (4) those who eat the food grown using pesticides.

The problems are made worse in the developing nations using the pesticides because many of the users do not read English; yet the cautions and instructions regarding use of the pesticides are printed in English. In addition, most workers do not have the protective equipment needed to use the pesticides safely. Training in safe use is rarely available.

Residues are the reason that pesticides cause health hazards for those who eat food grown using the chemicals. Residue is the amount of pesticide that is in food when it is sold to be eaten. To protect people from eating foods with dangerous levels of pesticides, many governments set tolerances. A tolerance is the level of pesticide considered safe in food. The EPA sets tolerances for foods consumed in the United States. The Food and Drug Administration tests foods to see how much pesticide residue they contain. However, the FDA is able to test only a few of the many shipments of imported food. The FDA tests do not find all of the pesticides that may be used. Consequently, many foods with residue levels above the established tolerances are believed to be eaten in the United States each year.

Source: Adapted from *Miracle Chemicals or Dirty Dozen?* (Boulder CO: Social Science Education Consortium, 1987).

Table 1

Pesticide	Level of Toxicity	Status in the U.S.	Human Health Effects	Environmental Effects
Aldrin, Dieldrin, Endrin	Extremely	Very Restricted	Cancer, brain, and nerve damage; problems with reproduction	Builds up in the environment; kills birds, fish, and animals
HCH/Lindane	Very	Banned	Cancer, problems in reproduction, liver and kidney damage, blood problems	Builds up in the environment, stays in the environment a long time, kills fish, contaminates water supplies
Paraquat	Very	Very Restricted	Lung damage	Kills fish and other small animals
Parathion	Extremely	Very Restricted	Possible cancer, problems in reproduction	Kills birds, bees, and other small animals
Pentachlorophenyl (PCP)	Extremely	Banned	Cancer, birth defects, nerve damage, liver damage, skin problems	Kills fish and other water animals, builds up in the environment

Definitions:

- "Extremely toxic" means that swallowing about a teaspoon of this pesticide will kill an average adult.
- "Very toxic" means that about two tablespoons of pesticide will kill an average adult.
- "Very restricted" means that the pesticide can only be used in certain ways. Protective clothing, gloves, respirators, and other safety measures must be used when applying these pesticides.
- "Banned" means that the pesticide cannot be used in this country.

In 1985, the Food and Agriculture Organization of the United Nations agreed to an International Code of Conduct on the Distribution and Use of Pesticides. This code presents standards to be followed in selling and using pesticides. Here are some of the code's main points:

- Governments of industrialized countries should give technical information about pesticides to governments of developing countries.
- Each pesticide should be tested to see how dangerous it is. Test results should be sent to every country using that pesticide.

- All countries should pass laws to control pesticide use.
- Industrialized countries should not export pesticides they have banned.
- Industrialized countries should help train people in the developing countries how to use pesticides correctly and how to treat cases of pesticide poisoning.
- All countries in the United Nations have been asked to follow this code, but there is no punishment for a country that does not follow it.

PESTICIDE USE WORKSHEET

1. List ways in which the use of pesticides is a problem.

   A.______________________________

   B.______________________________

   C.______________________________

   Describe how these problems illustrate global interdependence.

2. List ways in which the use of pesticides creates benefits.

   A.______________________________

   B.______________________________

   C.______________________________

   Describe how these benefits illustrate global interdependence.

3. Can global problems be solved by the actions of one country? Why or why not?

28. BIODEGRADABLE AND NONBIODEGRADABLE

Introduction:

Packaging for the things we purchase (food, clothing, household products, etc.) has added to the amount of waste with which we must deal. Each American throws away an average of four pounds of trash each day. Much of this garbage is biodegradable; it will breakdown or decompose. Paper, wood products, cloth, and food are good examples of biodegradable materials. Other materials, such as plastics, chemicals, and some metals, are not biodegradable and will never decompose.

In this activity, students look at their own "throw-away" lifestyles and determine the amount of nonbiodegradable material they throw away in a day's time. They then read an article on the hazards posed by plastic waste and suggest solutions to the problem.

Objectives: Students will be able to:

1. Explain that technology has helped create a great deai of waste.
2. Define biodegradable and nonbiodegradable.
3. Identify biodegradable and nonbiodegradable materials used during a day.
4. Suggest solutions to problems caused by nonbiodegradable (particularly plastic) waste.
5. Take responsibility for part of the waste problem.

Subject/Grade Level: Life science/grade 7; earth science/grade 8; general science/grade 9; physical science/grades 8-9; environmental studies/grades 9-10; biology/grade 10; ecology/grade 10; current events/grades 7-12

Time Required: 1 1/4 class periods

Materials and Preparation: Make copies of Handout 28-1 for all students.

Procedures:

1. Review with the students the difference between biodegradable and nonbiodegradable materials. Let the students brainstorm materials that fit into the two categories.

2. Ask students to keep two lists of materials they throw away from the time the students leave class until they return to class the next day. One list should include biodegradable materials; the other should include nonbiodegradable materials. Tell students their lists will be discussed during the next class period.

3. Write "biodegradable" and "nonbiodegradable" on the chalkboard as headings for a class list.

4. Ask volunteers to share their lists with the class while you list the various items on the board. Let students determine if each item is biodegradable or nonbiodegradable. Many of the items will be the same for all students, so write each item only once.

5. After a lengthy list has been developed, discuss with the class the following questions:
   - How could this list of nonbiodegradable materials be reduced?
   - What can you do personally to reduce nonbiodegradable waste?
   - How harmful do you think these nonbiodegradable materials are?

6. Give each student a copy of Handout 28-1. Let students read this article or have volunteers read it to the class.

7. After reading the article, discuss the impact of the article with the class, using the following questions:

- In what ways has technology created an environmental problem?
- Who should be responsible for the harm that is done to animals who eat plastic?
- How can this problem be monitored?
- What should be done about this problem?

Evaluation:

Students can be asked to turn in the lists they prepared as homework. From these, you will be able to determine whether students understand the concepts of biodegradable and nonbiodegradable.

Extension/Enrichment:

Have students do research on the plastics issue or on the amount of waste produced in America. Then ask students to write short papers on their topics. Students should describe the scope of the problem, what should be done about the problem, and what they can do personally to help solve the problem.

Resources:

Powell, Jerry, "Plastic Beverage Cans: What's Ahead?" *Resource Recycling* (November/December 1985).

Thompson, Kevin, "New Plastic Coke Can Sparks Controversy," *Journal of Commerce* (February 12, 1986).

Tracy, Eleanor Johnson, "Plastics That Won't Clutter the Countryside," *Fortune* (September 1, 1986).

CAUGHT IN A PLASTIC TRAP

By Michael Bowker

Even from a distance, it was obvious that something was wrong with the seal. The animal was sunning itself on a buoy near San Diego, just like dozens of other seals. But its neck was oddly pinched, as if it were wearing a too-tight necklace.

Our boat motored closer until we could see the cause, a band of plastic around the animal's neck. The seal had slipped its head into some cargo strapping that had been carelessly tossed into the water. Now, the seal was growing—and the plastic was holding tight. The animal's eventual fate would be a slow, constricting death.

The grim news is that the unfortunate seal is not alone. By some estimates, nylon fishing gear, plastic bags, and other forms of nonbiodegradable plastic waste in the oceans are killing up to a million seabirds, 100,000 sea mammals, and countless fish each year—and horror stories pour in from all around the world. A South African scientist recently pulled enough plastic from the gut of a starving leatherback turtle to make a ball several feet in diameter. Each day, California fishermen find dozens of pelicans that have become entangled in fishing nets. And one study showed that nearly one-third of the fish in the Atlantic Ocean have plastic pellets in their stomachs.

Many experts believe that plastic may be a worse scourge of the oceans than spilled oil. And although unusual climate patterns such as El Nino (an infrequent shift of ocean currents and wind in the Pacific) can kill tens of millions of seabirds, says Warren King of the International Council for Bird Preservation, "Plastic pollution is a force to be reckoned with on a par with El Nino because it is killing animals every year."

No one really knows how much plastic is fouling the oceans. But a recent report by the U.S. National Academy of Sciences estimated that up to 350 million pounds of packaging and fishing gear alone may be lost or dumped by commercial fishermen and sailors each year. Millions of pounds more may come from individuals, private boats, and the waste streams of factories. The problem is steadily increasing, experts say, because of the growing use of plastic.

The threat to marine life has begun to stir people into action. In November of 1984, more than 150 scientists gathered in Honolulu for the first international symposium on the problem of plastic pollution. And some U.S. states have taken steps to reduce the amount of plastic in their coastal waters.

Plastic in the sea can trap fish, mammals, turtles, and birds in knotted tangles, causing death by drowning, strangulation, or starvation. Or it can be eaten, leading to a whole host of ailments—and, often, starvation.

In accidental entanglement, scientists say, the major culprits are synthetic monofilament fishing nets. The nets are cheaper and more durable than traditional nets of flax, hemp, and cotton, but their thin strands are difficult for sea creatures to detect and avoid.

Monofilament lines are most insidious when they break off from fishermen's nets, forming "ghost nets" that may drift for years. "Unlike working nets, which fish for specified periods of time, these free-floating nets fish indefinitely," reports Cornell University biologist Duff Wehle.

"Ghost nets are not only a tremendous threat to fish," adds University of Alaska ornithologist Robert Day. "Hundreds of thousands of birds drown every year after they dive for the trapped fish and become trapped themselves."

Other forms of plastic can also snare unwary sea creatures. The natural curiosity of seals prompts the animals to nose into potentially fatal cargo strapping bands. And in their search for fish, such seabirds as pelicans accidentally dive into the yokes that hold six-packs together. The plastic rings can clamp their beaks shut.

Since 1962, when plastic was found in the stomachs of albatrosses nesting in Hawaii, scientists have discovered that many sea creatures eat plastic debris. The list now includes four species of turtles, animals at almost every level of the Galapagos food chain, mammals such as dolphins, and 42 species of seabirds.

In most cases, scientists believe, animals mistake plastic for food. Sea turtles cannot tell the difference between plastic bags and jellyfish, which are part of their normal diet. Robert Day has discovered that plastic beads eaten by parakeet auklets in Alaska resemble small crustaceans, a favorite food item.

Eating plastic is decidedly unhealthy. Toxins such as PCBs in some debris cause a number of maladies, including eggshell thinning in birds. Sharp edges on utensils tossed overboard by ships' crews lacerate animals' stomachs. But most often, the plastic, which is indigestible and not easily excreted, simply accumulates in the gut. Unable to put enough food into its stomach to survive, a fish, bird, or turtle dies of starvation.

Solutions to the problem of plastic pollution are hardly mysterious. Scientists recommend passing new laws to prevent sailors from dumping plastic waste overboard. They also urge that plastic be recycled instead of discarded, and that filters be place on the outflows from plastics manufacturing plants. But people's behavior is difficult to control—and the plastics industry has traditionally resisted large-scale recycling and other pollution-preventing measures. "We consider it a 'people problem'," explains Ron Bruner of the Society of the Plastics Industry. "The problems aren't caused so much by the material itself, but by how it is misused."

Many experts, however, believe that the plastics industry should be trying harder to find solutions—and some lawmakers in the United States apparently agree. The legislatures of both Oregon and Alaska recently put pressure on the industry by passing laws requiring that all six-pack yokes biodegrade within 120 days.

Meanwhile, other people are trying to remove plastic waste from the world's coastlines. An annual beach clean-up organized by Judie Neilson of the Oregon Fish and Wildlife Department, for example, netted more than 25 tons of plastic debris in Oregon alone last year.

Ultimately, scientists and environmentalists hope, educational efforts will help reduce the problem. "Most people are not aware of the devastating effects of plastic pollution." explains Neilson. "When they are educated, they will begin putting pressure on those who are causing the problem."

29. LETTERS TO THE CITY COUNCIL

Introduction:

If all the garbage in the United States was collected and put into garbage trucks that were parked bumper to bumper, the line of garbage trucks would stretch from California to Florida. This analogy suggests that the United States has a garbage problem. In some states, the problem is a monumental one. Most of the states in the Northeastern United States have run out of land on which garbage can be disposed. These states are turning to such alternatives as incineration and mandatory recycling programs.

In this lesson, students read about a hypothetical community that must decide what to do about its garbage problem. Students review information provided by various sources, work in a group to discuss the alternatives, and write individual reports to the city council regarding the decision to be made.

