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ABSTRACT

This publication is an energy curriculum for grades 7 through 9. In each of the six modules a number of activities are provided. The module titles are: (1) Energy: What is it About?; (2) Energy: Where Does it Go?; (3) Energy: Its Present Sources; (4) Energy: Policy and Prospects; (5) Energy: Is There Another Way?; and (6) Energy: How Can I Help? Objectives, explanations of what to do, and teacher's notes are given for each activity. Where needed, diagrams, tables and other teaching aids are provided for direct copying. The types of activities range from simple lab experiments to group discussions. Other features of this publication include a bibliography, a list of possible audio-visual aids, and an attitude survey to help measure the effect of these energy education materials. This curriculum is designed to be an interdisciplinary and fairly complete energy education program which ultimately brings students to energy conserving lifestyles. However, teachers may easily adapt modules and activities to fit their own designs. (MR)

Commonwealth of Pennsylvania
Milton J. Shapp, *Governor*
Ernest P. Kline, *Lieutenant Governor*

Department of Education
Caryl M. Kline, *Secretary*
Robert N. Hendershot, *Executive Deputy*

Office of Basic Education
Frank S. Manchester, *Commissioner*
Harry K. Gerlach, *Deputy Commissioner*

Bureau of Curriculum Services
David C. Campbell, *Director*

Division of Personal Education
Irvin T. Edgar, *Chief*
John J. McDermott, *Senior Program Adviser*
(*Chairperson* - Education Task Force)

Pennsylvania Department of Education
Box 911
Harrisburg, PA 17126

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF EDUCATION
BOX 911, HARRISBURG, PA 17126

THE SECRETARY

AREA CODE 717
787-5820

America is faced with an energy dilemma which President Carter has described as the "moral equivalent of war." Our nation's productivity and our own lifestyles are threated by the declining availability of some fossil fuels and the greatly increased prices of others. For the first time in the history of the United States, our economic well-being is dependent upon uncertain supplies of foreign fuel, the price of which is set by the Organization of Petroleum Exporting Countries. The nation must decrease its reliance upon these scarce and expensive fuels and develop alternate energy sources to meet its needs.

It is of the utmost importance that our youth understand the problem, its consequences, and the possible alternate solutions. The future well-being of all Americans depends upon our reactions to the energy challenge.

This curriculum was carefully developed under the direction of the Department of Education and the Governor's Energy Council to inform students about the current energy situation and to increase their awareness of what they, as individuals, can do about it.

Caryl M. Kline
Secretary of Education

EDUCATION TASK FORCE MEMBERS

Roy Allison
Professor of Science Education
Capitol Campus, Pennsylvania State University
Middletown, PA 17057
Home: 504 Redwood Street
Harrisburg, PA 17109

Michael Baker
Manager
Education Management Development Center
Carnegie Mellon University
Pittsburgh, PA 15213
Phone: (Office) 412-621-2600 Ext. 810

Charles Bell
Science Teacher
Wyomissing Area School District
Girard and Evans Avenues
Wyomissing, PA 19610
Home: 507 Lawrence Avenue
Reading, PA 19609
Phone: 215-374-4031 (Office)

William Bolles
Science Education Advisor
Pennsylvania Department of Education
Box 911
Harrisburg, PA 17126
Phone: (Office) 717-787-7320

Charles E. Bradley, Jr.
Pennsylvania Environmental Council
225 South 15th Street
Philadelphia, PA 19102
Phone: (Office) 215-PE5-0966

H. B. Brown
Keystone Bituminous Coal Association
660 Boas Street
Harrisburg, PA 17101
Phone: (Office) 717-236-5901

William J. Byron
President
University of Scranton
Scranton, PA 18510
Phone: (Office) 717-961-7500

Valerie Ann Dalski
Energy Action Office
Box 355
Pittsburgh, PA 15230
Phone: (Office) 412-373-4688
(Home) 412-823-1022

Heidi Ferrar
312 Ridge Avenue
State College, PA 16801
Phone: (Home) 814-237-0810

H. Seymour Fowler
Professor of Science Education
Pennsylvania State University
165 Chambers Building
University Park, PA 16802
Phone: (Office) 8-475-6321 Network

Janet Fay Jester
135 West Mitchell Avenue
State College, PA 16801
Phone: (Home) 814-128-4629

William Jester
Department of Nuclear Engineering
Pennsylvania State University
University Park, PA 16801
Phone: (Office) 8-475-2011 Network

Vernon Lyter
Science Teacher
Lower Dauphin Senior High School
Hummelstown, PA 17036
Home: R. D. 1
Trail Road
Hershey, PA 17033
Phone: (Office) 717-566-3721

John J. McDermott (Chairperson)
Senior Program Advisor
Bureau of Curriculum Services
Pennsylvania Department of Education
Box 911
Harrisburg, PA 17126
Phone: (Office) 717-787-7320

Richard Miller
Pennsylvania Gas Association
State Street Building
Harrisburg, PA 17101
Phone: (Office) 717-233-5814

Frank Montgomery
Richard Wall
Pennsylvania Electric Association
800 North Third Street
Harrisburg, PA 17101
Phone: (Office) 717-234-6171

Randall Pickett
Governor's Energy Council
905 Payne Shoemaker Building
Harrisburg, PA 17101
Phone: (Office) 717-787-9749

John Plank
Culbertson Elementary School
Goshen Road
Newtown Square, PA 19073
Home: 3720 School Lane
Newtown Square, PA 19073
Phone: (Office) 215-EL6-9400

Dorothy Pisano
Science Division
School District of Philadelphia
Room 305 Administration Building
21st and Parkway
Philadelphia, PA 19103
Home: 1365 Indian Creek Drive
Philadelphia, PA 19151
Phone: (Office) 215-299-7772

Sister Gregory Schessler
Mt. Alvernia High School
146 Hawthorne Road
Pittsburgh, PA 15209
Phone: (Office) 412-821-2200

Emanuel Sillman
Biology Department
Duquesne University
Pittsburgh, PA 15219
Phone: (Office) 412-434-6321 or 6332

Jeanne Snyder
Middletown Area School District
1637 Main Street, R. D. 3
Mechanicsburg, PA 17055
Phone: (Home) 717-697-1582

Nancy M. Sobolevitch
Governor's Energy Council
Energy Conservation Coordinator
905 Payne Shoemaker Building
Harrisburg, PA 17101
Phone: (Office) 717-787-9749

Pat Vaganka
1567 Old Abers Creek Road
Monroeville, PA 15146
Phone: (Home) 412-325-2042

Ronald Weaver
David L. Swartz Intermediate High School
Carlisle, PA 17013
Home: 2601 West Ridge Street,
Carlisle, PA 17013
Phone: (Home) 717-249-3383

Terry Webb (Mrs.)
Spanish Tract Road, R. D. 5
Sewickley, PA 15143
Phone: (Home) 412-741-9368

Samuel Wenger
Manheim Central School District
Manheim, PA 17545
Home: 2156 Main Street,
Rothsville, PA 17573
Phone: (Office) 717-665-2451
(Home) 717-626-4050

Paul Wighaman
Industrial Arts Department
Millersville State College
Millersville, PA 17551
Phone: (Office) 717-872-5411

Charles Young
District 4 Office
Hill School
32nd and Ridge Avenue
Philadelphia, PA 19132
Home: 422 East Gorgas Lane
Philadelphia, PA 19119
Phone: (Office) 215-CE5-1737
(Home) 215-CE8-5790

COMMONWEALTH OF PENNSYLVANIA
LIEUTENANT GOVERNOR'S OFFICE
HARRISBURG

ERNEST P. KLINE
LIEUTENANT GOVERNOR

Dear Energy Conservation Instructor:

As you know, conservation is presently the only real alternative that we have to the energy problems that presently confront us. Conservation of our natural resources involves a complex understanding of how things interact in our environment. For this reason, it is difficult to realize substantial immediate change in our present consumption, since many of our present decision makers were not afforded an opportunity to be involved in a comprehensive instructional program.

You, as educators, have the unique opportunity to help instill conservation awareness in our society since you are involved with our most precious natural resource - our children. Given proper instruction, these children will mature to be the energy-conscious decision makers of tomorrow.

Conservation concepts such as those presented in this six-volume Energy Curriculum Guide will better equip children to include conservation as part of their daily lives. This can only happen if we begin to inform children in our public and private schools by making energy conservation as integral part of the total curriculum.

Although these curriculum do not provide all the answers to the complex problems of energy, they do provide an excellent format from which to launch a conservation awareness program. We hope you will include the curriculum as part of your total instructional program.

Thank you for your cooperation.

Sincerely yours,

Ernest P Kline

ERNEST P. KLINE
Chairman
Governor's Energy Council

To the Teacher:

As the energy problem becomes increasingly important, it is critical that children and adults alike have a greater appreciation for the complexities involved in living in an energy-poor world. The social, technological, economic, and environmental aspects will all be necessary considerations in understanding and implementing an energy conservation ethic.

This guide is intended to help teachers plan an instructional program dealing with several aspects of the energy problem. The six modules can be used in their totality to provide a complete study, or can be used singly to enhance an ongoing program. As the topic is multi-disciplinary, the material can be inserted into many different areas of study. Within a given module, the information and activities can be used as presented, rearranged, added to, or deleted to fit your specific program.

While many of the activity pages can be reproduced for student use, the background information was written for you the teacher, and thus may not be on an appropriate reading level for your students.

This guide contains the following helps for the teacher:

An outline of the contents of the modules. Each section of the modules contains background information for your use followed by related activities for your students.

A bibliography of a wide variety of sources of more information.

Names and addresses of trade associations and government agencies to which you or your students may write for more information.

Energy sites to visit in Pennsylvania.

A list of multi-media materials and their sources.

An attitude survey to help you measure change in student attitude as a result of their learning.

Through the use of the modules and your interest and enthusiasm, the students should develop an appreciation of the energy problem as well as a conservation ethic. This is the goal of the energy curriculum.

CONTENTS OF THE ENERGY MODULES

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Webb, Mary T. *Energy Module for Pa: Teaching Concepts and Activities for the Understanding of Energy*, April 1976. Written as a Research 422 requirement for Duquesne University, Pittsburgh, PA.

OTHER SOURCES OF INFORMATION

Coal:
National Coal Association
Attn: Director of Educational Services
1130 Seventeenth St., NW
Washington, DC 20036

Electricity:
Edison Electric Institute
Attn: Public Relations Dept.
90 Park Ave.
New York, NY 10016

Natural Gas:
American Gas Association
1515 Wilson Blvd.
Arlington, VA 22209

Nuclear Power:
Atomic Industrial Forum
Attn: Public Relations Dept.
7101 Wisconsin Ave.
Bethesda, MD 20014

U.S. Nuclear Regulatory Commission
Attn: Public Affairs Dept.
Bethesda, MD 20014

Oil or Gasoline:
American Petroleum Institute
Attn: Information Service Dept.
2101 L St., NW
Washington, DC 20037

National Petroleum Council
Attn: Director of Information
1625 K St., NW, Suite 601
Washington, DC 20006

General Energy Topics:
U.S. Energy Research and Development Admin.
Attn: Public Affairs Office
Washington, DC 20545

Federal Energy Administration
Office of Energy Conservation
12th and Pennsylvania Ave., NW
Washington, DC 20461

Consumer Information
Public Documents Distribution Center
Pueblo, CO 81009

ENERGY SITES TO VISIT IN PENNSYLVANIA

Limerick Generating Station
Linfield, PA

The information center is open Wednesday through Sunday and holidays from 10 am to 4 pm. It is closed on Christmas and New Year's Day.

The Limerick Generating Station, which is being built by the Philadelphia Electric Company, will have two boiling water reactors. At the information center on the construction site, there are exhibits on atomic energy, electricity, and energy. A scale model of the Limerick Generating Station and animated exhibits about its operation are also provided.

To arrange for group tours and special programs, or to obtain additional information, please contact:

Philadelphia Electric Company
Limerick Atomic Information Center
198 Longview Road
Linfield, PA 19468

Peach Bottom Atomic Power Station
Delta, PA

The information center is open Wednesday through Sunday and holidays from 10 am to 4 pm. It is closed on Christmas and New Year's Day.

Peach Bottom Atomic Power Station, with two boiling water reactors in operation, is one of the largest nuclear generating units in the world. In the information center are exhibits on electricity, nuclear power, and energy. After a tour of the exhibit area, visitors may hear lectures and watch demonstrations and films in the auditorium.

Planned programs for groups can be scheduled. For additional information, please contact:

Philadelphia Electric Company
Atomic Information Center
Delta R.D. #1
Peach Bottom, PA 17563

Muddy Run Pumped-Storage Hydroelectric Plant
Drumore, PA

The Muddy Run Plant is operated in cooperation with the Conowingo Hydroelectric Station. Water is drawn from a reservoir above the powerhouse to generate electricity at times of peak demand, and water is pumped up into the reservoir at times of low demand. A 100-acre recreational lake was developed at the reservoir, with camping, fishing, boating, and picnicking facilities.

For additonal information, please contact:

Philadelphia Electric Company
Community Relations Department
2301 Market Street
Philadelphia, PA 19101

Seldom Seen Valley Coal Mine
St. Boniface, PA

The mine is open daily from 9 am to 8 pm from April 15 to Labor Day. It is open only on weekends from Labor Day to October 31.

Visitors may ride 2200 feet into the mine. Exhibits show many mining details. There is a museum at the main portal. Special group tours may be arranged.

For additional information, please contact:

Seldom Seen Valley Coal Mine
St. Boniface, PA 16675

Tour-Ed Mine
Tarentum, PA

The mine is open daily from 1 pm to 5:30 pm from Memorial Day to Labor Day. During May and September it is open only on Saturday and Sunday from 1 pm to 5:30 pm.

The visitor views display areas a half-mile underground, showing various machines and mining methods of the past and present. The Tour-Ed Mine display was created from a worked-out section of an operating coal mine. For additional information, please contact:

Tour-Ed Mine
R.D. 2
Tarentum, PA 15084

Drake Well Park and Museum
Titusville, PA

The park and museum are open Tuesday through Saturday from 10:30 am to 4:30 pm; on Sundays from 1 pm to 4:30 pm. They are closed on major holidays and election days.

The Drake well was the world's first commercial oil well. Today, an operating replica of the derrick and enginehouse, a museum, and a park with picnic area mark the site of this oil well. The museum contains working models, dioramas, an electric map, and complete audiovisual facilities, along with a research library on the beginnings of the oil industry.

For further information, please contact:

Drake Well Museum
R. D. 3
Titusville, PA 16354

MODERN TALKING PICTURE SERVICE. INC.

Exxon Film Library
2323 New Hyde Park Road
New Hyde Park, NY 22040

Three E's (Energy, Economics and the Environment) #04900

28 minutes, 16mm color, high school to adult, available with teacher's guide.

This film describes the complex relationship between energy, economics and the environment. It shows how the three E's are interdependent, relates the problems that have arisen in each area, and offers some solutions by experts in a number of areas. This film confronts the viewer with a basic question: How much is each of us willing to sacrifice in order to solve the problem?

A Funny Thing Happened On The Way To The Gas Station, #04903

28 minutes, 16mm color, elementary to junior high school through adults, available with teacher's guide and classroom posters.

This is the story of a 13-year old boy's remarkable journey as he follows the making of gasoline from a producing well in Texas to a service station in New Jersey. By means of a fantasy journey, the boy visits an actual oil production site, rides aboard an oil tanker, visits a modern refinery and an oil marketing terminal as he learns in entertaining fashion the many steps involved in producing a gallon of gasoline.

Faces of Energy, #04906

28 minutes, 16mm color, high school through adult.

This magnificent documentary tells the story of the petroleum industry through a series of individual portraits of people at work in its various functions. The story was filmed in the Atlantic with an exploration ship, along the Alaskan pipeline, offshore in the Gulf of Mexico on an oil platform, aboard a tanker moving along the lower Mississippi River, in a California refinery, and at a lobster-loading dock in Beals Island, Maine.

World Beneath The Sea, #04904

28 minutes, 16mm color, high school through adult.

The relentless search for oil and gas off the coasts of the United States is described in this film. World Beneath the Sea tells how offshore drilling developed through the years and shows the various types of platforms used today. The film explains and shows the devices used by the industry for safety and environmental protection. It also deals with the onshore side of offshore development.

Refinery, #4879

16 minutes, 16mm color, high school to adult, available with a teacher's guide.

The amazing process of converting crude oil into everyday consumer products, such as gasoline and home heating oil, is shown in this film. Though the steps are complex, this film explains clearly and simply through animation and live action footage how the crude oil is turned into numerous useful products to serve mankind.

Nuclear Energy: Power For Today and Tomorrow, #4884

28 minutes, 16mm color, high school to adult, available with teacher's guide.

Nuclear energy will play an increasingly important role in the years ahead in helping America meet its expanding energy needs. This film describes Exxon's part in the search for, mining, milling and fabrication of nuclear fuel for power generation.

A World of Energy, A Dresser Industries, Inc. Production #30707

29 minutes, 16mm color, junior high to adult.

This important film focuses on today's most critical problem: How and where will we get enough energy to meet our needs while protecting our environment? And what will it cost? An up-to-date analysis of the development and use of today's energy sources is shown, as well as an examination of new forms of energy being researched. This provocative film will stimulate viewers to make their own conclusions for the challenge ahead.

The New Jet Set, a General Motors Corporation Production #30364

15 minutes, 16mm color, 9th grade and higher.

The turbine engine is increasingly important as we seek efficient sources of energy. This film shows a variety of gas turbine engines at work....in the air, on the ground, and in the sea. There are also behind-the-scenes visits at the factory where turbines are made. Free printed teaching materials provided with this film.

Energy vs. Ecology.....The Great Debate, an Allis-Chalmers Corporation Production #30031

27 1/2 minutes, 16mm color, 9th grade and higher

Coal is the most abundant source of energy in this country. This film indicates how we utilize this valuable source without disrupting our environment. It illustrates the surface mining of thousands of acres of land and shows how that same land is then restored to usable productivity and ecologically sound conditions.

Struggle For Power, a Caterpiller Tractor Company Production #30573

28 minutes, 16mm color, junior high school to adult.

This film's objective is to show how coal can do the most to solve the energy crunch.....how it can and must be utilized in the future, due to its abundance, versatility and inexpensiveness.

Pennzoil and The Energy Crisis, Pennzoil Company #30371

37 minutes, 16mm color, junior high school to adult.

This film is a candid discussion of the energy shortage in America....the causes, effects, policies, controversies, misconceptions, truths, and myths involved.

One Hoe For Kalabo, a National Machine Tool Builders Association Production #4663

27 minutes, 16mm color, junior high school to adult.

From United States industrial plant to African Village....the story of how machine tools have given dignity and power to human labor and world civilization.

PENNSYLVANIA POWER AND LIGHT COMPANY
Information Center
Two North Ninth Street
Allentown, PA 18101

A is for Atom

15 minutes, 16mm color.
Through the use of lively animation, facts about the atom are presented in easily understood terms. Explains the electrical forces which hold the atom together, discusses radioactivity, and shows the uses of particle accelerators. Shows nuclear applications in space, agriculture, medicine, industry, and many research areas, as well as in our daily lives.

Nuclear Power and the Environment

15 minutes, 16mm color.
Tells how our nation's ever-expanding need for electrical power can be balanced with the need to preserve and protect our environment. Explains the reasons why nuclear electrical generation will be needed in the future, and how it can be done without jeopardizing the natural environment.