Objectives: Students will be able to:

1. Explain why the United States has a garbage problem and where that problem is most severe.
2. Describe risks involved with the various disposal technologies.
3. Analyze a case study and propose a solution to the problem presented in the case study.
4. Value the ability of each individual to help solve the garbage problem.
5. Value the process by which consensus is reached.

Subject/Grade Level: Any secondary science course; civics/grade 9; government/grade 12

Time Required: 1-2 class periods

Materials and Preparation: Make copies of Handout 29-1 for all students. Make a set of Consultant Cards for each group of five students.

Procedures:

1. Introduce the garbage problem using the analogy provided in the **Introduction.**

2. Distribute copies of Handout 29-1. Have students read this information individually. Review the information provided with the class.

3. Go over the steps involved in making a decision. List these on the chalkboard:
   - Identify the issue.
   - Determine alternative solutions for the issue.
   - Weigh the costs and benefits of each alternative solution.
   - Determine the most appropriate solution for the issue.

   Discuss each step with the students.

4. Divide the class into groups of five students. Give each group a set of Consultant Cards. Have students read and discuss the cards in their groups. They should then begin the decision-making process. Each group should appoint one person to take notes as the decision-making process is implemented. This person will report back to the entire class. Allow groups time to determine a proposed plan of action for this situation.

5. When all groups have completed their decision-making process, ask each group to report back to the class. The group reporters should report the following:

- What was the issue identified?
- What were the alternatives?
- What were the costs and benefits of each alternative?
- What was the final solution adopted by the group?
- Why was this alternative adopted?

6. After each group has reported, ask the entire class the following questions:

- What is the value of using this type of decision-making process to help solve a problem?
- What could individuals do to help solve a local garbage problem?
- Who should be responsible for deciding what kind of garbage disposal facility a community uses?
- How important should individual opinions be in a community decision?
- How can individuals become more involved in local, state, and national decision-making?

7. Conclude the lesson by asking each student to prepare a written report, addressed to the Greenville City Council, that will help the city council make its decision about the kind of garbage disposal facility to build.

Evaluation:

Key to this activity is the students' understanding of the decision-making process. You will need to circulate around the groups, listening to the discussion to determine if all students are participating in the process. The written report prepared by each student should give evidence of the process that was conducted by each group, as well as students' understanding of the garbage issue.

Extension/Enrichment:

1. Have students visit a city council or county commissioners meeting to learn more about how local decisions are made. Or invite the mayor, city manager, council member, or commissioner to address the class, discussing the individual's input into the decision-making process of a community.

2. Identify local issues through the newspaper or electronic media. Have students research these issues, discuss the alternatives that could be suggested, and come up with a proposed solution. Encourage students to write letters to the local newspaper expressing opinions about the issue studied.

Resources:

"Buried in Garbage," *Washington Times* (January 27, 1986), pp. 6-17.

Diamond, Stuart, "Garbage - Our Wasted Resource," *Newsday's Magazine* (May 6, 1979), pp. 18 +.

Hornig, Roberta, and James Welsh, "Garbage Piles Up, And Up, And Up," *The Washington Star* (1970).

Johnson, David P., "Trash Tells a Tale," *The National Observer* (December 20, 1975), pp. 1-14.

Marcus, Steven J., "The Cost of Waste," *New England/Boston Sunday Globe* (May 23, 1976), pp. 11-12+.

Shavitz, Burt, "Fighting to Save the Earth From Man," *Time* (1970).

Solid Waste Management - Recycling and the Consumer (Washington, DC: U.S. Environmental Protection Agency, 1974).

Stein, Jane, "Plans Are Piling Up to Handle Bottle and Can Problem," *Smithsonian Magazine* (May 1974).

GREENVILLE'S GARBAGE

Greenville, a city of 63,000 people, is faced with a technology dilemma. Because of the amount of garbage produced in the city, the landfill will be full within two years. After extensive research, city officials have determined that two solutions to the problem must be considered. Either the city will build another landfill next to the current landfill, or it will build an incinerator where the city's garbage can be burned.

These two options have been carefully considered by the city council. Experts have presented information for the city council to consider. Input from residents of Greenville will also be important for the city council to consider prior to making its decision. After all the citizen input has been considered, the city council will make its decision.

You are a member of a citizen's group that will send a recommendation to the council. In your group, review the information provided by the six special consultants. With your group, decide what action to recommend to the city council.

CONSULTANT CARDS

Carol Johnson, Hydrologist

As a hydrologist, I evaluate the levels of pollutants found in our groundwater. Since Greenville relies on groundwater for its drinking water, our water supply must remain uncontaminated. If a new landfill is built at the proposed site, there is a 35 percent chance that contamination will occur. Although the Environmental Protection Agency requires that all new landfills be lined with special plastic materials and that regular testing be done for leaching of hazardous chemicals into the soil and eventually the groundwater, strong evidence shows that even the best-built landfill will eventually leak, contaminating the soil and water. Testing to determine if leaking is occurring is very expensive. However, cleaning up contamination can cost as much as $50 million.

Jake Summers, Sanitation Engineer

The current landfill will be completely filled in less than two years. The proposed landfill can be built at a cost of $78,000. It will cover 10.3 acres of land. At the rate at which Greenville's garbage production is increasing, this facility should last the city about 20 years. Because of its increased capacity, the city should consider hiring an additional 25 workers to pick up, haul, and manage the solid waste at the landfill site. Every regulation will be followed to ensure that this new landfill will be safe and will not cause pollution.

Ed Winters, Environmental Consultant

I have very mixed concerns about both of the suggested waste disposal facilities. The landfill will be built adjacent to the existing facility, but the proposed area will also use part of the land that has been set aside as a wildlife preserve. This area has been a favorite for hikers, campers, and birdwatchers. The proposed landfill could endanger the wildlife. Unless the city is very careful about disposal of hazardous chemicals in this new landfill, air and water pollution could be a problem.

The proposed incineration facility could also present environmental problems. Unless adequate technology is used, dioxins—hazardous chemicals produced during incineration—would escape into the atmosphere and pose health threat to those living in Greenville.

Maggie Henry, Construction Engineer

The incineration facility that has been proposed for Greenville will cost approximately $12.3 million and will be able to handle 450 tons of garbage per day. If all safety specifications are followed, air pollution will be minimized. Because the ash that results from the burned garbage has been classified as a hazardous waste by the EPA, it will need to be disposed of safely. The Morrison landfill has agreed to let Greenville dispose of its ash there if properly stored in sealed barrels. This will add an additional $55,000 per year in disposal costs.

Gary Miller, City Personnel Manager

Both of the proposed facilities have economic pros and cons. I have listed those in a chart.

Landfill—

Pros: Will provide adequate garbage disposal for 20 years.
If monitored, will not cause air pollution.
Is less expensive than incineration facility.
Will employ 25 new individuals.

Cons: Has the potential to cause groundwater pollution.
Has a limited life (20 years).
Will damage part of the wildlife preserve.

Incinerator—

Pros: Can handle 450 tons of garbage per day.
Will employ 43 new workers.
Will provide some of the heat and electrical energy for the city, saving the city $35,000 per year.

Cons: Will cost an additional $55,000 per year to dispose of toxic ash.
Could be a source of air pollution, particularly dioxins, which are hazardous to health.

30. ECOLOGY AND THE GOVERNMENT

Introduction:

As part of flood control efforts, streams have been widened, deepened, and straightened. Agriculture has benefited, but conservation groups have begun to argue that in many cases the biological damage inflicted on a shrinking supply of wetlands, and on streams themselves, overwhelmingly offsets any economic benefits.

In this lesson, students are provided an excerpt about Crow Creek and the conflict that developed when this small waterway was altered. Students apply a decision-making model to this case study, looking at the various alternatives, the costs and benefits of each alternative, and what the best plan would have been.

Objectives: Students will be able to:

1. Define environment and ecological balance.

2. Describe the effects of disturbing the balance of nature.

3. Analyze a case study that illustrates disturbing the ecological balance.

4. Implement a decision-making model to determine the costs and benefits involved in the case study.

5. Recognize the need to control damage done by floods and maintain ecological balance.

Subject/Grade Level: Earth science/grade 8; general science/grade 9; biology/grade 10; environmental studies/grade 9 or 10; ecology/grade 10; government/grade 12

Materials and Preparation: Make copies of Handouts 30-1 and 30-2 for all students.

Time Required: 1 class period

Procedures:

1. Assign students to read the short case study (Handout 30-1) either as homework or at the beginning of the class.

2. Go over the reading so students understand the conflicts involved in this case study. Discuss the following issues with the students:

   - The societal conflict (whether farmers and agriculturalists should have priority over biologists).
   - The science conflicts (whether flooding should be controlled at the risk of destroying the ecological balance).
   - The technology involved.

3. Help students develop definitions for ecological balance and environment.

4. Distribute Handout 30-2. Review the steps in decision-making with the class:

   - Identify the issue.
   - Identify alternative courses of action.
   - Weigh the costs and benefits of each course of action.

- Determine the best course of action to take.

Allow sufficient time for students to complete the worksheet.

5. When students have completed their worksheets, discuss each of the steps in the decision-making model as it applies to the Crow Creek case study. Make a class list of each step. Discuss each alternative course of action suggested, as well as the costs and benefits suggested for each.

6. Let the class decide which suggested course of action would have been the best one for this situation. Students may wish to vote by a show of hands or by a written ballot.

7. Conclude the activity with the following questions:

- How does this case study show that people's efforts to increase their quality of life could adversely affect the environment?
- Why and how did humans disturb the ecological balance of Crow Creek?
- A major problem in this case was flood control. The solution was to rechannel the stream. This solution proved to be unwise. How can people solve problems such as flood control without creating an ecological imbalance?
- Are humans part of the ecological system?
- How did the decision-making model help you look at this problem more objectively?
- Could this model be applied to other important issues for which a decision must be made? Can you name some?
- Could you use this decision-making model to help you make important decisions?

Evaluation:

Since each student completes a separate worksheet, these can be reviewed to determine if all students understand the decision-making process.

Extension/Enrichment:

Have students apply this decision-making model to other issues. An important local issue would be perfect for consideration.

Resources:

Book VII Water Quality · Environmental Resource Papers, developed by Biological Science Curriculum Study (Menlo Park, CA: Addison-Wesley, 1975).

STREAM CHANNELIZATION, ECOLOGY, AND THE GOVERNMENT

by Robert Gillette

Crow Creek was a clear, lovely stream that flowed through gentle Appalachian Mountain valleys in Tennessee and south across the Alabama line. Sweet gum, dogwood, and dense stands of hickory and oak shaded its banks, rainbow trout thrived in the coolness, and wood ducks flourished in the dense forest they require. In the words of a 1965 government report, the area drained by Crow Creek was a "truly scenic wonderland" of forests, meadows, and swift brooks.

But, in 1966, the U.S. Department of Agriculture's Soil Conservation Service (SCS) approved a flood-control project that involved straightening, widening, and deepening the creek. Its cost was estimated at $979,000, of which the federal government would pay just under 90 percent. Construction was delayed until the summer of 1971, in part because the Soil Conservation Service and local sponsors spent months haggling with Tennessee and Alabama fish and game authorities over features planned to lessen environmental damage.

State and SCS biologists had much influence in the planning—perhaps more than in most stream channel projects. Indeed, the biologists won $65,000 worth of concessions, including construction of inlet pipes to allow water to continue circulating through six meandering portions of Crow Creek that were to be cut off in its straightening. The inlets were to help sustain the vegetation, fish, and wildlife along those cutoff portions. They would provide water for the original populations of animals and plants on the original stream bottom. Life in the new channel, in contrast, would have to migrate there.

The SCS also agreed to leave a canopy of trees along parts of one bank and to reduce slightly the amount of channel excavated. In addition, water deflectors were to be built at some points along the creek. These would direct the flow of water to the creek's center and create ponds, temporary habitats for fish that would migrate upstream from a large Tennessee Valley Authority reservoir. Ponds would also be still places where insects and shellfish could live and breed.

Thus, by conventional standards, the "improvement" of Crow Creek followed all the rules. Yet when biologists from the Philadelphia Academy of Natural Sciences visited the scene in January of 1972, they found Crow Creek already nearly lifeless—"an ecological disaster," they said.

Soft clay banks, stripped bare of vegetation, crumbled into the muddied stream even as they watched. A long search could find no rooted plants in the stream bed and no established populations of fish or other animals. A few aquatic creatures and some rotting insect pupae were found stuck to the wet clay banks, now deeper and wider than ever before. In some places, black flies had become the "dominant organism," but even they had evidently drifted from untouched reaches far upstream.

Ironically, all the features planned for environmental reasons seem to have failed. Inlets to the six cutoff meanders were covered with silt, or fine soil, and the water in them was stagnant. Heavy, large trees left perched on 6- to 8-foot vertical clay banks had inevitably slumped into the channel—as should have been expected. The outlook for biotic recovery of Crow Creek was pronounced "very dim."

Source: Adapted from "Stream Channelization: Conflict Between Ditchers, Conservationists," *Science*, volume 176 (May 26, 1972), pp. 890-894.

Crow Creek is only one recent example of an expanding ecological problem that began in the 1870s, when the federal government began its flood control efforts and the Army Corps of Engineers began working along the Mississippi River Valley. But it was not until the mid-1950s, shortly after Congress passed the Watershed Protection and Flood Prevention Act of 1954 (Public Law 556), that the federal government's help in altering the nation's small waterways for agricultural purposes began in earnest.

Through this program, the SCS has helped farmers in every state widen and deepen and "straighten" more than 8,000 miles of streams and rivers. During the same time, the Army Corps of Engineers has "improved on nature" along another 1,500 miles of waterway.

The underlying rationale for reaming and rebuilding these thousands of miles of stream bed, and thereby altering the drainage patterns of more than 10 million acres of land, is fundamentally economic: to protect the land from floods; to improve navigation; and to help private landowners drain tracts of marsh, swamp, and forest, so that the new land might be opened to cultivation. Incredible as it now seems, little thought was given at first to the ecological importance of marshes, of swamps, or of the rich, wet hardwood forest found in the flood plains of the southeastern United States. Planners are now much more aware that such habitats support many links in food webs that may include human beings, even when they appear to be useless areas.

Flooding was indeed the basic reason for the government's rechannelization of Crow Creek. The creek emptied eventually into the Tennessee Valley Authority's huge Guntersville Reservoir. In times of heavy rain, the reservoir would back up along the creek and flood 125 small, hardscrabble farms that lay along 24 miles of the stream's flood plain. As a remedy, local governments had prevailed upon the SCS to straighten, widen, and deepen 44.2 miles of Crow Creek.

Without question, stream rechanneling has benefited agriculture and the country as a whole. Crow Creek itself—for the time being, at least—no long floods the farms along its banks. Similar flood control has been achieved with other stream projects. The Corps and the SCS have earned the sincere gratitude of the farmers and the communities they have served.

Now, however, a number of conservation groups have begun to argue that in many cases the biological damage inflicted on a shrinking supply of wetlands, and on the streams themselves, overwhelmingly offsets any economic benefits.

DECISION-MAKING WORKSHEET

1. What is the problem or issue to be addressed? ______________________________

____

2. What are the alternatives?

   Alternative 1 ____

   ____

   Alternative 2 ____

   ____

   Alternative 3 ____

   ____

3. What are the pros and cons of each alternative?

   Alternative 1:

      Pros ____

      Cons ____

   Alternative 2:

      Pros ____

      Cons ____

   Alternative 3:

      Pros ____

      Cons ____

4. What is the best course of action to solve this issue or problem? ______________

____

5. Explain why you think this course of action is the best.

____

____

31. FOREST PRODUCTS ALL AROUND US

Introduction:

The forest industry, like every other industry based on a major natural resource, provides goods that are integral parts of our country's economy and lifestyle. In turn, the continuing supply of those integral parts depends upon the intelligent management of the forest resource.

This activity explores our dependence on forest products in the hope that students will be able to make more intelligent consumer choices. At the end of the lesson, students should be able to list ways in which their lifestyles are dependent on forest products and determine which products are critical to their lives and which could be eliminated. Finally, students discuss the seriousness of forest depletion in the United States and other parts of the world.

Objectives: Students will be able to:

1. List ways in which American lifestyles depend on forest products.

2. Identify the consequences of unchecked consumption of forests.

3. Determine how consumption of wood could be reduced.

4. Evaluate priorities for forest product consumption.

5. Recognize the individual's role in conserving natural resources.

Subject/Grade Level: Life science/grade 7; environmental studies/grades 9-10; biology/grade 10; world geography/grades 7, 10

Time Required: 2 class periods

Materials and Preparation: Make copies of Handout 31-1 for all students.

Procedures:

1. Allow ten minutes for students to work individually, listing as many products or materials made of wood or wood fiber as they can. Then the class should compile a master list. Item by item, have the class discuss:

- What would happen if this product were suddenly unavailable?
- Could we find a substitute for this forest product? Is the substitute made from a renewable or nonrenewable raw material? What would be the environmental and economic impact of using the substitute?

2. Next, allow 15 minutes for each student to list ways he or she has used paper and other forest products within the past week. Then ask students to rank each item, from most important to least important. The three items students consider essential or most important should be circled.

3. Next to each of the three top priority items, the student should write a product or material that could replace it. For example, instead of using paper to record thoughts, cassette tapes could be substituted.

Source: Adapted from *Supplementary Activity Guide for Grades 7-12* (Washington, DC: American Forest Council, 1987). Reprinted with permission of the American Forest Council. Copyright 1987 Project Learning Tree.

4. Lead a class discussion on the comparative merits of the alternatives proposed. Use the following questions:

- Does the substitute serve the same purpose as efficiently and as cheaply?
- Is the substitute made from a renewable or a nonrenewable raw material?
- Will the substitute require more or less energy to produce than the original forest product?

5. Ask your students to brainstorm a class list of forest products used in these areas:

- Kitchen (cutting board, knife handles)
- Other rooms of the home (furniture, shutters, coat hangers)
- For home maintenance (broom handle, vacuum cleaner bags)
- Food (vanilla, nuts, wild game)
- For outside the house (fence post, picnic table)

6. Divide the class into small groups. Ask the groups to answer these questions about the class list:

- Which of the items listed are necessary for human survival?
- How would your lifestyle change if the items listed were suddenly unavailable?
- Which of the items are wasteful? Which reflect sound conservation practices? What criteria do you use to make this judgment? Which of the wasteful products are you willing to eliminate or find a substitute for? What would be the environmental and economic impact on our society if everyone avoided the wasteful products?
- Look at the items you decided were essential. Using existing technology, are there materials available that could be substituted for the forest products used? What are the environmental and economic trade-offs involved in the substitution? Do you think the substitute material would serve as well or as efficiently as the forest product?

7. In the same small groups, have students study Handout 31-1. Groups should discuss the questions on the handout in preparation for a whole-class discussion of the problem.

Evaluation:

Evaluate participation in group and class discussion by scoring the contributions each student makes. If written evaluation is necessary, have students write letters to the editor summarizing their views on use of forest products.

Extension/Enrichment:

1. Encourage interested students to do research on desertification or on reforestation efforts.

2. Tell students to find a map showing world population densities and compare it with the map showing desertification. Do they see any relationship between the two?

THE SPREAD OF DESERTS

Directions: Read the information below. Then answer the questions that follow.

Today, about 8 million square kilometers on earth are desert. But our deserts are growing, due in part to the cutting down of forests. *The Global 2000 Report* predicted that if all areas having a high risk of becoming deserts do become deserts, 24 million square kilometers will be desert in the year 2000!

Every continent has some areas that are at risk of becoming desert. The western United States and Northern Mexico in North America, for example, face this risk. The problem is especially severe in Australia and Africa, where the Sahara is advancing south every year. The problem is least severe in Europe, where only small portions of Spain and southern Italy are at risk.

The cutting down of forests is not the only reason for the spread of deserts. Certain farming practices also contribute to the problem. But the use of wood is an important contributor to this global problem.

Questions to Think About

1. What problem does the reading discuss? Is this a serious problem?
2. How will the environment be affected by the loss of forest areas?
3. How will the economy of the United States be affected by this problem? How will the economies of other world nations be affected by this problem?
4. How can individuals help solve or lessen this problem?

32. NUCLEAR ENERGY: RISKS INVOLVED IN A NEW TECHNOLOGY

Introduction:

Development of new technologies is not without risk. Since the dawn of civilization, people have accepted the risks of new technologies in order to reap the benefits. Some, however, oppose the introduction of new technologies on the grounds that the benefits are not worth the risks. Nuclear power has generated more continuing opposition than most technologies.

In this lesson, students are given a brief history of the development of nuclear power, focusing on both the risks and benefits of this technology. Then students look at one specific use of nuclear power—the application of radioisotopes for medical purposes. The levels of radiation acceptable for medical use are discussed, as are the ill-effects of high levels of radiation. Students complete a worksheet to determine how much radiation they receive each year and again discuss the risks involved.

Objectives: Students will be able to:

1. Understand that every new technology has both benefits and risks.

2. List some of the risks and benefits of nuclear energy.

3. Identify the use of various radioisotopes in selected medical applications.

4. Understand that the human body has a limited tolerance to doses of nuclear energy.

5. Predict the use of various radioisotopes for nonmedical applications.

6. Calculate the approximate dosage of nuclear radiation received each year.

7. Value the use of nuclear energy for the treatment of illnesses and diseases.

Subject/Grade Level: Environmental studies/grades 9-10; chemistry/grade 11; physics/grade 12

Time Required: 2-3 class periods

Materials and Preparation: Make copies of Handouts 32-1, 32-2 (optional), and 32-4 for all students. Make a copy of Handout 32-3 for each group of five students.

Because this activity has fairly technical information, it is important to read it prior to its presentation and anticipate the questions or difficulties students might have.

Procedures:

1. Give each student a copy of Handout 32-1 as a homework assignment the day prior to the lesson or at the beginning of the lesson. You may want to have the material read aloud by volunteer students.

2. Prior to discussing the reading, tell the students that they will be looking at a specific but small part of nuclear energy—radioisotopes. Nuclear energy is a fairly modern technology. Like all technological developments, nuclear energy is not without both risks and benefits.

Source: Adapted from *ChemCom: Chemistry in the Community* (Dubuque, IA: Kendall/Hunt, 1988).

3. Tell students that risk-benefit analysis is not an exact science. For example, some technologies present high risks to people one year, while other technologies may present chronic, low-level risks. Some risks are impossible to measure with certainty. Some risks can be controlled by individuals, while others are controlled by the government. Even though risks are often difficult to measure, decisions about technologies must still be made. Each person must become knowledgeable enough to make sound decisions about technologies that present risks to people.

4. Pass out Handout 32-2, or present the questions orally. Answers are as follows:

1. Bicycle = (500/10) x 0.000001 + 0.00005; automobile = 0.0000017; jet = 0.0000005. Thus, jet travel is the safest; bicycling is the least safe.
2. People may have the false impression that air travel is the most dangerous form of transportation due to media attention given to air disasters. People may have the false impression that automobiles are the safest due to their familiarity with driving.
3. Traveling by bicycle is the cheapest mode of transportation. The automobile is faster than the bicycle. Transportation by jet is the fastest and is more worry-free in terms of responsibility for guiding the vehicle. In this case the cost savings of going 500 miles by bicycle probably does not outweigh the risk of death and the extended travel time. Traveling by car represents a real cost savings over traveling by air and may outweigh the risk associated with traveling by automobile.
4. Cost (including meals and overnight expenses), time, responsibility for vehicle, space, payload (luggage, load), freedom to stop vehicle or detour, exercise, pleasure, lack of worry regarding mechanical breakdown.
5. A risk/benefit analysis could never yield same results for every individual; each person places a different priority and value on each mode of transportation.
6. These statistics would probably not hold true for 25 years, given an increase in the population and automobile transportation and air travel. On the other hand, new technologies might make transportation safer or even provide totally new options.
7. Same as question 4.
8. There is no way to visit your friend that is risk-free. Even deciding not to visit your friend may pose unknown risks. The world is composed of risks. Even conscious decisions not to risk may put one in a position of greater risk, due to future developments unknown to the risk-taker at the time of decision. The idea here is to minimize risk by taking a more knowledgeable approach toward known risks.
9. Seat belts, infant car seats, driver's licenses, stop lights. maintenance requirements for aircraft, and many others are legislated safety factors. Given the transportation problems, especially in large cities, outlawing a transportation mode due to a high risk factor is not an educated approach to solving problems that contribute to the high risk.
10. Risks and benefits in everyday life include diagnostic X-rays, jogging, sunbathing, handguns, pharmaceuticals, childbirth, power lawn mowers, chlorinated drinking water, smoking, and many, many others.

5. Introduce the students to a specific aspect of nuclear energy—the use of radioisotopes. Divide the class into groups of five students. Give each group a copy of Handout 32-3 and have the group appoint one student to read the section entitled "Radioisotopes" to the group. Each group should also appoint one student to act as recorder and fill out the group worksheet. This same student or another student should be appointed as reporter. The reporter will provide input to the entire class from the group. Groups should complete all the questions on the worksheet by the end of the class period.