The Mighty Atom

17 minutes, 16mm color.
Reddy Kilowatt presents this animated story of electricity with humor and audience appeal. He takes the audience from the discovery of electricity in 600 B.C., through Edison's inventions, up to atomic energy used today in generating electric power.

The Petrified River

25 minutes, 16mm color.
Scenically portrays the search for uranium, how one prospects for it with pick and Geiger counter, how it is mined and how it is used in medicine, manufacturing, and for other peaceful purposes. An animated sequence shows how an atomic power station works.

Now That The Dinosaurs Are Gone

28 minutes, 16mm color.
Explains the necessity of nuclear power at a time when the fossil fuel situation is unpredictable. Gives a synopsis of nuclear power and how it works.

Electricity

13 minutes, 16mm color.
Live action, animated diagrams, working models and photographs of actual application are combined with original music to answer three basic questions about electricity: Where does it come from? How does it work? How does it get to me?

Not Enough Power

17 minutes, 16mm color.
Shows what life today would be like without electricity or with its use highly restricted as happened during a coal strike in Britian in 1972.

Energy: Less Is More

18 minutes, 16mm color.
Illustrates the necessary changes our transportation system should undergo to move people and cargo more efficiently, and the need to design buildings that are more efficient in their use of energy.

The Eager Minds

27 minutes, 16mm color.
Relates the story of electricity....its past, present and future.

The Energy Challenge

25 minutes, 16mm color.
Provides a concise, up-to-date and penetrating study of the endless search for new and abundant sources of energy.

The Great Search

13 minutes, 16mm color.
This Walt Disney animation depicts the story of the discovery, development and application of the major sources of energy.

Electricity - The Way It Works

16 minutes, 16mm color.
Explains where electricity comes from.....what it is.....how it is produced and transmitted.....and what are America's future needs and sources.

To Be Continued

28 minutes, 16mm color.
Explains the conversion of primary energy to electric energy and its delivery to the public. Shows the latest advances in electric production that keep the cost low and efficiency high.

What Time Is The Power On Today?

28 minutes, 16mm color.
Scheduled electric power only a few hours a day.....jobs gone, food scarce, hand-operated gas pumps, manual traffic signals, ice men, washboards, schools closed. At 10:30 am, the city's power is shut off until 4:30 pm. At 11 pm it will be shut off again until 8 am. Who is responsible for this catastrophe? Why did it happen? What can be done to get the power back? In the presence of the press and live TV coverage a special commission, determined to fix the blame and get to the bottom of it, cross-examines witnesses.

When the Circuit Breaks: America's Energy Cricis - FEA Production

28 minutes, 16mm color.
Shows how America's energy crisis happened and what possibilities the future holds. Examines some solutions available through development of coal, oil, natural gas, nuclear, geothermal and solar energy sources. Stresses importance of conserving energy at home, in transportation, business and industry.

You Are There

28 minutes, 16mm black and white.

Depicts the exciting moments around the successful experiments of the incandescent lamp bulb by Thomas Edison in 1879. Portrays the long, tiring hours spent by Edison and his associates as they watched and hoped that each test they made would be the successful one.

INTERMEDIATE UNIT INSTRUCTIONAL MATERIALS CENTER

Several located in Pennsylvania. Contact nearest office.

These centers might have in their film library an excellent series of films produced on the subject of energy and energy conservation for classroom use in junior high through adult levels. This provocative film series, produced by A Churchill Film, 662 North Robertson Boulevard, Los Angeles, CA 90069 in cooperation with Environmental Quality Laboratory, California Institute of Technology, Pasadena, CA, explores various aspects and alternatives in helping to solve the energy problem. This film series includes the following film titles:

Energy: The Dilemma
Energy: The Nuclear Alternative
Energy: New Sources
Energy: Less Is More (conservation)

Energy: The Dilemma

20 minutes, 16mm color.
Subject Areas: Social studies, contemporary problems.

This film surveys our dramatic increase in the use of energy. Examines the North American and world supply of oil and gas, the increased cost, difficulties and environmental hazards of obtaining them, and the fact that readily obtainable domestic sources will be used up within a few decades. Considers the problems of obtaining oil from shale. A major section deals with the supply of coal and the environmental consequences of full exploitation of our western deposits. The slow development of nuclear energy and its attendant difficulties are examined. The dilemma is that we are trying to supply increasing amounts of energy from dwindling supplies in ways that are increasingly costly, hazardous and damaging.

Energy: The Nuclear Alternative

20 minutes, 16mm color.
Subject Areas: Social studies

The film deals with the nuclear power program as a controversy, with concerned scientists and citizens engaged against the utilities, industry, and government agencies.

There is a brief survey of the nuclear plant building program and an explanation of how a reactor powers a turbogenerator to make electricity. Thereafter the film explores operational problems and hazards, (1) at the reactor, where a malfunction of the emergency core cooling system could cause a melt-down, and where accidents could result from sabotage, war, natural disasters and human error; (2) during transportation of radioactive materials to reprocessing plants is to dispose of it in such a way that plutonium is kept out of the biosphere for 500,000 years.

The debate centers on how safe are the safeguards, whether we can find solutions to certain as yet unsolved problems, and whether we should have a moratorium.

Energy: New Sources

20 minutes, 16mm color.
Subject Areas: Social studies, contemporary problems.

This film surveys briefly some of the potential sources of energy which have not received much attention: wind, tides, burning of trash, methane from trash or animal wastes, and thermal gradients in the oceans. The body of the film deals with geothermal, fusion and solar energy. The possibilities of solar cells, solar panels for hot water and temperature control of buildings, and solar heat for generation of electricity are considered. Discussed also is the national policy which has led to neglect of these sources in favor of nuclear energy.

Energy: Less Is More

18 minutes, 16mm color.
Subject Areas: Social studies, contemporary problems.

Considering the developing shortages of fossil fuels and the problems with other energy sources, we are faced with the need to cut back in areas of major energy use. Four principal areas are discussed: transportation, buildings, appliances, waste.

Alternatives to the way we use automobiles; the worst fuel waster, are probed. Ways to make cooling, heating and lighting of buildings more efficient are shown. The need for more efficient design of appliances is noted. Our throw-away society which encourages unneeded packaging, disposable containers, and built-in obsolesence is discussed.

Other Available Intermediate Unit Instructional Materials Center Films:

Energy

Intermediate and junior high level

This film presents an artistic analysis of a dynamic concept. Examines the interactions between various forms of matter and energy in physical processes. Treats in a loose historical fashion how people gradually related phenomenons such as gravity, heat, electricity, magnetism, and radioactivity under a single idea of growing complexity.

Energy to Burn

Junior high school to senior high school.

This film notes that making and storing energy has gone on for hundreds of millions of years. Traces various energy conversions. Contrasts the use of energy by agricultural societies vs. industrialized societies. Questions what we will do when the oil and gas run out. It offers suggestions for new technological development but shows that each new development seems to involve additional problems.

CONSOLIDATION COAL COMPANY
One Oliver Plaza
Pittsburgh, PA 15222

The following films are offered for free loan.

Profile of a Modern Mining Company

24 minutes
Complete story of coal, from where it is located, mining methods, and on through land reclamation.

Evolution of Pollution

28 minutes
Cartoon story of pollution and how it came about.

Rebirth of the Land–The Dent's Run Project

27 minutes
Environmental clean-up of a 14 square mile area in West Virginia.

Energy vs. Ecology–The Great Debate

28 minutes
Surface mining of coal and reclamation, and how it fits into the overall energy picture.

An American Asset

28 minutes
Coal mining techniques and overall uses.

North Dakota–The Land of Two Harvests

8 minutes
Western reclamation

AMERICAN GAS ASSOCIATION
Film Service Library
1515 Wilson Boulevard
Arlington, VA 22209

Clean Energy for Today and Tomorrow

27 minutes, color film, 1975.
Hosted by Hugh Downs. Tells the role of natural gas and experiments for new sources of energy.

Energy

20 minutes, color film, 1972.
Traces energy sources from the first fires to fossil fuel to atomic energy. Outlines problems and offers solutions.

ASSOCIATION-SERLING FILMS
325 Delaware Avenue
Oakmont, PA 15139

Gas from Navajo Coal

22 minutes, color.
Coal gasification and solving pollution problems.

King Zog and the Energy Crunch

19 minutes, color, junior high up.
King kept palace comfortable and conserved energy. How he did it.

INSTITUTE OF SCRAP IRON AND STEEL, INC.
1719 H Street, NW
Washington, DC 20006

The Endless Search

28 minute film, color.

It's Our Choice

11 minutes, sound-slide film, color, 33-1/3 record

MacMILLAN LIBRARY SERVICES
202B Brown Street
Riverside, NJ 08075

Energy and the Environment: How to Live on the Earth a Long Time Without Using It All Up.

Four color sound filmstrips; 12-15 minutes each, available with records or cassettes. 32-page illustrated teacher's manual and study prints. Complete set about $80.

Created for upper elementary and junior high students. Explains such concepts as energy waste, new sources of energy, and ways of reducing the energy drain.

MICHIGAN STATE UNIVERSITY
Instructional Media Center
Off campus scheduling
East Lansing, MI 48824

Energy and All That

30 minutes, 1973.
Problems of crisis. Narrated by laymen and oil personnel. Tells how to educate people to economize.

PENNSYLVNAIA DEPARTMENT OF EDUCATION
Environmental Education Films
Box 911
Harrisburg, PA 17126

Helios

Color.
Focuses on the sun as the prime source of energy. Examines problems associated with increased use and limited supplies of our main fuel sources of energy. Presents information on the prospects for our meeting energy needs in the future.

Investigating Heat Loss.

20 minute, color TV tape. Send blank TV tape cassette to PDE who will tape the lesson free upon request.

Following a view and discussion of a number of ways in which energy is used, a diagram of a house and a home heating system are shown to illustrate heat loss in a home and ways in which insulation can cut down on this loss of heat.