6. Begin the next class period by asking group reporters to offer input from the worksheets completed by their groups. Assign each reporter a different question. Answers are as follows:

1. In the case of oil, either an oil-soluble or insoluble compound could be used; in the case of gas, a gaseous form would be needed. Given that the fuel may be traveling across country, isotopes with half-lives on the order of days or years would be needed. If the company placed different tracers at the start of each new shipment, the receiver of the shipments could monitor when each new shipment arrived. Actual isotopes used for this purpose include: Sb-124 (60.3 d), Co-60 (5.24 y), and Cs-137 (30.23 y).
2. Radioactive forms of metals that are a normal part of the piston rings and/or cylinders with half-lives less than the expected life of the engine parts (10 years, but actually these tests are done under accelerated time schedules). Possibilities include: Fe-55 (2.6 y), Zn-65 (245 d), etc.
3. At least two options exist: (a) for intermittent tests where the product would not be subsequently consumed, a water-soluble radioactive compound would be desired such as water laced with tritium; (b) if a continuous feedback system were desired, one could design a system based on the absorption of radiation. The system could be designed so the fluid continued to be added until a detector placed on the opposite side of the container from the radiation source signaled a certain level.
4. Radioisotopes in compounds that are either oil or water soluble depending on specific type of leak of concern. Half-lives on the order of minutes to hours depending on the pipe length being searched. Also, in the case of pipes carrying domestic water, public safety would require short-lived isotopes.
5. Radioisotopes in water-soluble compounds with half-lives on the order of days to years. Actual isotopes used for this purpose include: H-3 (12.26 y), Br-82 (35.5 h), I-131 (8.1 d), etc.
6. Prepare special dirt, oil, or grease containing a radioisotope such as P-32 (14.3 d); measure radioactivity in soiled clothing before and after laundering.
7. Would need a radioactive compound that would be readily diluted throughout the body, emit only safe levels of radiation and be readily eliminated in urine. Low dose of H-3 (12.26 y) might be suitable.
8. The chief elements of concern as fertilizers are N, P, and K. The radioisotopes of nitrogen are too short-lived to be of practical value. P-32 (14.3 d) has been used extensively for this purpose, as have some forms of potassium (K-42 12.4 h, K-43 22.4 h).
9. A radioactive form of the herbicide would need to be synthesized. P-32 (14.3 d) and I-131 (8.1 d) would be useful.
10. The chief mineral required by red blood cells is iron, so either Fe-55 (2.6 y) or Fe-59 (45.1 d) would be useful.
11. Unlike the above tracer applications, this medical treatment requires the use of a high energy emitter. Co-60 (5.24 y), a powerful gamma emitter, is commonly used for this purpose. The source is outside the body, finely focused, and the dose level carefully controlled.

7. Continue the group work by telling the class that although radioisotopes provide benefits to humans, the radiation that comes from nuclear energy also creates risks. Tell students to read the next section of Handout 32-3, "Ionizing Radiation." Allow students time to read and discuss this material.

8. Distribute Handout 32-4. Allow time for students to complete the worksheet.

9. Ask volunteer students to share the results of their worksheets on radiation dosages per year. (All students will probably have approximately the same dosage.)

10. Debrief the activity with the following questions:

- Nuclear energy provides both risks and benefits. What are some of the risks? What are some of the benefits? (List answers in a chart on the chalkboard.)

- Why has nuclear energy become one of the most controversial technologies ever invented?
- What other technologies have created a great deal of controversy?
- How could the amount of radiation you receive each year be limited?
- Whose responsibility is it to ensure that the amount of radiation you receive is a safe level?
- If you feel very strongly about the use of nuclear energy, to whom could you communicate?
- How important do you think the input from individual citizens is in helping the government make decisions about the use of nuclear energy?

Evaluation:

It is less critical that students retain the technical information provided in this lesson than that they understand that every new technology involves both benefits and risks. The debriefing questions should allow you to evaluate whether students understand what risks and benefits are and how these risks and benefits can be weighed in determining whether a technology is good or harmful to people exposed to it.

Extension/Enrichment:

It would be helpful to bring in specialists and experts, both for and against the use of nuclear energy, to provide input on why the use of nuclear energy is necessary and good or unnecessary and bad. Ensure, however, that these speakers can provide data and accurate information, rather than relying totally on emotional appeal.

THE HISTORY OF NUCLEAR ENERGY

Since the dawn of civilization, people have accepted the risks of new technologies in order to reap the benefits. Fire, one of the earliest tools of civilization, gave people the ability to cook, to keep warm in winter, and to forge tools from metals, but at the risk of setting the earth on fire, and possibly even being burned to death. Every subsequent technology has offered its benefits at a price.

Nevertheless, improvements in water systems, nutrition, and health care have given human beings in the developed nations the longest average life span in history. Still, people often oppose the introduction of new technologies on the grounds that the benefits are not worth the risks. Many opposed the introduction of both trains and automobiles. Nuclear power has generated more continuing opposition than most technologies.

In 1938, two German scientists, Otto Hahn and Fritz Strassman, bombarded uranium-238 with neutrons. They expected to observe a simple transformation of the uranium to the slightly heavier isotope uranium-239, accompanied by the release of a beta particle, to form a product isotope with atomic number 93.

One of the unexpected elements they found in their search of the reaction products was the element barium, atomic number 56. It was Austrian physicist Lise Meitner, working in Denmark after having fled the Nazis, who first understood what had happened. She suggested a physical explanation for the process by which the neutron bombardment had split the uranium nuclei into roughly equal halves. Eventually it was learned that uranium-235 was the fissioning isotope and not uranium-238.

Other scientists immediately verified Meitner's explanation. The world had seen its first nuclear fission reaction. Fission induced by the neutron bombardment of uranium-235 releases at least a million times as much energy as that produced in any chemical reaction. This energy is what makes atomic explosions so devastating and nuclear energy so powerful.

The source of atomic energy lies in the forces that hold the protons and neutrons together in the nucleus. This force, called the strong force, is fundamentally different from, and a thousand times stronger than, the electrical forces of ionic and covalent chemical bonds that hold chemical compounds together. This force is involved when matter is converted into energy, or vice versa. Its range is exceedingly short. It does not extend beyond the diameter of the atomic nucleus. The nuclear energy released from the conversion of a gram of matter to energy is equivalent to the energy released on burning more than 700,000 gallons of octane fuel.

How does all that energy become liberated? Recall the laws of conservation of energy and matter. Energy and matter are neither created nor destroyed. But they are now considered to be different forms of the same thing. When changes take place in the nuclei of atoms, energy and matter become interconvertable, according to Albert Einstein's equation. The change in energy equals the change in mass times the speed of light squared ($E = mc^2$). When nuclear fission occurs, the mass of the fission products is hundredths of a molar mass less than the mass of the atom that was fissioned. The quantity of mass lost is so small that you do not account for it in mass numbers of the nuclear equations you balance. What happens to the mass? It is converted into a tremendous quantity of energy.

The first nuclear reactors were designed during World War II solely to produce plutonium-239 for use in atomic bombs. Today in the United States, about 80 commercial nuclear reactors produce electricity. In 1984, nuclear power met 4.85 percent of our energy needs and 13.56 percent of electrical energy needs. Many small reactors produce radioisotopes for research, industry, and medicine. A few reactors run by the Department of Energy produce plutonium-239 for weapons.

TRIP TO SEE A FRIEND

Suppose you wish to visit a friend who lives 500 miles away. You want to use the "best" means of transportation. While many factors might enter into your definition of best, reliable statistics published by insurance companies are certainly worth considering. Using the table below, answer the following questions:

Safety of Three Methods of Travel

Mode of Transportation	Distance at which chance of death* is increased by 0.000001
Bicycle	10 miles
Automobile	300 miles
Jet	1000 miles

*On average, one person in a million traveling this distance will suffer accidental death.

1. Assuming there is a simple, linear relationship between distance traveled and chance of accidental death, what is the numerical value of your risk factor for traveling the 500 miles to visit your friend by each mode of transportation? Which is the safest mode? The least safe?
2. The results obtained in Question 1 might surprise many persons. Why?
3. List the benefits of each mode of transportation. Do the benefits of the modes that are less safe outweigh their increased risks? Explain your reasoning.
4. What other factor(s) besides the risk to personal safety would you want to consider in this risk-benefit analysis? If these "costs" have an economic value, use them to estimate additional costs.
5. Which mode of transportation would you choose and why? Would such a risk-benefit analysis yield the same results for all individuals? In other words, all factors considered, is there a single "best" method of transportation? Explain your answer.
6. Do you think these same statistics would have held true 25 years ago? Why or why not?
7. What other type of information would you need in order to make a better decision?
8. Is there any way of visiting your friend that is risk-free? Would deciding to not visit your friend necessarily be the safest decision?
9. How has the government attempted to legislate certain safety factors into the transportation industries? Should it attempt to outlaw the transportation mode with the highest risk factor? Why or why not?
10. Briefly describe another aspect of your everyday life that involves risks and benefits.

NUCLEAR ENERGY GROUP PACKET

Radioisotopes

Some nuclear technologies use the ionizing radiation given off by the decay of specific radioisotopes in tracer studies, where the object is to detect the presence of the isotope, or in irradiation, where the radiation is an energy source.

Perhaps the most important of these is the application of radioisotopes in medicine, in detecting abnormalities and in therapy. Doctors place radioisotopes having short half-lives into the body, like a scout sent out on a mission, to find out what's happening. These radioisotopes are called tracers. They have several properties that make them ideally suited for this task. First, radioisotopes behave chemically and biologically like stable isotopes of the same element. Doctors know that certain elements go to specific parts of the body; thus, to investigate that part of the body, they send the appropriate radioisotope.

Second, the radioisotopes are detectable with a nuclear radiation detection system, which allows a doctor to determine whether that element is being properly distributed in the body. Tracer compounds can be sent through the body in solution, or biologically active compounds can be synthesized to contain a radioactive atom, then fed to or injected into the patient.

One common use of a radioisotope tracer is to diagnose thyroid problems. At one time, if a doctor suspected that a person's thyroid was not functioning properly, the most common method of diagnosis was surgery. Today, radioactive isotopes offer a much less drastic option. The patient simply drinks a solution containing radioiodine (I-131), most of which will concentrate in the thyroid. The doctor then follows movement of the I-131 tracer in the thyroid with a radiation detection system, measuring the rate at which it disappears.

A healthy thyroid will incorporate a known amount of iodine. An overactive or underactive thyroid will take up more or less iodine. The doctor then compares this rate to that which is normal for a person of that age, sex, and weight, and takes appropriate action.

Technetium-99m, a synthetic radioisotope, has replaced surgery as a way of scanning for brain tumors. Tumors are areas of runaway cell growth. The element concentrates where cell growth is fastest. A bank of radiation detectors is arranged around the patient's head. These can pinpoint the precise location of the tumor. Phosphorus-32 can be used in a similar way to detect bone cancers.

Irradiation is used in cancer therapy. In treatment of thyroid cancer, the patient receives a highly concentrated internal dose of radioiodine, so that the ionizing radiation will kill the cancer. In treatment of other cancers, cobalt-60 is often used to beam ionizing radiation from an external source at the cancerous spot. Such treatments must be administered very carefully because the higher doses of radiation can kill or damage normal cells.

Both the tracing and cell-killing properties of other radioisotopes are used to diagnose and treat other cancers. Radiosodium (Na-24) can be used to look for abnormalities in the circulatory system, and radioxenon (Xe-133) can be used to search for embolisms (blood clots), and abnormalities of the lung. The table on the next page outlines still other medical applications of radioisotopes.

Selected Medical Applications of Radioisotopes

Radioisotope	Use
Used as tracers	
Cobalt-58	Determine the intake of vitamin B_{12} (which contains nonradioactive cobalt)
Iron-59	Determine the rate of red blood cell formation (these contain Fe)
Chromium-51	Determine blood volume and the lifespan of red blood cells
Hydrogen-3 (tritium)	Determine the volume of water in a person's body; determine the use of (labeled) vitamin D in the body; research in cellular chemistry of many kinds
Strontium-85	Bone scans
Gold-198	Liver scans
Used for irradiation therapy	
Cesium-137 (external source)	Treatment of shallow tumors
Phosphorus-32 (external source)	Treatment of skin cancers
Strontium-90	Treatment of eye disease
Iridium-192	Treatment of tumors with imbedded wire
Yttrium-90	Internal treatment of pituitary gland cancer with ceramic beads
Gold-198	Treatment of body cavity cancers with a radiocolloid that coats the body cavity

Irradiation is also useful in industrial processes, for sterilization of medical disposables such as injection needles, and of surgical masks and gowns. It is also used for sealing plastic containers. There are over 35 irradiators operating in the United States, and well over 100 worldwide.