NATIONAL ASSOCIATION OF RECYCLING MATERIALS, INC.
Attn: Filmstrip Distribution
33 Madison Ave.,
New York, NY 10017

Recycling Resources

13 minutes, filmstrip

NEW JERSEY STATE MUSEUM
Film Loan Service
Trenton, NJ 08625

Time to Live

29 minutes, color.

Human progress is dependent on production and utilization of cheap, versatile sources of energy; some sources of energy that meet the criteria are discussed.

ATTITUDE SURVEY

The following attitude survey can be used to determine any difference in student attitude that might occur as a result of this curriculum.

The accompanying answer key indicates the most positive response to each question in terms of energy conservation. The most positive response in each case is to be scored 5, while all other responses are to be scored in a diminishing order from 5.

For example: Questions 1, 2 and 3: The E response should be scored 5, D response scored 4, C response scored 3, B response scored 2, and the A response scored 1.

Question 4: The most positive response was A, which should be scored 5, B response should be scored 4, C response scored 3, D response scored 2, and the E response scored 1.

Most Positive Responses

1.	E	13.	A
2.	E	14.	A
3.	E	15.	A
4.	A	16.	A
5.	E	17.	E
6.	E	18.	A
7.	A	19.	A
8.	A	20.	A
9.	A	21.	A
10.	A	22.	A
11.	E	23.	E
12.	E	24.	E

The survey is given on the following pages so that it can be copied directly.

Attitudes Toward Energy Conservation

The purpose of this survey is to determine how you feel about energy conservation. Because this measures how you feel, there are no right or wrong answers. Read each statement carefully and record your feelings about what the statement says by placing an "X" on the scale, and by recording the letter of your choice in the space to the left, as shown in the example.

Example:

B 1. Most students like chocolate candy.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	X			
A	B	C	D	E

Since the person answering this question agreed that most students like chocolate, he/she placed an "X" above "Agree" on the scale, and recorded the letter B assigned to "Agree" in the space to the left of the item number.

____ 1. There is no energy crisis.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 2. The automobile is an efficient means of transportation.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 3. Rationing of gasoline is the best way to solve the energy crisis.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 4. The 55 mph speed limit is an efficient means of fuel conservation.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 5. Only the government can solve the energy problem.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 6. Big business created the energy scare in order to raise prices.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 7. All citizens should be willing to make sacrifices to conserve energy.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 8. Even though coal contributes to air pollution, it should be used to produce energy.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

_____ 9. Oil is such a valuable source of petrochemicals that it is too precious to be burned as fuel.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

_____ 10. Means of mass transportation should be developed to save fuel.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

_____ 11. The energy crisis is over.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

_____ 12. Oil companies are not really concerned with ways to find new sources of oil to solve the energy situation.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

_____ 13. We will soon run out of oil.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

_____ 14. To save energy we should not permit night sports events.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

_____ 15. To save energy all shopping centers should close at sundown.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C		E

____ 16. The automobile is a very inefficient source of energy.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 17. Industry should be required to cut back on energy before the general public.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 18. The life style in the United States is related to the amount of energy we use.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 19. We should not depend on foreign nations for energy.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 20. We should launch national programs to find new types of energy sources.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 21. Nuclear reactors are safe sources of energy.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

____ 22. Airlines should reduce the number of flights to conserve energy.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

___ 23. The energy sources we now have available are all that we really need.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

___ 24. The government should stay out of the energy market.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A	B	C	D	E

ENERGY

WHAT IS IT ALL ABOUT?

MODULE 1

AN ENERGY CURRICULUM
MODULE #1

Governor's Energy Council

Pennsylvania Department of Education 1977

DEFINITION OF ENERGY

Before people can really understand the energy problems facing the world today, they need to know what energy is, how it is measured and changed, how it affects our lives, and how it "disappears".

In this first module, we will present such background material, in the hope that any further study of energy problems will be more meaningful.

The word "energy" can have a number of meanings. In this text, we will define it as scientists and engineers do: energy is the ability to do work. The word "work" in this definition also has a special meaning: it refers to the movement of matter from one point to another. For example, we do work when we push or pull an object for some distance, and energy is the ability to do this work.

Energy can appear in different forms. One of the most familiar is mechanical energy – that which is produced when objects are moving. Other common forms are radiant energy, chemical energy, and electrical energy. We will talk at greater length about these different forms of energy in later sections of this module. We will also discuss how the various forms of energy can be changed from one form into another.

Throughout history, people have developed sources of energy to work for them. Primitive humans had only the strength of their bodies, and later the use of fire. People tamed animals to work for them. They used the energy of wind to move sailing vessels, and the energy of water to turn mills. With the invention of the steam engine, steam could be used to run machines. The discovery of electricity created another important way of using energy. So did the invention of the gasoline engine. A new era in the use of energy was entered with the application of nuclear energy.

Most of the energy we use comes directly or indirectly from the sun. For example, when the radiant energy of the sun falls on the earth, it is changed to heat energy, warming the earth. When the sunlight falls on the leaves of plants, it is changed into chemical energy, enabling the plants to make food for animal consumption, and wood which we can burn to work for us. Other plants have been stored under the surface of the earth, where they have undergone chemical changes into coal, oil, and gas. These are called the fossil fuels, and they are presently our major source of energy.

Activity I-1

Objectives:

The student will develop a definition of energy based on how energy was used in the past and based on the student's own personal experience with energy.

The student will demonstrate an understanding of what energy is.

The student will modify the original definition to include ideas demonstrated by the teacher and other members of the class.

The student will arrive at an understanding of energy based on motion and work concepts.

What to do?

A. What is energy? Have students define energy in terms of how they as individuals look at energy in the way it was used in the past. Use transparencies prepared from included sketches in this section for consideration by the class. What ideas about energy does each picture suggest?

1. early caveman
2. early colonial miller
3. early sailor
4. Indian starting a fire using the friction heat from a turning stick
5. Conestoga Wagon and horse team
6. railroad steam engine
7. early xylophone player
8. nuclear powered submarine
9. Franklin's kite experiment
10. early colonial blacksmith
11. potato farmer
12. automobile driver
13. boy drinking water
14. camera used in taking a picture
15. early man using fire and rock with lever to hunt an animal.

B. In light of the illustrations and the student descriptions of energy, what does energy mean to you?

C. Have each student demonstrate what energy is, using present day ideas and activities. Encourage students to use their imagination in working up a demonstration for the class. In introducing this aspect of the activity, suggest that the students consider this question: If you were to show someone what energy is, how would you do it?

D. How would you need to change your initial definition of energy to include all the ideas about energy which have been demonstrated by the class members and by the teacher?

E. Lead the student to an understanding that each demonstration did not actually show what energy is, but rather the *effects of energy*.

F. What then is energy?

Energy is defined as simply the ability to do work.

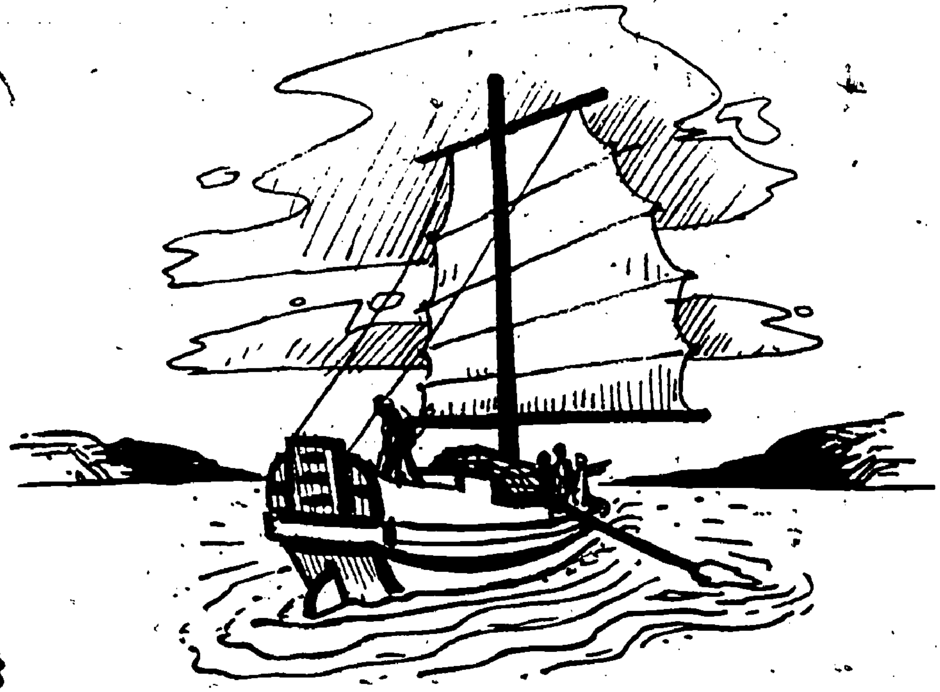
Activity I-2

Objective:

The students will recognize and discuss the relationships between common, everyday objects and energy

What to do?

Develop a surprise drawer or a grab bag by setting aside a special place for keeping objects and pictures which students bring to school. Request that these objects or pictures relate to energy or natural resources. (Items such as a piece of wood, a light bulb, a sample of trash, a mineral-bearing rock, a gas tank cap, a vial of motor oil, pictures of power plants, refineries, forests, coal mines.

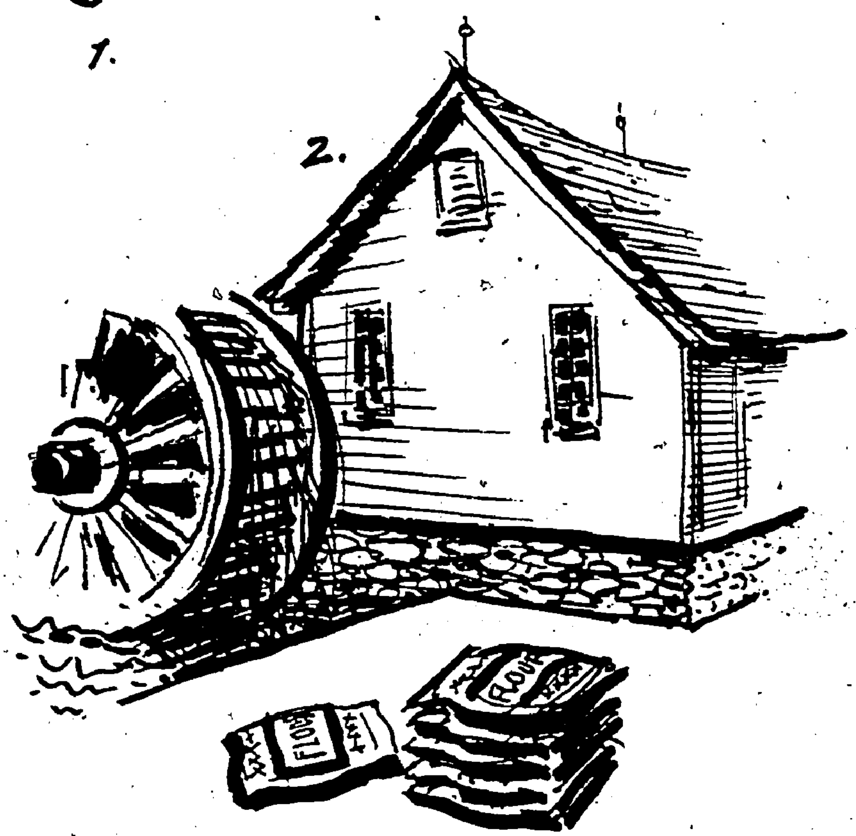


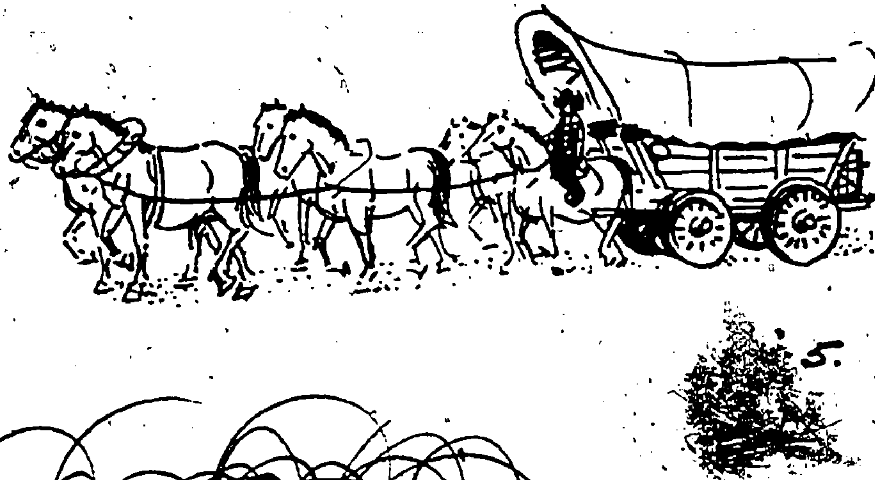
3.

1.

4.

2.





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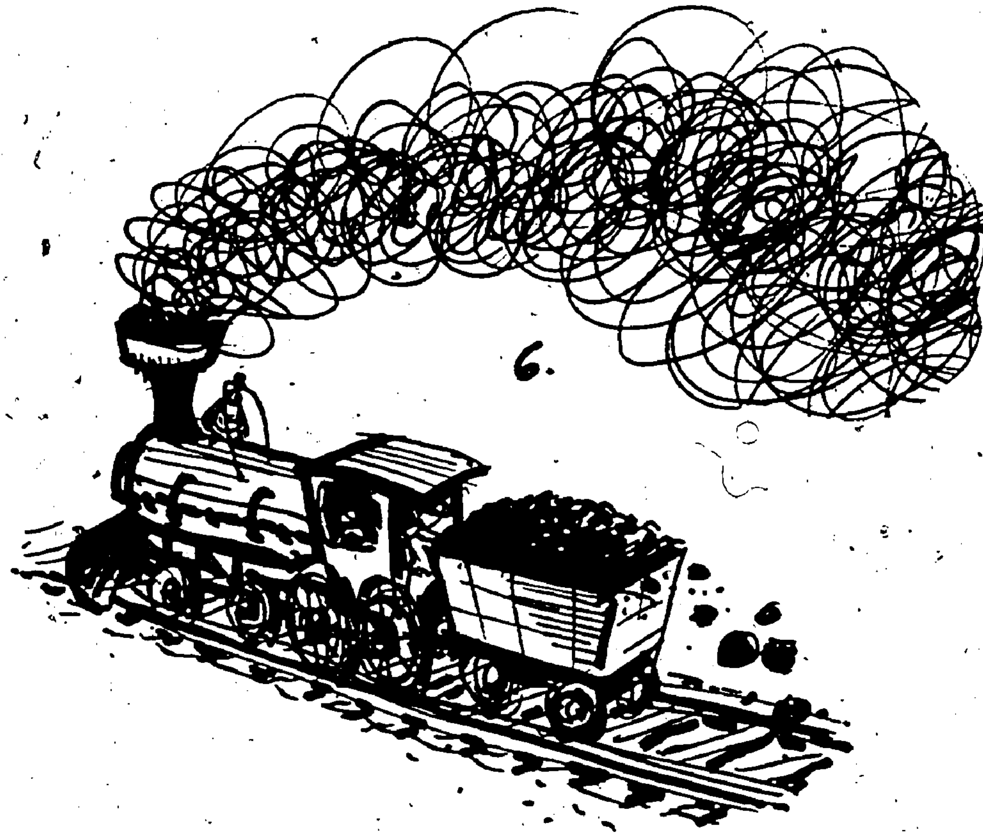

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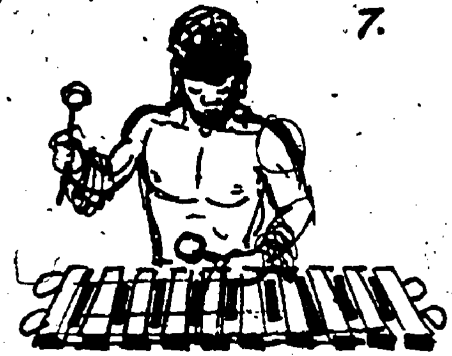

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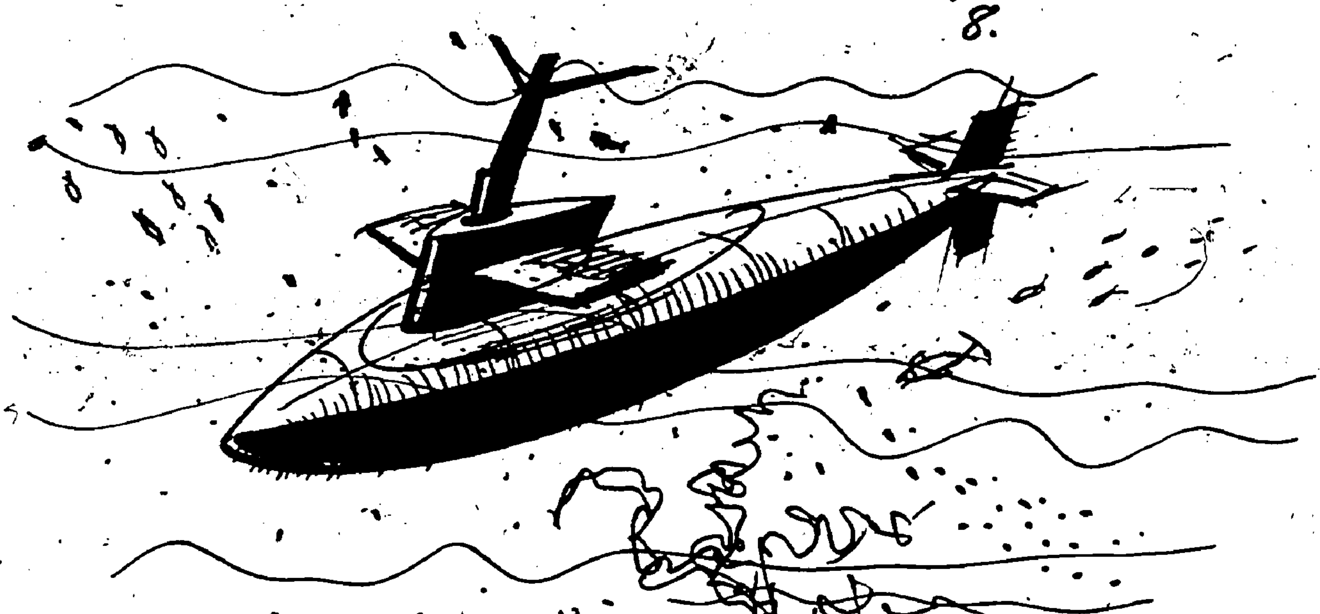
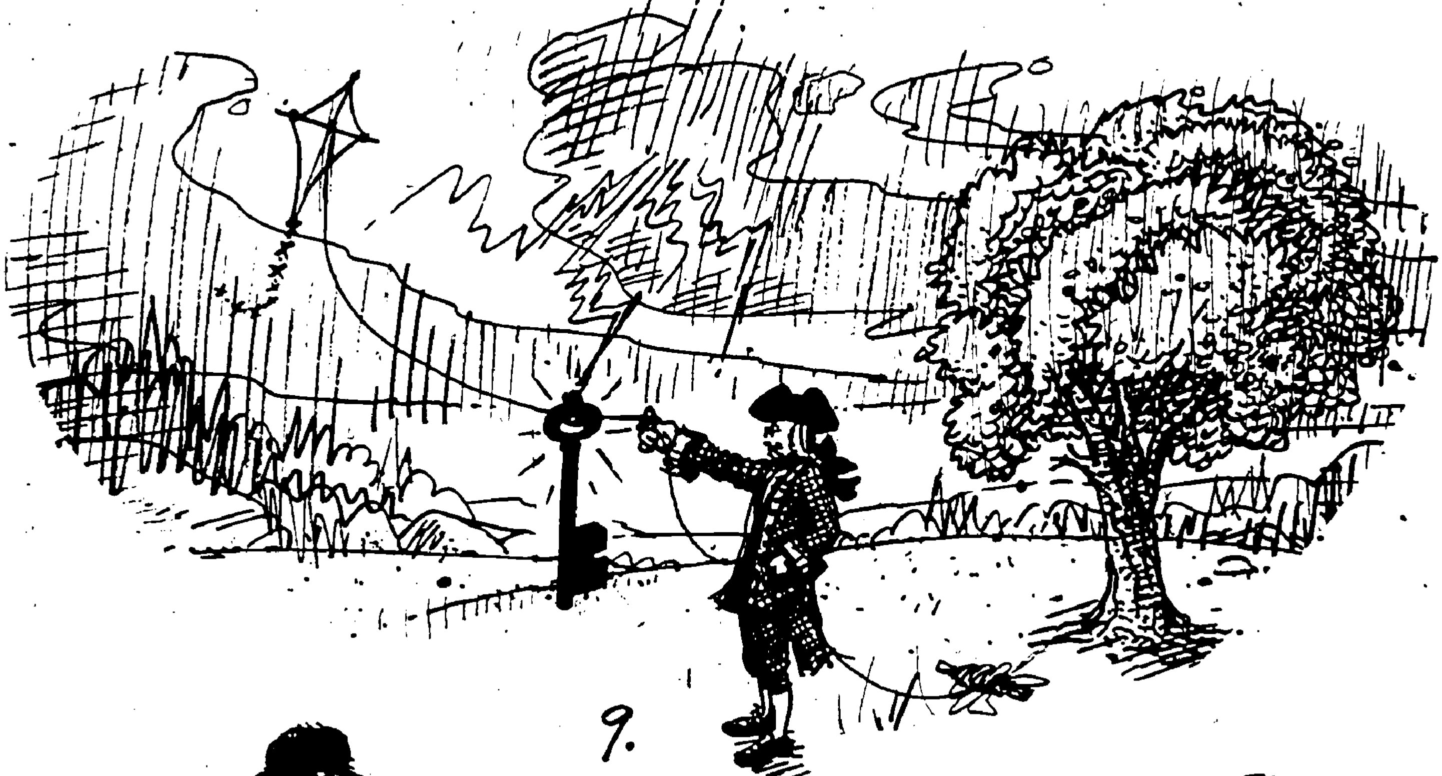