Irradiators are very simple. They have an irradiation chamber that contains pellets of a radioisotope, usually cobalt-60. The material to be irradiated is placed upon a conveyer belt that slides past the radioisotope. The ionizing radiation kills bacteria. Irradiation is one way to preserve food, because it can kill bacteria that cause food to spoil.

High doses of irradiation can be used to sterilize meat, so that it can be kept vacuum-packed for years at room temperature. Although several foreign countries have small food irradiation industries, U.S. food processors have been slow to adopt the method. The U.S. Food and Drug Administration approved the sterilization of pork by irradiation in 1985.

Since the 1950s, scientists and eng used radioisotopes in such fields as agriculture, medicine, and industry. To give you a of the value of this technology, complete the following activity.

Putting the Atom to Work

Each problem listed below has already been solved in real life through the use of radioisotopes. See if you can design your own solution to each problem, making use of radioisotopes. Your teacher will assign you to a team to work on these items.

For each problem prepare a brief, one-paragraph description of your proposed solution. Each group reporter should be prepared to make a brief oral presentation on one of your solutions.

You may wish to consider these points:

- What type of radioisotope should be used? Consider half-life, the specific type of radiation, and physical and chemical state.
- How should the system be designed? You may construct a diagram.
- What, if any, safety and health precautions are necessary?
- Does the problem require continuous use of radioisotopes or a one-shot approach?
- Could a non-nuclear technology solve the problem just as easily? Would this be less expensive?

Problems

1. Many oil companies use the same pipelines to ship oil and gas from Texas to midwestern states. How can radioisotopes be used to inform operators in Michigan which company's oil or gas is arriving at any particular time?

2. An automobile manufacturer exploring ways to extend the life and efficiency of automobile engines wants to know how fast the piston rings will wear.

3. A manufacturer of soft drinks wants to be sure that the automatic can-filling machine is adding exactly the right amount of liquid at all times.

4. Underground pipelines sometimes spring leaks that are hard to detect. It is expensive as well as impractical to dig up huge sections of pipeline in hopes of finding the leak. How can these leaks be located so that they can be repaired at the least cost? Would a similar solution be appropriate for both water and oil pipelines? If not, how and why should they differ?

5. A local conservation group wants to determine how long it takes for underground water to leach from an old, illegal chemical dump site to a lake 5 km away, and the amount of water leaching.

6. An industrial chemist wishes to compare the cleansing effectiveness of a new detergent formulation to that of a well-established product.

7. A medical researcher wishes to measure the percentage of the human body that is water, in order to map variations with age, sex, and body build.

8. Applying more fertilizer than crops can use harms the environment through runoff into streams. It's also a waste of money. An agricultural chemist wants to know what application method will result in the highest ratio of fertilizer uptake to runoff.

9. A chemist develops a new herbicide that is intended to selectively attack broadleaf weeds and not be absorbed at harmful levels (harmful either to the crops or consumers) by grain crops. How might this be tested?

10. A medical researcher wishes to know how efficient the body is in extracting a key mineral needed by red blood cells from a given diet.

11 doctor treating a patient with inoperable lung cancer wishes to kill the maximum number of cancer cells while causing the least damage to healthy tissues.

Ionizing Radiation

There are many different ways to measure radiation. Radiation is measured in counts per minute (cpm). It is also measured by rads and rems.

The **rad** (radiation absorbed dose) is the absorbed dose c any type of ionizing radiation.

The **rem** (roentgen equivalent man) is a measure of the power of radiation to ionize human tissue. This measurement takes into account the levels of tissue damage caused by different types of ionizing radiation. It is calculated by multiplying rads by a unit of biological damage.

The ways in which each type of radiation can cause harm are distinct. X rays and gamma rays, ionizing forms of electromagnetic radiation, can penetrate deeply into the body, but they are least damaging per amount of tissue traversed, compared to alpha and beta particles. Alpha particles are easily stopped, but once they reach the lungs or the bloodstream, they cause extensive damage over a very short path length (about 0.0025 cm) because of their relatively large mass and slower velocities. The primary factors that determine tissue damage are the density of ionization—the number of ionizations per tissue unit—and the dose (the quantity of radiation received).

Ionizing radiation breaks bonds and therefore tears molecules apart. At low levels of radiation, only a very small percentage of isolated molecules are harmed, and the body systems can usually repair the damage.

The greater the dose (or quantity of radiation) received, however, the more molecules are affected. The macromolecules of the body are of greatest concern, particularly the proteins and nucleic acids. Proteins form much of the body's soft tissue structure and make up the enzymes that control bodily function. When a large number of these molecules are torn apart in close proximity to one another, the body does not have enough functioning molecules to heal itself within a suitable period.

The nucleic acids that make up DNA (the genetic coding molecules controlling cell reproduction and the synthesis of bodily proteins) can be damaged in two ways. Minor damage causes mutations (changes in the structure of the DNA, which then direct the synthesis of new proteins). Most mutations kill the organism, but some merely cause change. It is believed that mutations can lead to cancer—a disease of cell growth and metabolism out of control. If, on the other hand, the DNA in many body cells is severely damaged, the immediate effect is that bodily proteins can no longer be synthesized to replace damaged ones, and death follows. The tables below list the factors determining the extent of biological damage from radiation and the biological effects of increasing dosages of radiation.

Factors Affecting Biological Damage from Radiation

Factor	Effect
Dose	Most scientists assume that increase in radiation dose produces a proportionate increase in risk
Length of time of exposure	The more a given dose is spread out over time, the less harm it does. The same is true from drugs and alcohol
Area of body exposed	The larger the area exposed to a given number of rems, the greater the damage
Type of tissue exposed	Rapidly dividing cells, such as blood cells and sex cells, are more susceptible to radiation damage than slowly dividing or non-dividing cells such as nerve cells. Fetuses and children are more susceptible to radiation damage than are adults

Biological Effects of Different Dose Levels

Dose (rems)	Effect
0-25	No immediate observable effects
25-50	Small decrease in white blood cell count causes lowered resistance to infections
50-100	Marked decrease in white blood cell count; development of lesions
100-200	Radiation sickness: Nausea, vomiting loss of hair. Blood cells die
200-300	Hemorrhaging, ulcers, deaths

Dose (rems)	Effect
300-500	Acute radiation sickness. Fifty percent die in a few weeks
700	One hundred percent die

The effects of large doses of radiation are drastic. Conclusive evidence that high doses of radiation cause cancer have come from uranium miners, accident victims, and bomb victims in Hiroshima and Nagasaki. Some of the best case studies were made on workers who painted the numbers on radium watch dials. Unknowingly they touched the paintbrushes to their tongues to sharpen the tips, and thus took radium into their bodies.

Leukemia, cancer of the white blood cells, is the most rapidly appearing and the most common cancer associated with radiation. Other forms of cancer may also occur, as well as anemia, heart-related problems, and cataracts (opaque spots on the lens inside the eye).

There is considerable controversy over whether very low doses of radiation can cause cancer. Most of the data concerning cancer have come from human exposure at high doses, with extrapolation to low doses. Very few studies have reported direct observation of cancer that resulted from low radiation doses. Although most scientists will agree that natural levels of radiation (about 150 millirem [mrem]) are safe for most people, a report released in 1981 by the National Academy of Sciences and the Nuclear Regulatory Commission takes the position that any increased quantity of radiation increases the probability for cancer. The situation is very similar to the one posed by chemical carcinogens.

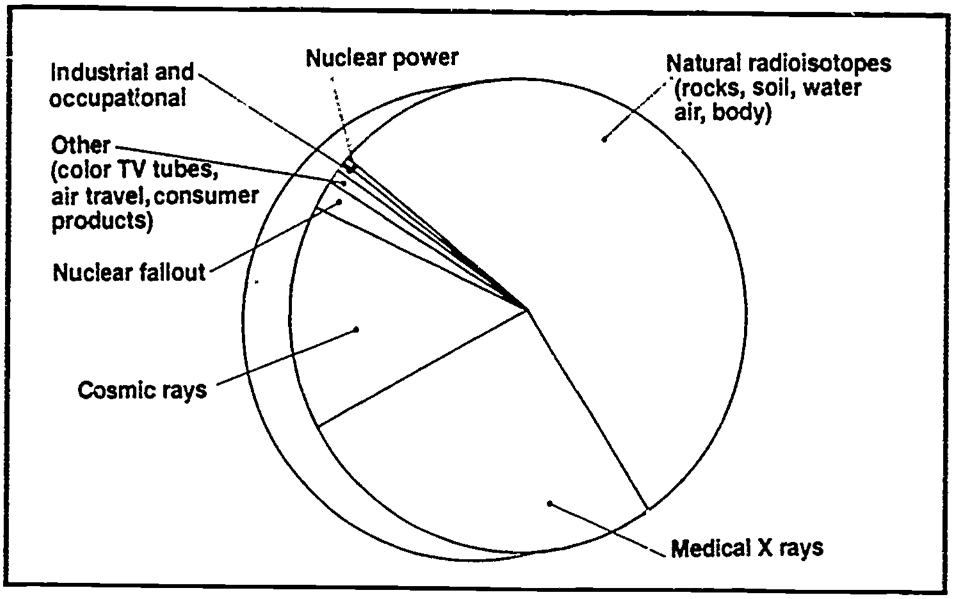
What level of radiation is considered safe for the average person? The current radiation standard, set in 1977 by the Nuclear Regulatory Commission for the general public, allows the population to receive an average annual dose of 170 mrems. An individual may receive 500 mrem (0.5 rem) a year, or about three times the natural background. For those occupationally exposed, the annual limit is 5 rem per year. This level of radiation increases the risk of cancer by 1-3 percent according to the National Institutes of Health.

We are all subject to irradiation at low levels from both natural and human sources. Natural sources include cosmic rays, exceedingly high-energy particles that bombard the earth from outer space; uranium-238, uranium-235, thorium-232; and their decay products; and potassium-40, which are in rocks and soil and frequently dissolve in groundwater. Radon-222 and its decay products, including polonium-210, are present in the atmosphere.

Background radioactivity of human origin includes fallout from nuclear weapons testing, medical X rays and irradiation, air travelers' increased exposure to cosmic radiation, and radioactivity released into the environment from the use of nuclear power and technology.

Some of the radiation we are naturally exposed to is within our own bodies. The total background exposure is estimated at 135 mrem per year at sea level. The graph below shows the relative quantities of background radiation we receive from each source.

Although we cannot avoid some radiation sources, such as those in the ground and atmosphere, we do have a choice about other sources of radiation. We can choose whether or not to have a diagnostic X ray. We can decide whether or not we will have done medical studies that use radioactive isotopes. We can choose whether to fly and how often, which limits our exposure to cosmic radiation. We can choose where we live. Each of these situations, of course, involves benefit-risk analysis.


Industrial and occupational
Nuclear power
Natural radioisotopes (rocks, soil, water air, body)
Other (color TV tubes, air travel, consumer products)
Nuclear fallout
Cosmic rays
Medical X rays

YOUR RADIATION DOSAGE PER YEAR

Fill in the blanks with the missing numbers. Add the millirem values when you finish to approximate the dosage of radiation you receive each year.

Source of radiation	Quantity
1. Location of your town or city.	
a. Cosmic radiation at sea level (U.S. average). (Cosmic radiation is radiation emitted by stars across the universe. Much of this is deflected by the Earth's atmosphere and ionosphere.)	30 mrem
b. Add an additional millirem value based on your town or city's elevation above sea level: 1000 m (3300 ft) above sea level = 10 mrem; 2000 m (6600 ft) above sea level = 30 mrem; 3000 m (9900 ft) above sea level = 90 mrem. (Estimate the mrem value for any intermediate elevation.)	___mrem
2. House construction. Choose the material from which your house is made; enter the correct value. (Building materials contain a very small percentage of radioisotopes.) Brick, 75 mrem; wood, 40 mrem; concrete, 85 mrem.	___mrem
3. Ground. Radiation from rocks and soil (U.S. average).	15 mrem
4. Food, water, and air (U.S. average).	25 mrem
5. Fallout from nuclear weapons testing (U.S. average).	4 mrem
6. Medical and dental X rays.	
a. Chest X ray (number of visits times 10 mrem per visit).	___mrem
b. Gastrointestinal tract X ray (number of visits times 200 mrem per visit).	___mrem
c. Dental X rays (number of visits times 10 mrem per visit).	___mrem
7. Jet travel. (Jet travel increases exposure to cosmic radiation.) Number of flights (five-hour flights at 30,000 ft or 9000 m) times 3 mrem per flight.	___mrem
8. Nuclear power plants. If your home is adjacent to a plant site, add 1 mrem.	___mrem
Total	___mrem

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33. CAN WE CONTINUE TO USE THINGS UP?

Introduction:

We depend upon the lithosphere, the solid part of the earth, for most chemical resources. These resources, of which the supply is finite, are very unevenly spread around the earth. Although the law of conservation of matter states that changes in matter are actually rearrangements among atoms, nature's rate of producing molecules is negligible compared to the rate at which humans extract and use these molecules. To address this differential, humans have begun mimicking nature's recycling system. In the first part of this activity, students read about the dynamic described above. They use tables and a graph to discover where most chemical resources are found. Students then work in groups to discuss recycling and determine what they can do, as individuals, to help in the effort to conserve chemical resources.

Objectives: Students will be able to:

1. Explain that chemical resources are unequally distributed around the world.

2. Define recycling.

3. Identify resources that we use daily that could be recycled.

4. Use a table and graph to gather information on U.S. dependence on other countries for chemical resources.

5. Draw conclusions on resource use based on a reading, table, and graph.

6. Recognize the value of recycling as a means of protecting resources.

Subject/Grade Level: Ecology/grade 10; environmental studies/grades 9-10; chemistry/grade 11; physics/grade 12; civics/grade 9; government/grade 12

Time **Required:** 1-2 class periods

Materials and Preparation: Make copies of Handout 33-1 for all students; make enough copies of 33-2 for each group of four students to have a copy.

Procedures:

1. Distribute copies of Handout 33-1. Provide time to read this material.

2. After students have finished the reading, discuss the material with the class. Use the following questions to stimulate discussion:

- Uneven distribution of resources has resulted in great achievements as well as brutal wars. Give examples of these achievements and wars. (Some of those might include the discovery of gold in the western United States, the use of uranium for atomic power, oil resources in the Middle East, etc.)
- Why is the United States so dependent upon other countries for chemical resources? (It does not have all the resources needed, it uses more of the world's resources than many countries.)

Source: Adapted from *ChemCom: Chemistry in the Community* (Dubuque, IA: Kendall/Hunt 1988). © 1988 by the American Chemical Society. Reprinted by permission of the Kendall/Hunt Publishing Company.

- Identify some of the resources that are "running out" quite rapidly. Why are these resources being exhausted?
- The fast-food meal is an example of our "throwaway" society. Give other examples of products that are overpackaged.
- What other materials besides paper, aluminum, and glass can be recycled?

3. Divide class into groups of four students. Give each group a copy of Handout 33-2 to use as a guide for a group discussion. Each group should select one member to record the group answers on the worksheet.

4. After each group has had an opportunity to complete its worksheet, bring the class back together to discuss the results of the group work. You may want to use the following questions in the debriefing:

- Should the federal government require that certain materials be recycled? Why or why not?
- If recycling were required by law, what materials should be recycled?
- How could a recycling law be enforced?
- How can various industries, such as the fast-food industry, be forced to reduce the amount of packaging materials used?
- Can the United States become less dependent upon other countries for chemical resources? Why or why not?

Evaluation:

Through the discussion, determine whether students understand that chemical resources are limited, but can be made to last longer through wise consumption and recycling. Each student could be given Handout G-2 to complete for evaluation purposes.

Enrichment/Extension:

1. Have students do research on aqua-mining.

2. Students can select a particular chemical resource and research how it is mined, processed, or made into usable resources.

3. Have students develop a plan for recycling materials used at school (newspapers, aluminum cans, etc.).

CAN WE CONTINUE TO USE THINGS UP?

Chemical Resources on Spaceship Earth

Despite advances in space travel, our resource needs must continue to be met by the chemical "supplies" located on Spaceship Earth. These supplies or resources are often inventoried in terms of where they are found.

We rely on the lithosphere, the solid part of the earth, for nearly all of our chemical resources. Our deepest mines barely scratch the surface of the earth's crust. If the earth were the size of an apple, all accessible resources would be concentrated in the apple skin. From this thin band of soil and rock, we obtain all the raw materials from which we construct homes, automobiles, appliances, computers, cassette tapes, records, and tennis rackets—in fact, all manufactured objects.

These chemical supplies are well suited to support complex life forms. However, many important resources are not distributed uniformly. There is no correlation between the abundance of these resources and either land area or population.

Many nations have a surplus of one or more chemical resources but a deficiency of others. Throughout history, unequal distribution of these resources has motivated some of our greatest achievements and some of our most brutal wars. Much of our nation's development was due to the quantity and diversity of chemical resources. Yet, in recent years the United States has imported increasing amounts of certain chemical resources. (See the table on the following page.)

In addition to the land, which provides most of our chemical resources, the oceans contain significant dissolved amounts of some 17 metals. Also, solid nodules discovered on the ocean floor contain as much as 24 percent manganese (Mn), 14 percent iron (Fe), and trace amounts of copper (Cu), nickel (Ni), and cobalt (Co). The availability of minerals from seawater and from underwater nodules raises hope that these and perhaps other metal-rich sediments can someday be "aqua-mined."

Even if aqua-mining becomes a major source of new resources, there will still be a finite supply of nonrenewable resources to meet the growing demands of humans. The real question is not whether we will run out, but how we can deal wisely with the resources of the earth. A partial answer can be found in conservation.

Conservation—By Nature, By People

The law of conservation of matter is based on the notion that the basic "stuff" of our world is indestructible. Chemists explain observable phenomena in terms of atoms. All the changes we observe in matter can be interpreted as rearrangements among atoms.

Chemical reactions are exact—they do not involve random or fractional numbers of atoms. Thus, we can write a specific symbolic statement, called a balanced chemical equation, to describe any particular chemical change.

If nature always conserves, then why is it sometimes reported that a resource is "running out"? Is this a hoax to raise prices? In what sense can we "run out" of a resource?

One can talk about depletion of a resource in two related ways. First, remember that nature conserves atoms, but not necessarily molecules. Nature's rate of production of molecules, such as those which compose petroleum, is negligible compared with the rate at which we extract and burn them.

Major Foreign Sources of Some Minerals

Material and uses	Percent imported (0–100)	Major foreign sources
Mica (sheet) Electrical insulators; filler (plasterboard, rolled roofing, shingles)	100	India, Brazil, Malagasy Republic
Manganese Steel, alloys	99	Brazil, Gabon, Australia, South Africa
Cobalt Alloys, catalysts, ceramics, pigments	98	Zaire, Belgium, Luxembourg, Finland, Norway, Canada
Chromium Steel (up to 25%), alloys, decorative plating	91	South Africa, Soviet Union, Turkey, Rhodesia
Aluminum (ores and metal) Building materials, powerlines, vehicle parts, packaging	85	Jamaica, Surinam, Australia, Dominican Republic
Fluorine Uranium production, specialty chemicals	82	Mexico, Spain, Italy
Platinum group metals Catalysts, electronics, jewelry, medical and dental applications	80	South Africa, United Kingdom, Soviet Union
Tin Plated food cans, solder, bronze, bearing metals	75	Malaysia, Thailand, Bolivia
Mercury Agriculture (e.g., pesticides), electrodes in Cl_2 production, street lights, gauges	73	Canada, Algeria, Mexico, Spain
Selenium Tinted glass, xerography, electronic devices, photoelectric cells	58	Canada, Japan, Mexico

A second sense in which we can deplete a resource applies to metals. For profitable mining, an ore must contain some minimum concentration of metal. (This minimum value depends on the metal ore— from as high as 30 percent for aluminum to as low as 1 percent for copper or 0.001 percent for gold.) As sites with high metal concentrations are depleted, lower concentration sites are developed. Meanwhile, through use, we disperse the originally concentrated resource. At some future time, our economy may not be able to support further extraction of such a metal for general use. For practical purposes, we will have depleted our supply of this resource.

Can we keep from doing this? Can we mimic nature's recycling systems? Can substitute materials and processes lessen or even eliminate our need for a resource now considered crucial? Nature conserves automatically at the atomic level. Let's look at what conservation means in human terms.

We gather a wide variety of chemical resources, organize or process them, and build from them the materials that support our varied activities. These resources range from metal ores to petroleum, from water to forest timber. But this is only half the story.

Gathering, processing, and using resources generates unwanted materials. We must also manage these materials to avoid dispersing them throughout the environment and to avoid being overwhelmed by unwanted wastes. In many cases, they are actually "resources out of place." The waste and dispersion of nonrenewable resources may eventually pose serious threats to the well-being of our society.

Thus, the by-products of what we use also must be gathered and organized. We call this recycling. Unsorted, scattered materials are often considered trash. After reprocessing, such materials or the chemical resources they represent can be used again.

Many communities realize the wisdom of this aspect of resource management. How is a recycling program planned and organized?

Recycling

Our nation has been called a "throwaway" society. It is true, for example, that 30 percent of the country's production of major materials is eventually discarded. In 1980 alone, by-product or waste disposal cost U.S. taxpayers $4 billion. Ten percent of the nation's energy use is devoted to handling these discarded materials.

Some critics say that our society overpackages food and consumer items. For example, think about the single-use packaging involved in one fast-food meal. The packaging inventory would include a plastic or paper hamburger container, plastic-coated cup, plastic lid, plastic straw, paper French fry bag, plastic catsup pouch, paper packages for the salt and pepper, paper napkin, and even a paper bag to hold the meal!

Some packaging is necessary. Packaging protects ingredients, keeps small items together, and in many instances promotes cleanliness and safety. But even a simple ballpoint pen is often packaged in plastic and cardboard and is placed in a bag by the cashier for you to take home. (And, like many other consumer items, the ballpoint pen is designed to be discarded rather than refilled or reused.)

Do you buy milk in a plastic container, glass bottle, or cardboard container? What do you do with a pocket radio or calculator when it breaks? Do you have it repaired or toss it out and buy another? How many used batteries did your family discard in the past year? Do you mend worn socks or throw them away?

What are the alternatives? One is to use less. Another is to buy in bulk to use less packaging material. Two other alternatives are to use items for a longer time or to reuse (recycle) them. Recycling requires considerable work. What are its benefits? To find answers, let's examine three materials: paper, aluminum, and glass.

Paper. This is an important renewable resource. Since paper is made from tree pulp, new seedlings can be planted to replace trees cut down. However, it takes about 25 years for the seedlings to grow large enough to be economically useful. The "renewing" of this resource takes time! About 17 trees are needed to produce a ton of paper. That is just enough to supply two average citizens with the paper they use in one year!

Energy is required to make paper from a tree. Less than half as much energy is needed to process recycled paper than is used in making new paper. Unfortunately, only about 20 percent of the paper we use is currently recycled.

Aluminum (Al). This is a nonrenewable chemical resource—the number of aluminum atoms on earth is, for all practical purposes, fixed. That is all we can expect to have.

Aluminum is the most abundant metal in the earth's crust (8 percent). However, much of this aluminum is in the form of silicates, from which it is not easily extracted. Our national demand for aluminum is so great that our own supplies of the ore, bauxite, cannot meet our needs. We import approximately 90 percent of the aluminum used in this country. Producing aluminum even from bauxite requires considerable energy. Recycling used aluminum consumes only one-twentieth of the energy needed to produce it from aluminum-containing ore. At one time we discarded 50 billion aluminum cans yearly. Thanks to organized national efforts, we now recycle about half of our used aluminum.

Glass. A simple glass is made by melting together, at high temperatures, sand (silicon dioxide, SiO_2), soda ash (sodium carbonate, Na_2CO_3), and limestone (calcium carbonate, $CaCO_3$). All three materials are nonrenewable but plentiful. Glass recycling uses so much energy that it is more efficient to reuse old containers than it is to make new ones from used glass. In the not-too-distant past, most milk, juice, and carbonated beverages were sold in returnable (reusuable) glass containers.

RECYCLING WORKSHEET

1. Paper, aluminum, and glass are the three most commonly recycled resources. Which of these is most important to recycle for economic reasons? Why?

   ____

   ____

   Which of these three is most important to recycle for political reasons? Why?

   ____

   ____

   Which of these three is most important to recycle for environmental reasons? Why?