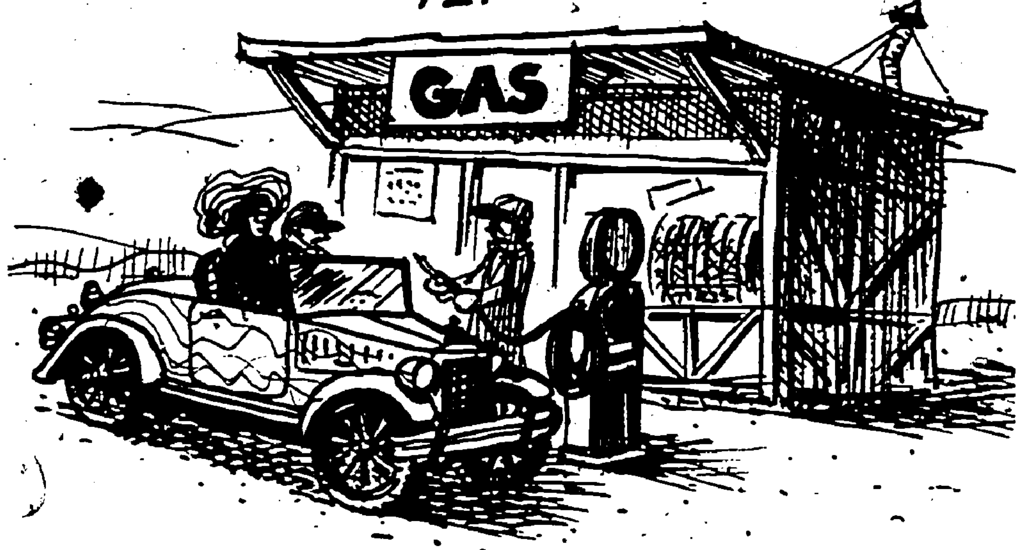


9.

10.

11.

12.



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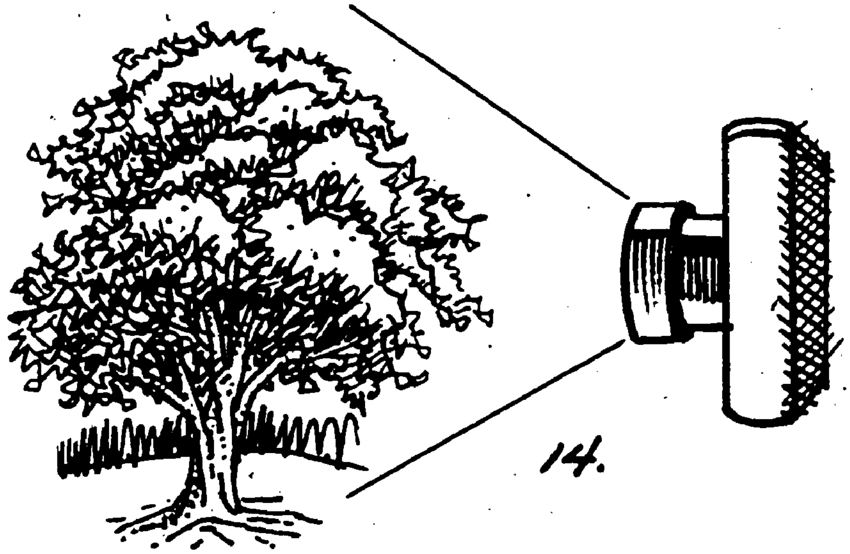

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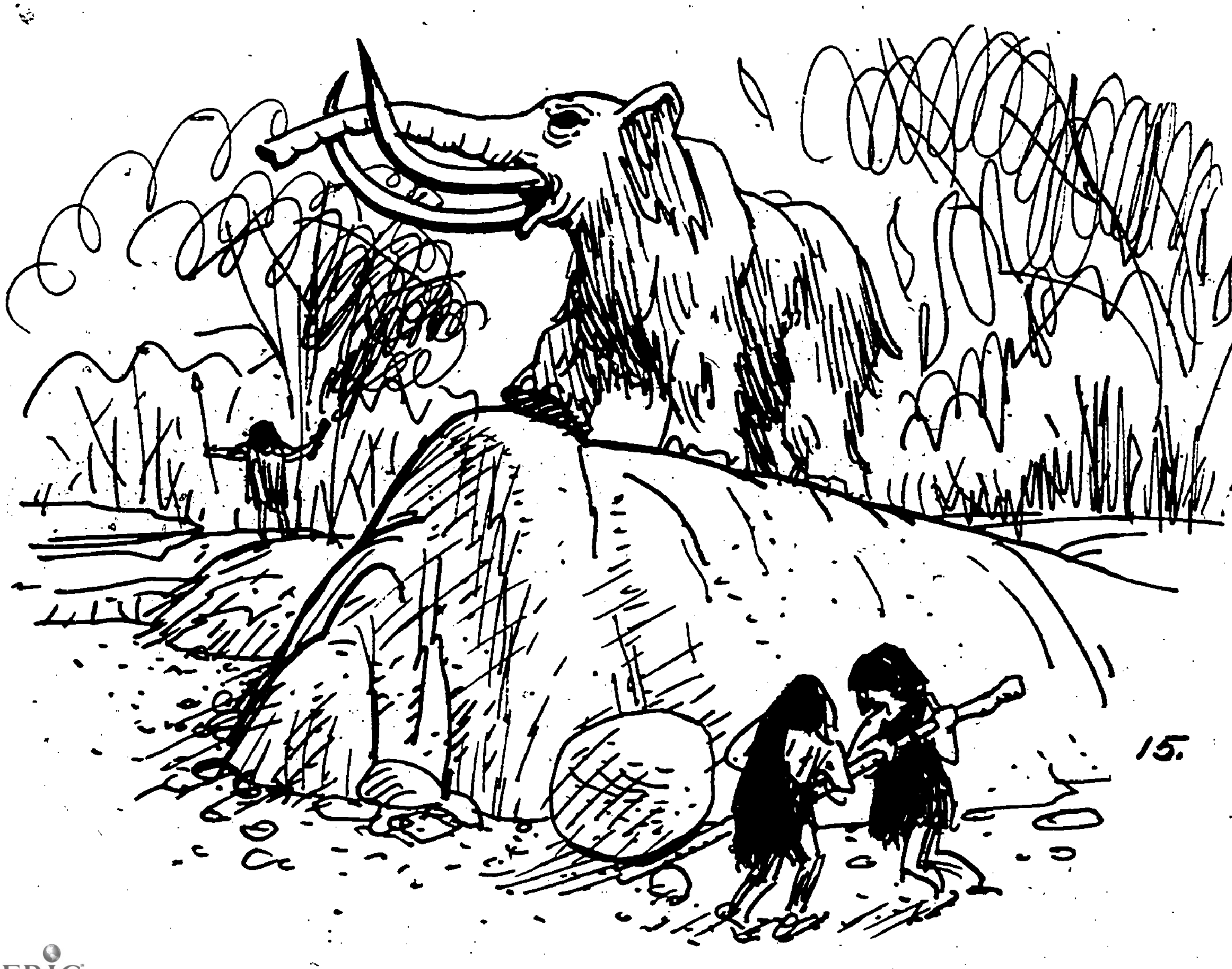


15.