   ____

   ____

2. As individuals, we can conserve, reuse, or recycle materials in many different ways. For example, we can write on both sides of paper or buy beverages in returnable, reusable bottles. Identify at least five other ways that we, as individuals, can conserve, reuse, or recycle materials.

   ____

   ____

   ____

   ____

   ____

   ____

3. Describe three everyday activities you would be willing to change to reduce the problems of solid waste disposal.

   ____

   ____

   ____

   ____

34. SOIL DETERIORATION

Introduction:

Soil depletion is severe in many areas of our country. Whether natural or caused by humans, soil deterioration reduces soil to a nonproductive state. The end result is reduction in the amount of usable land. The "Dust Bowl" of the 1930s is a good example of soil depletion that led to widespread tragedy. Many local examples, although not as severe, still are causing great alarm. Often controversy arises over the sources of the problem, as well as possible solutions.

Through a field experience, students observe two areas of land—one that is productive and one that is deteriorated or eroded. This investigation is extended in a case study in which students must decide on a solution to a soil deterioration problem.

Objectives: Students should be able to:

1. Explain the difference between productive and nonproductive soil.
2. List some ways that humans cause soil deterioration.
3. Gather data on the productivity of two plots of soil.
4. Make inferences based on the data gathered.
5. Analyze a case study and recommend a solution.
6. Recognize the conflict between alternative uses of land.

Subject/Grade Level: Earth science/grade 8; general science/grade 9; environmental studies/grades 9-10; biology/grade 10; ecology/grade 10; world geography/grades 7, 10

Time Required: 2-3 class periods

Materials and Preparation: Select two field sites. One should have productive soils with good plant growth. The other should be poor, depleted, or eroded soil. Once you have selected the sites, you will need to make arrangements for students to be transported to them. In addition, you will need copies of Handouts 34-1 and 34-2 for all students.

Procedures:

1. Begin the lesson by describing briefly to the class the conditions in the Dust Bowl in the 1930s. Stress the economic and social costs of the loss of soil, as well as the human and natural contributions to the problem.

2. Take students to the first site. Ask them to make observations about the types of plants growing in the area, any wildlife apparent, any special ecological features of the area, and the topography of the area. Have students make notes on Handout 34-1 as they make their observations. They can complete their notes on site one while you are en route to site two. After similar observations at site two, have students complete the handout.

3. Conduct a class discussion of the following questions:
   - Were there differences in the plants and animals living at the two sites?
   - What do you think accounts for the differences you observed?
   - Do these differences affect the productive capacity of the soil?

- What would the economic impacts be?

4. Give each student a copy of Handout 34-2 to read. (This could be done as homework.)

5. Divide the class into two groups (four if the class is so large that two groups would be unwieldly). One group should take the position of the people living in Los Angeles, who need coal from Black Mesa to generate electricity for their homes. The other group should take the position of the Navajo and Hopi, who use the land to raise their crops and graze sheep. Ask each group to appoint one student to act as a spokesperson. Give the groups an opportunity to discuss the case and prepare the arguments for their position.

6. Bring the class together and let each group report its position. If time permits, you may wish to allow questions from the "opposition."

7. When both groups have completed their reports, summarize with the following questions:

- What caused the soil depletion in Black Mesa?
- Who is responsible for the problem?
- Should mining companies be allowed to mine coal in this area? Who should decide?
- What would be the best solution to this problem? (Write the solution on the board.)
- Who would benefit most from this solution? Who would benefit least?
- If you lived in Los Angeles and depended on the coal mined from Black Canyon to provide electricity for your home, would you think this solution was fair?
- If you were a Navajo or Hopi Indian who depended on this area for your food, would you think this solution was fair?

Evaluation

Ask each student to prepare a list of five issues that should be considered before reaching a decision on a soil depletion issue.

Enrichment/Extension

1. Have students research the local newspapers to find other case studies or issues where one group benefits and another loses. Students might make posters espousing one position or the other.

2. Students might also read and report on *The Grapes of Wrath*, by John Steinbeck.

Resources:

Brown, Lester R., and Edward C. Wolf, *Soil Erosion: Quiet Crisis in the World Economy* (New York: Worldwatch Institute, 1984).

Investigating Your Environment Series (Washington, DC: U.S. Department of Agriculture, 1980).

SITE NOTES

1. What kind of plants did you see growing at each site?

   Site 1 ______________________________

   ____

   Site 2 ______________________________

   ____

2. List the animals you observed at each site.

   Site 1 ______________________________

   ____

   Site 2 ______________________________

   ____

3. Were there any special ecological features in the area?

   Site 1 ______________________________

   ____

   Site 2 ______________________________

   ____

4. Describe the topography (landforms) in the area.

   Site 1 ______________________________

   ____

   Site 2 ______________________________

   ____

5. Evaluate the soil at each site.

   Site 1 (Circle one) productive deteriorated

   Site 2 (Circle one) productive deteriorated

THE BLACK MESA

Black Mesa is a great highland in the Navajo and Hopi Reservations of northeast Arizona. It is hundreds of square miles of high valleys, dry washes, and aspen-laced piney canyons descending from a surrounding rim to a basin-like center. Navajo Indians live in the northern part—gardening and grazing sheep and cows. The southern end breaks away in a series of deep canyons interspersed by high peninsulas of the mesa. Here the Hopi Indians have their villages. These remarkable people have lived here nearly a thousand years—just about the way they live now. An island of forest and grass in the desert, last outpost of ancient cultures—that's part of what Black Mesa is about.

But then there is the coal. It is spread thin over the mining lease area of 25,600 hectares (64,000 acres). That means extensive stripping and widespread devastation. It means networks of roads, big roads to carry heavy loads. The main road is a monument to all that is ecologically and esthetically wrong. This means flooding and washouts and all manner of drainage destruction and clogging. Cuts through the ridges make no attempt to run with the contours. Huge expanses of bare, wounded earth will slump and slide, and the bulldozers will come back to shove the debris into the washes. The road is a crime, a gash, and a folly.

Source: *Environmental Concerns: The Nation*, by George Peter Gregory (New York Harcourt Brace Jovanovich, 1977), p. 14. Reprinted by permission of Social Studies Curriculum Center, Carnegie-Mellon University.

35. SCIENTIFIC EXPERIMENTATION WITH ANIMALS

Introduction:

The issue of using animals, such as monkeys, apes, rats, dogs, and rabbits, for scientific experimentation is an ongoing controversy. Many argue that any type of experimentation on animals is unnecessary and cruel. They further argue that new scientific techniques allow research to be conducted without using animals. Others believe that animals are critical to physiological understanding and the development of medical treatment and cures for many diseases.

Decisions about scientific experimentation have been and will continue to be made by concerned citizens. In this activity, students investigate and then debate the issue. Debate is a process for resolving controversy, one of the most common methods used by lawmakers or government officials in decision making. During this experience, students are exposed to a method of clarifying issues that they can employ in their own lives.

Objectives: Students will be able to:

1. Explain opposing positions on the issue of animal experimentation.

2. Identify the values underlying each side of this issue.

3. Take and defend a position on the issue in a debate.

4. Appreciate the value of debate in the decision-making process.

Subject/Grade Level: General science/grade 9; biology/grade 10; chemistry/grade 11; current events/grades 9-12

Time Required: 2-3 class periods

Materials and Preparation: Make copies of Handouts 35-1, 35-2, 35-3, and 35-4 for all students. Gather resource materials that provide data for the debaters' use in preparing their arguments.

Procedures:

1. Assign the reading on Handout 35-1 to the class, either for homework the day preceding the activity or at the beginning of class, allowing time for students to read the material.

2. Explain the procedures for this and the next day or two—that the students will be involved in a debate on the issue of experimentation with animals.

3. Hand out copies of Handout 35-2 and read the dilemma with the students.

4. Assign students to debate teams of three or four students. One team supporting animal research will be pitted against another team opposing animal research.

5. Pairs of debate teams (one team for and one against) should meet and determine rules for the debate. The rules should cover the following areas:

- Time allowed for each speaker's presentation.

Source: Adapted from *Animals, Nature, and People*, one of 12 modules in the series *Science-Technology-Society: Preparing for Tomorrow's World* (Longmont, CO: Sopris West, 1982). Reprinted by permission of the publisher. For more information, call 303/651-2829.

- Time allowed for each rebuttal. (Calculate time so all debates can occur during one class period.)
- Whether questions from the opposing team or audience will be allowed.
- Criteria and procedure for selecting the winning team.
- The organizing question for the debate.

6. Teams should review the issue and complete Handout 35-3, identifying the evidence that supports the team's position, determining if the evidence will help prove the team's point of view, and assessing the reasonableness and logic of the evidence.

7. Teams should then rank their arguments from most important to least important. They should then develop a short statement that clearly explains each argument. It will be helpful if team members try to imagine the arguments that the opposing side will present.

8. The remainder of the class period should be used to prepare arguments for and against the issue.

9. At the beginning of the next class period, distribute evaluation sheets (Handout 35-4) to each student. Those who are not debating can evaluate the debating students. As an alternative, you might invite outside judges for the debates.

10. Determine the order in which the teams will debate.

11. As each team debates the issue, evaluators should:

- Identify the major arguments presented by each side.
- Rate each argument. (This might be a number from 1 to 10 with 10 being excellent.) In rating or evaluating each argument, the evaluators should determine if the argument is well presented, if the argument is supported by evidence, if the argument follows logically, and if the arguments are based on emotion or facts.

12. When all teams have debated, poll the class to determine whether the majority favors or opposes experimentation with animals. Discuss how the debates helped clarify students' positions. Why is debate a useful part of the decision-making process?

Evaluation:

Have students write letters to the editor explaining their positions on this issue. The best letters on each side of the issue could be sent to the local newspaper.

Extension/Enrichment:

1. Students could contact local universities or hospitals to get copies of the procedures they use to regulate research with animals. What improvements could students suggest?

2. Encourage students to attend a meeting of a local decision-making body or investigate Congressional debates on a science-related social issue. How did the debates aid in the decision-making process.

BURDEN OF THE BEASTS

by James Gorman

Some 60 million animals will be killed in the United States this year in the course of scientific research. Awesome tolls like this, year after year, have been shrilly denounced by antivivisectionists, whose opposition to virtually all animal research led scientists to look upon them as sentimental eccentrics. Now a more pragmatic group of opponents, the animal welfare movement, is using scientific arguments in a campaign to find responsible alternatives to animal experimentation. In December 1980, the new movement won its biggest victory yet. Revlon, which has been criticized for its animal research, announced that it was giving more than $750,000 over three years to Rockefeller University in New York City to finance a scientific search for an eye-irritancy test (for cosmetics and other products) that does not use animals.

Animals are used in about 60 percent of all biomedical research in the United States. In 1980, for example, scientific history was made when new genes were added to mouse embryos to produce a genetically altered mouse. A 1980 Nobel laureate in medicine won his prize for using skin grafts and tumor transplants in mice to advance knowledge of the human immune system. Monkeys and apes are used to study diseases like dysentery, pneumonia, malaria, and hepatitis. Animal research includes teaching sign language to chimpanzees, depriving baby monkeys of their mothers, cutting open dogs to develop lifesaving operations like open-heart surgery, and feeding millions of mice high doses of chemicals that may cause cancer.

The new opponents of animal research recognize the value of many experiments and do not want to bring science to a halt. But they contend that scientists can often get the same results with some remarkable new research techniques. Examples: testing chemicals and bacteria on bits of living tissue grown in the laboratory, creating computer models of living systems, and developing ever more sophisticated instruments to analyze chemicals. When people in the animal welfare movement join the fray with scientists, they come equipped with experts and argue science—Is this experiment valid? Is that research poorly designed?—as much as morality.

The movement for animal welfare has been active since the 19th century, when organizations for the prevention of cruelty to animals were formed in England and the United States. Its new approach was perhaps best set forth in the 1975 book *Animal Liberation*, by an Australian philosopher named Peter Singer. He argues that the natural successor to the human rights movement is an animal rights movement. He is not asking for one puppy, one vote; he is concerned primarily with pain.

Singer thinks that causing pain is wrong, and that the gulf of intelligence that separates humans from beasts does not lessen the wrong. Inability to do calculus does not make an electric shock hurt less, or a tiny cage seem more spacious. Singer finds his roots in the British utilitarian philosopher Jeremy Bentham (1748-1832), who wrote of animals: "The question is not, Can they reason? nor, Can they talk? but, Can they suffer?" If society agrees that a brain-damaged infant who can never learn to talk or a person in an irreversible coma should not be the subject of painful experiments, why deny the same compassion to a dog or a monkey? Animals have needs, desires, and lives of their own, apart from their usefulness to human beings.