Invite the students to go to this drawer in small groups during free time or at other times when it does not interfere with classroom activities. Encourage the students to talk together about the items they find and write down some of their findings and ideas. Compare these ideas with those of other members of the class.

Teachers Notes:

Questions to consider

1. What kind of energy does each object contain or suggest?
2. Is this an object that you can do without?
3. How many of these objects depend on fossil fuels, animal power, or wind power in order to operate?
4. What could you substitute for the object in order to conserve energy?

Activity I-3

Objective:

The students will examine the economic factors and energy considerations for their community's transportation system.

What to do?

Have the students examine the community's transportation system. Ask: Where do people go and how do they get there? How much does it cost (in terms of the energy the vehicle uses)? How do we get the energy for the transportation?

Teacher Notes:

Assign individuals or groups of students to investigate one aspect of the transportation system. The results of this study could be presented to the class as an oral report. Perhpas a representative from the local municipality, such as a member of the planning commission, could be brought to class to discuss transportation problems. What considerations are the local government officials giving to energy conservation in the transportation plan for the community?

Activity I-4

Objective:

The students will develop criteria for identifying energy and for classifying their observations when performing several different tasks using energy.

What to do?

Begin the class discussion by having the class do a few physical exercises. Ask the students this question:" What is happening as we exercise?" Record these ideas on the blackboard. Next, turn on the record player, a fan, or other electrical device that produces motion. Ask the students: "What happens when I turn the switch on?" Turn on a light bulb. Ask this question: "What happens when I turn on the light switch?" Finally, light a candle or bunsen burner. "What is happening when the device is lighted?" Bring a radiometer (providing one is available) close to a burning candle. Ask students to observe the radiometer. Record all observations and findings under the appropriate heading:

Activity
Immediate source of energy
How the energy is being used
Primary energy source

Summarize by asking the students if they are familiar with the word energy. How can the student determine what kind of energy is being used? Was energy being used in all the activities performed? Formulate a description of energy with each use of energy.

Teacher Notes:

Motion, heat and light are forms of energy being used. Perhaps you can lead into a discussion of how we know energy is being used in still other activities, such as a car travelling at 30 mph, a hamburger cooking on a charcoal grill, or clothes being washed in a washing machine. In these examples, chemical energy, mechanical energy, electrical energy, and heat energy are being used.

Activity I-5

Objective:

The student will identify the energy source of various devices associated with heat, light and/or motion.

What to do?

Divide the class into three groups and assign the topic of Heat, Light or Motion to each group. Have them brainstorm and list as many energy using devices as possible under each topic. Make a summary chart. Identify the immediate soucrce of energy for each device listed. This information should be added to the blackboard chart. Have students identify the general characteristics of the source of energy.

Teacher Notes:

As an example, the beginning of such a chart may appear like this:

Motion	energy user	immediate source	describe energy source
moving automobile	driver and passengers being transported	combustion of gasoline	fossil fuels formed from plants which existed a long time ago

Activity I-6

Objective:

The student will express the meaning of energy.

What to do?

Using any medium such as art, music, poetry, skit or others, express "Energy, where are you?"

KINETIC AND POTENTIAL ENERGY

We have previously stated that energy comes in many forms. Two general categories of energy, encompassing all the various forms, are potential energy and kinetic energy.

Energy that is stored is called potential energy. It is energy that an object has because of its position or condition. For example, a tightly stretched spring has potential energy – it has the ability to do work if released. A rock lying at the top of a hill also has potential energy – it can do work if allowed to roll down the hill. A pile of coal has potential energy, since work can be done when the coal is burned. A rifle that is loaded and ready to fire also has potential energy.

On the other hand, the energy that an object has because of its motion is called kinetic energy. If a stretched spring is released, it has kinetic energy. A rock rolling downhill also has kinetic energy.

Potential energy represents work that has already been done. For example, suppose someone lifts a weight off the ground. As a result of this work, the weight possesses a certain amount of potential energy. If the weight is allowed to fall, its potential energy is changed into kinetic energy. At the instant it strikes the ground, its potential energy is gone. When it rests on the ground, the kinetic energy is also gone, having been changed into some other form of energy, usually heat. (See Figures 1 and 2).

When a loaded rifle is fired, heat and expanding gases cause the bullet to have kinetic energy. When the bullet is transferred to the target, its kinetic energy becomes heat energy, which is taken up by the target and the air.