Discussing the ethics of eating animals or experimenting on them, Singer says that in the Judaic and Christian traditions, man is given dominion over animals. He quotes Thomas Aquinas: "It matters not how man behaves to animals, because God has subjected all things to man's power." The tradition of Hinduism, says Singer, shows more respect for nonhuman animals, and strict Hindus have been vegetarians for 2,000 years.

Source: From *Discover* (February 1981), pp. 22-26. Reprinted by permission of the publisher.

Singer argues the obvious, that physical pain hurts all mammals, and the less obvious, that emotional pain hurts too. He writes of dogs and rabbits killed by being subjected to heat from microwaves. He cites infant monkeys deprived of their mothers and given mechanical mothers covered with cloth. To see how strong a baby's need to cling to its mother was, the experimenters created a variety of monster surrogate mothers, one of which could shoot out sharp brass spikes that jabbed the baby. Yet the babies, alone in a cage with this mechanism, would return to cling to it, again and again.

Singer's philosophy underlies the animal welfare movement, but in practice perhaps nothing sums up its nature as well as its battle against Revlon. The company uses a test, named for pharmacologist John Draize, to determine whether a chemical is likely to irritate human eyes. A substance is put into the eyes of rabbits, their heads briefly held in stocks to restrict movement. The effects, which are given numerical scores, range from mild reddening to ulceration and blinding. Revlon and other cosmetics companies use the test to measure the safety of their products for human beings, as required by federal regulations.

In 1980, a New York City high school teacher named Henry Spira began a campaign against Revlon. A former merchant seaman and labor organizer who several years ago led demonstrations against experiments on cats at the American Museum of Natural History, Spira brought together more than 400 animal welfare groups to lobby, advertise, write letters, and stage demonstrations. With political pragmatism, he chose Revlon because it is big and vulnerable. It must protect its image; fashion-model glamour fits poorly with the notion of tortured rabbits. Yet it cannot claim that eyeliners are scientifically important. Spira craftily demanded not that Revlon stop making new cosmetics, but that it pay for a program to develop an alternative testing method.

While Spira handles the rough stuff (one of his favorite phrases is "The meek don't make it"), the campaign has marshaled scientific arguments about the defects of the Draize test. In a book written for the Research Defense Society in England, animal researcher D.H. Smyth suggested that the Draize test could and should be replaced. Biochemist Andrew Rowan, of the U.S. Humane Society, one of the organizations in Spira's coalition, has written a detailed critique of the test, arguing that it is outdated and imprecise. He says that the test has been used for chemicals already known to be irritants, and proposes that tissue cultures be developed to provide the needed information.

Revlon responds that in its laboratories no rabbits are blinded, killed, abused, or even misused. "Rarely do we ever test a substance that is more than mildly and temporarily irritating, and never knowingly," writes Roger Shelley, the company's vice president for corporate affairs.

The federal government has also felt the impact of the animal welfare movement. The Interagency Regulatory Liaison Group of government agencies involved in safety testing issued new guidelines at the end of 1980. One stated that acids and bases and other known irritants should not be tested in eyes; substances as corrosive as oven cleaners have been dropped into rabbits' eyes.

The battle against the Draize test and Revlon seems to be just the beginning. Rowan believes that many kinds of animal research can be done by other methods. "If the research is worth doing, the Humane Society does not come out against it," he says. "We agree that legitimate research should be permitted to continue. The argument is about what really constitutes legitimate."

On his scale of legitimacy, basic research ranks a good deal higher than the maw of safety testing that devours mice and rats by the truckload. He objects in particular to a test called the LD-50. The name refers to the dose that is high enough to be lethal for 50 percent of the animals tested—a way of finding out how poisonous a substance is. "Extrapolating from mouse to human in this case is fraught with so many problems," says Rowan, "that using the LD-50 as a precise measurement for human beings is utter nonsense."

Like other animal welfare activists, Rowan hopes that some day no animals used in research will be hurt. But even in the short term the animal movement is asking for a basic change. Whereas the government requires good care for experimental animals, it does not regulate experiments. As Rowan puts it, researchers "can do what they damn well please." He sides with Bernard Rollin, a professor of philosophy, physiology, and biophysics at Colorado State University, who writes: "We ought to legitimately demand of all uses of animals in research that the benefits (or likely benefits) to humans (or to humans and animals) clearly outweigh the pain and suffering experienced by the experimental animals."

To many scientists, that is a restriction on freedom of inquiry, comparable to restrictions on human research, and they react to it as if someone were trespassing in their laboratories.

Joe Held, a veterinarian who is the NIH's director of research services (one function: breeding lab animals), states the basic biomedical defense of research with animals by contending that human welfare requires it. He terms the notion that all or most experimental animals suffer terribly a "gross misconception." In most research, he says, animals are well treated and the experiments are not painful. "I feel we ought to be using more animals in research," he says. "At this time, it gives a false impression to the public to say that we can reduce research and continue to improve health." The alternatives that animal activists tout, says Held, are not fully developed and in many cases are unsatisfactory because the success of an experiment depends on the complexity of a living animal.

Held recently opened a lecture with a slide showing a deformed child whose mother had been given thalidomide during the first trimester of her pregnancy. He followed that with a slide of a baby rhesus monkey similarly deformed by thalidomide. If the monkey test had been done first, Held said, the deformities in human babies might have been avoided. Other examples (among many) of the benefits to human beings of animal research: pacemakers, tetanus antitoxin, and polio vaccine.

Clarence Dennis, past president and current secretary-treasurer of the National Society for Medical Research, points out that scientists often do not know where research will lead. Dennis himself studied absorption in the intestine by operating on dogs. His work led to a new way of sewing intestines back together that has saved the lives of children who develop intestinal problems in the first two years of life.

Nevertheless, the pragmatic tactics of the animal welfare movement seem to have mollified some scientists and converted others. Dennis says he has objections to the Draize test. Many scientists are willing to credit the animal welfare movement with sensitizing researchers to what animals feel. According to Susan Fowler, editor of a magazine called *Lab Animal*, "Scientists are getting a little less nervous; both sides are willing to compromise."

As evidence of the rapprochement between science and animal welfare, several scientists helped found the Scientists' Center for Animal Welfare. The Humane Society has set up an Institute for the Study of Animal Problems. Its associate director is biochemist Rowan, who acknowledges that he killed laboratory mice in the course of his education. The institute publishes a journal in which veterinarians, behavioral scientists, biomedical researchers, and animal welfare activists discuss the shortcomings of experimentation on animals.

Gordon Burghardt, a professor of psychology and ecology at the University of Tennessee at Knoxville who sympathizes with the basic principle of animal welfare, says ethologists and others who study animals in their natural environments are far more likely than laboratory researchers to support restrictions on animal use. As an example, he points to Jane Goodall, who wrote about her experiences watching chimpanzees in a book titled *In the Shadow of Man*. She and others give scientific support to a view of animals as complex creatures that deserve respect. Ecological research, a mainstay of the environmental movement, is often cited to show that human beings belong inside rather than outside natural systems. Says Burghardt, "It's the difference between 'The world is created for man's use' and 'We're all in this together'." While disagreeing with the "abolitionists" who want to stop all animal research, Burghardt believes that the scientists who want no restrictions are just as extreme.

If Burghardt meets the animal activists halfway, Ardith Eudey goes the full distance. A primatologist at the University of Nevada at Reno who studies macaques in Thailand, she is an animal activist and co-chairman of the International Primate Protection League (IPPL). Says Eudey, "We champion the rights of primates wherever we feel there is a potential for abuse."

Eudey says that even well established uses of monkeys could be changed. The Sabin polio vaccine is grown in the kidney cells of African green monkeys (and tested in Rhesus monkeys). The fragile greens often die on the way from Africa, where they are captured wild. If medicine were to switch back to the Salk method, the vaccine could be grown and tested in human cells cultured in the laboratory.

The IPPL's push to reduce use of primates is concerned not only with the individual animal. Eudey points out that "primates throughout the world are threatened with extinction." Until recently, most primates used in research in the United States were caught wild, and Eudey says that sometimes they were used simply because they were animals of great scientific prestige.

Eudey's organization, less than ten years old, has about a thousand members, many of them primatologists. "We don't assume an antivivisectionist position as such," says Eudey; but, like Rowan, she would welcome the day when painful animal experiments ended for good.

There is little chance of animals disappearing from research labs any time soon. As the animal welfare movement well knows, if experimentation is reduced, it will not be done by holding back scientific progress. It will be done by scientists themselves finding new ways to get the answers they seek.

A DILEMMA: BEAUTY ON THE SURFACE

Lewis Ames, married with three children, has been superintendent of the animal quarters at the Beves Cosmetic Company for the past three years. He is in charge of caring and feeding of the animals used in the safety testing of the cosmetics manufactured by the company. Under his care are several thousand rabbits, hamsters, and dogs.

In the past, the company simply tested the safety of the cosmetic by applying the product—face cream, powder, lipstick, or hair coloring—on the shaved skin of the animals and observed whether the product produces skin irritations. But a number of lawsuits brought against other cosmetic companies, by parents of children who accidentally swallowed or ate the products and fell ill, have alarmed Beves company officials. The company now believes that it needs a more thorough testing program and has added new tests.

Among one of these new tests used at the lab is the acute toxicity test or LD/50 test. In this test, experimenters feed large amounts of the product to the animals to determine the amount needed to kill half the animals. In some cases, the amounts the animals must ingest are too large to be simply mixed into their food. Thus, the product tested, such as face powder, is pumped directly into the stomach of the animals. Ames observes that this force-feeding bloats the animal's stomach, causing severe discomfort and often rupturing the organ. In addition, he has watched animals suffer great distress, dying a slow death a week or two later.

Ames feels that the animals are needlessly tortured. He tried to convince the scientists to discontinue that type of testing program. He wrote government officials, but they informed him that there was nothing they can do. Since no one in the company or government seems to be interested in how lab animals are treated, Ames decided that the problem must be brought before the public. His plan is designed to attract so much attention and public outrage that the company will be forced to change its method of testing. Tonight he will take the caged test animals from the lab and place the cages in different locations all over town. When the news reporters begin to question the sudden appearance of sick and dying caged animals all over town, Ames will step forward and tell his story.

By taking such an action, Ames could immediately be fired. Should Ames carry out his plan? Why or why not?

Discussion Questions

- What right has Ames to take property from the company?
- When Ames accepted his job, did that mean that he is obliged to accept the activities the company engages in? Why or why not?
- Since Ames needs his job to support his wife and children, shouldn't he consider how losing his job might affect his family? Is this an important consideration? Why or why not?
- Should Ames be punished if he takes this action? Why or why not?
- Why might it be important to test the safety of a product before it is sold for human use?
- Since animals can't speak for themselves, should it be important for Ames to inform the public?
- Should people who use the products that have been tested on animals have any responsibility toward these animals? Why or why not?
- Should safety of a product to humans be the most important consideration for using animals to try out the product first?
- Often it is possible to test products without using animals, but this can greatly increase the cost. Should people be required to pay more for a product? Why or why not?

- Are cosmetics such as shaving lotions, shampoos, lipsticks, mascara, and suntan creams necessary when one considers the suffering animal's experience? Would it be difficult for people to give these up?
- To what rights should laboratory test animals be entitled? How might such rights be protected?
- If products are not adequately tested, we would never know whether they can cause dangerous illnesses. Is that reason enough to use animals in testing?
- What do you consider to be acceptable ways to use animals in laboratories? Unacceptable?

DEBATER'S WORKSHEET

Issue____ Pro___ Con___

Argument	Evidence or Facts	Further Explanation (what does the argument mean in terms of benefits or effects?)
1		
2		
3		
4		
5		

DEBATE EVALUATION SHEET

Debate Question: ____

	For		Against	
	Arguments	Rating	Arguments	Rating
Issue 1: ______________	1.		1.	
____________________	2.		2.	
	3.		3.	
	4.		4.	
	5.		5.	
Issue 2: ______________	1.		1.	
____________________	2.		2.	
	3.		3.	
	4.		4.	
	5.		5.	
Issue 3: ______________	1.		1.	
____________________	2.		2.	
	3.		3.	
	4.		4.	
	5.		5.	
Issue 4: ______________	1.		1.	
____________________	2.		2.	
	3.		3.	
	4.		4.	
	5.		5.	
Issue 5: ______________	1.		1.	
____________________	2.		2.	
	3.		3.	
	4.		4.	
	5.		5.	