ENERGY CONVERSION - A FALLING BOOK

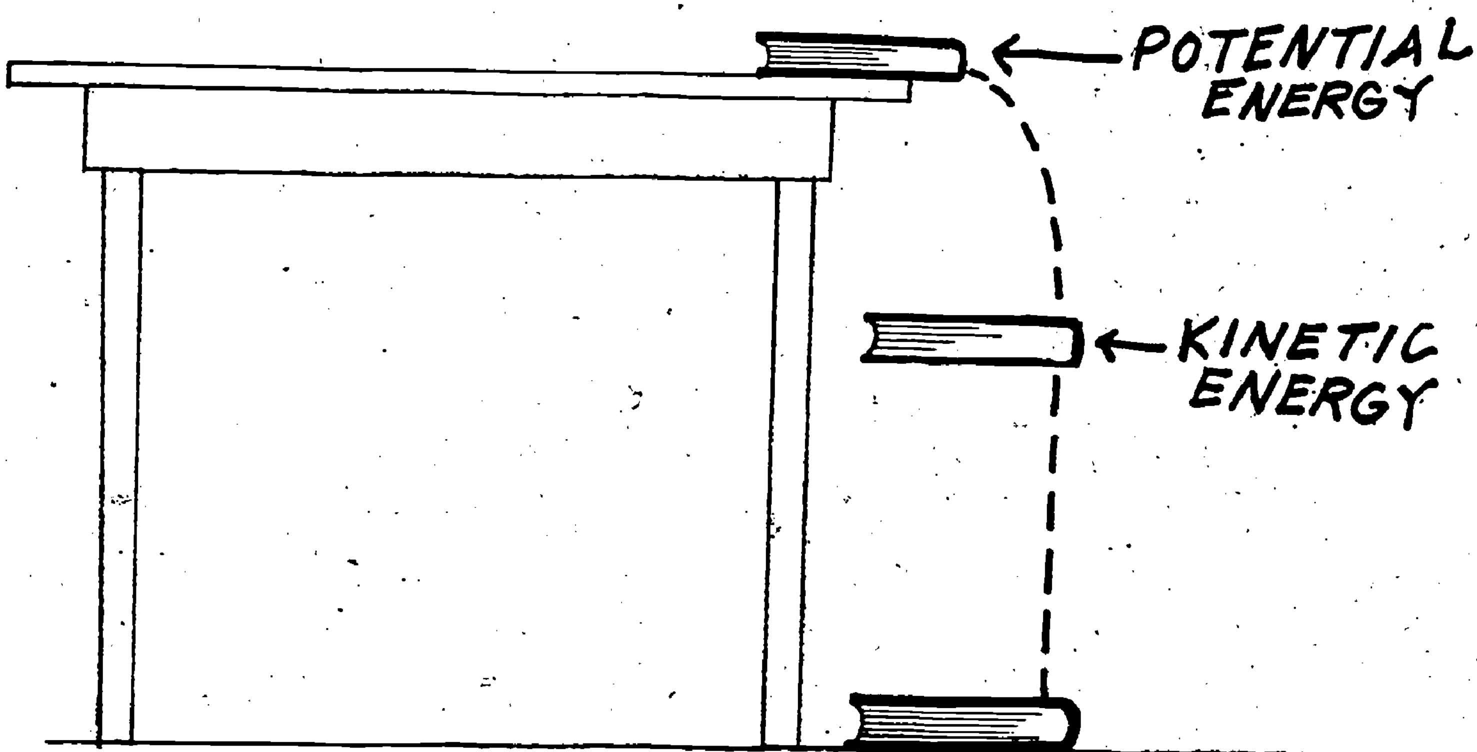


Figure 1

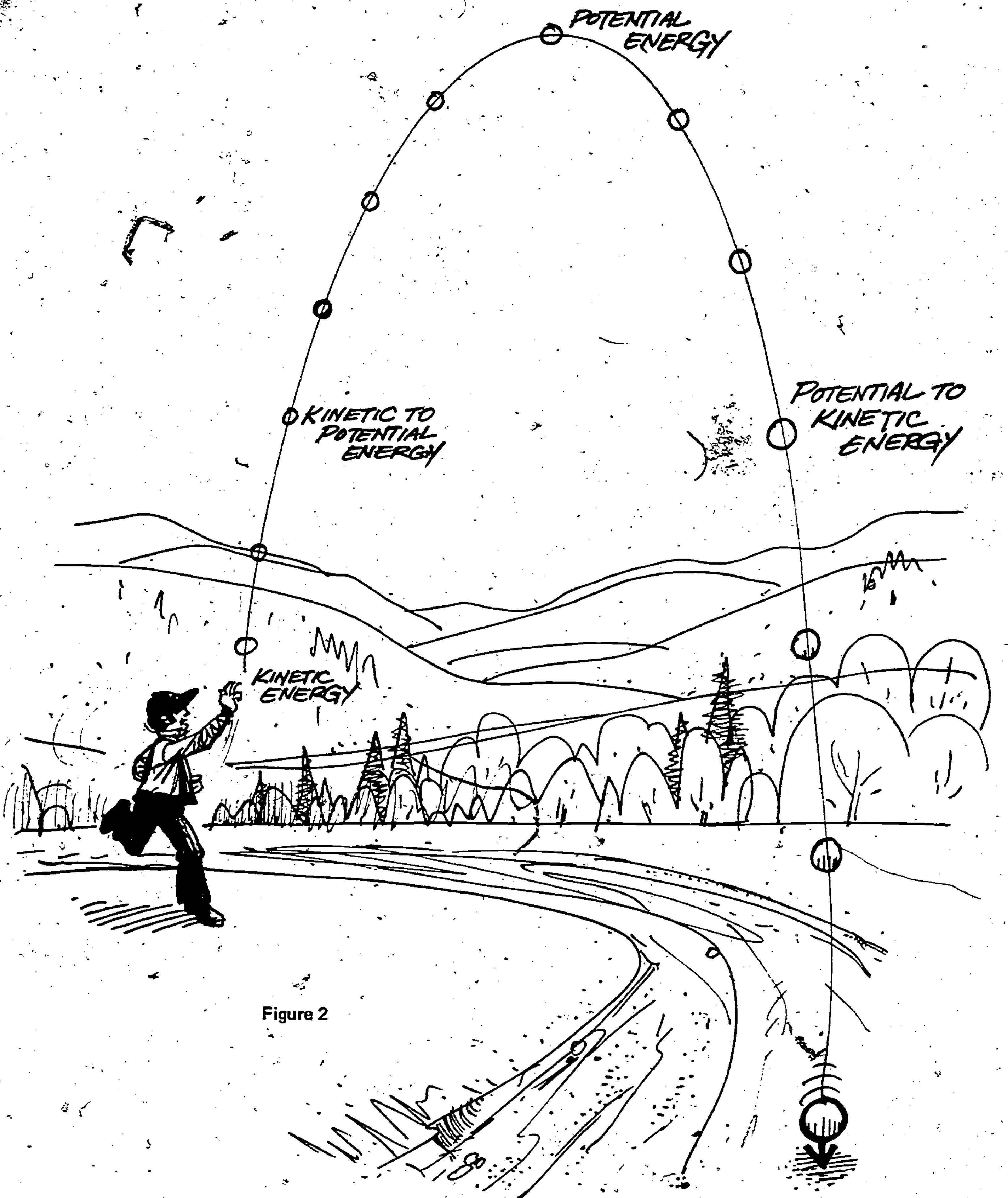

POTENTIAL ENERGY
KINETIC TO POTENTIAL ENERGY
POTENTIAL TO KINETIC ENERGY
KINETIC ENERGY

Figure 2

Activity I-7

Objectives:

The students will identify the production of kinetic and potential energy related to the stretching and releasing of a rubber band.

The student will investigate the effect of varying the amount of stretch of a rubber band with respect to the distance traveled by a launched missile.

What to do?

The teacher will set up the following device: a rubber band stretched with a clothespin attached. The rubber band will be stretched and released at various distances to observe the different distances the missile (clothespin) will travel after being launched. Stop the rubber band at three inches, four inches and five inches. Ask the students whether the rubber band has potential or kinetic energy. If so, which form of energy increase with additional stretching? What kind of energy does the rubber gand have after it is released, sending the missile through the air? How did the rubber band get the potential energy?

Teacher Notes:

In the first part of this activity, the increased stretching of the rubber band will result in the missile travelling a greater distance due to the increased stress in the rubber band. The greater the amount of stretching, the greater the amount of stored energy (potential) which is available for doing work on the clothespin. The launching of the clothespin demonstrates the production of kinetic energy. This represents the changing of potential energy (caused by stretching) into kinetic energy (caused by releasing of the rubber band and the movement of the clothespin).

Activity I-8

Objective:

The student will measure the force exerted in the stretching of a rubber band and will investigate the distribution of force between two scales used to make the measurement.

What to do?

Materials needed: 2 spring scales, rubber band

Hook two spring scales to the opposite ends of a rubber band. Pull on each scale, stretching the rubber band between the two scales. Observe the readings of each scale as you increase the pull on the rubber band. Ask this question: "How did the reading on the two scales compare with each other as the rubber band was stretched?" Next, using the two scales, try to stretch the rubber band so that the readings on the two scales differ quite a bit. Can you do it?

Teacher Notes:

The stretching effect on the two scales will be such that the total force will be distributed equally between the two scales. In other words, each scale will be observed as having the same reading, and the sum of the two readings represents the total force exerted or *potential energy produced* by the stretching. Further investigations by the student to try to create a reading difference between the two scales will reveal no further change in this observed behavior.

Activity I-9

Objective:

The teacher will carefully heat water in a stoppered test tube to create movement of a cork.

The student will identify in this system the transformations between potential and kinetic energy.

What to do?

Place about one inch (2.5 cm) of water in a test tube. Fit a cork stopper loosely in the mouth of the tube. Hold the tube with the mouth pointing away from you and other persons in the room as you heat the water over a burner flame. When the water turns to vapor and steam, it will cause pressure build-up. The stopper will be driven out of the tube with a pop. What thing or things were moved through a distance? What kind of energy did these moving things have? What caused the steam to form? Explain all of your observations in terms of kinetic and potential energy.

Teacher Notes:

When the water in the test tube is heated, the steam produces pressure and increases the potential energy to do work on the cork. During this process of heating the water, the molecules of water move more rapidly (increasing their kinetic energy). As the water vaporizes to a gas, kinetic energy is converted into potential energy and is stored in the water molecules of the gaseous state. As a gas, the molecules occupy a much larger volume than as a liquid. This creates the pressure build-up in the system. When the cork is propelled suddenly out of the tube, this movement represents a change of potential energy to kinetic energy.

Activity I-10

Objective:

The student will investigate potential and kinetic energy considerations in moving a rolling cart along a flat table surface.

What to do?

Materials: Rubber band, cart, spring scale

Hook one end of the rubber band to the cart and the other end to the spring scale. Stretch the rubber band by pulling on it with a force of 150 grams. Hold the cart to keep it from moving. Then release the cart and allow it to roll along the table. Where did the cart get the energy to move? What form of energy does the rubber band have in its stretched condition? Again, repeat the above experiment, but this time measure the distances (in cm) that the cart moved when forces of 50 g, 100 g, 150 g, 200 g and 250 g were applied to the stretched rubber band. What effect did the increased force have on the speed and movement of the cart? Describe its behavior in terms of kinetic and potential energy.

Teacher Notes:

The cart received its energy for movement from the stretched rubber band (potential energy). However, work was previously done in stretching the rubber band (as kinetic energy) to create the necessary potential energy source.

Complete the following chart for the last part of this activity:

Force	50 g	100 g	150 g	200 g	250 g
Distance					

Prepare a graph correlating force (g) with distance (cm) What relationship is suggested by the curve of the graph?

Activity I-11

Objective:

The student will discover the relationship between potential and kinetic energy by observing a swinging pendulum bob.

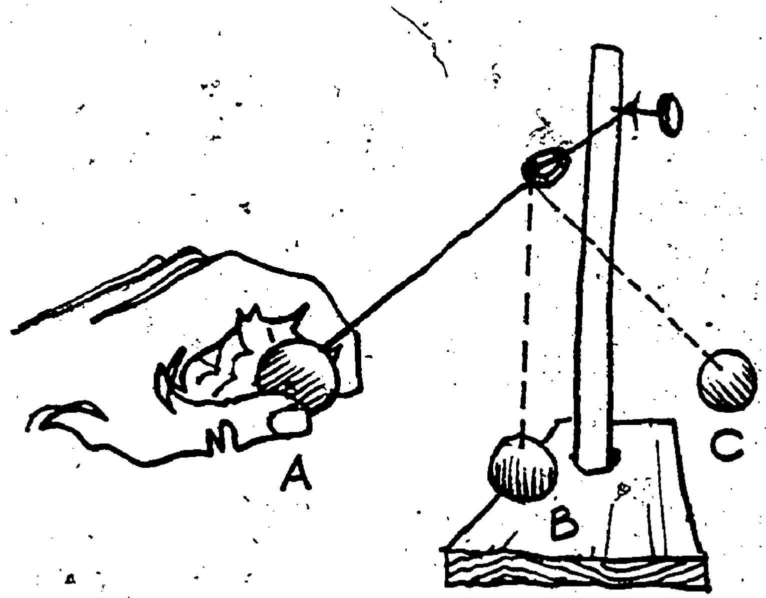
What to do?

Materials needed: Support rod, thread, pendulum bob

Suspend a simple pendulum from a supporting ring attached to a ring stand as illustrated in the diagram. You can use any object that can be attached to a string as a pendulum bob. Start the pendulum bob swinging by holding it at position A and releasing it in such a way that it falls freely. Observe the back and forth motion. Describe what is happening in terms of kinetic and potential energy.

Teacher Notes:

Initially, the hand did work in moving the pendulum bob to position A where it has taken on potential energy. When the pendulum bob is released at A and moves toward position B, the potential energy is converted increasingly to kinetic energy, which reaches a maximum value at position



B. As expected, the pendulum bob continues to swing through position B to C. In this segment of its path, the energy is being changed from kinetic energy to potential energy, until the peak of its potential energy is reached at position C. This same energy change pattern continues with the back and forth motion of the pendulum bob until the bob comes to rest at position B. Assuming there is no other force acting upon the bob, why does it eventually come to rest? With each back and forth swing some energy is lost to the surrounding air due to the friction between the moving pendulum bob and the air. Each succeeding peak in the potential energy reached will be somewhat less than the previous height obtained. In other words, there is less and less movement with each back and forth swing. When the bob comes to rest, all the energy it had initially has been dissipated to the atmosphere as low quality heat energy.

Activity I-12

Objective:

The student will distinguish between examples of kinetic and potential energy.

1. moving truck ______ truck waiting at stoplight ______
2. stretched rubber band ______ released rubber band ______
3. speeding bullet ______ bullet in a loaded rifle ______
4. fresh dry cell ______ a lighted flashlight ______
5. A tank of gasoline ______ a gasoline-fueled lawnmower cutting grass ______
6. A river current ______ water stored behind a dam ______
7. A stick of dynamite ______ a dynamite blast ______
8. A piece of coal ______ an operating coal furnace ______
9. falling weight ______ falling weight stopped halfway in its fall ______
10. In number 3, what happens to the energy when the bullet is transferred to the target? ______

Teacher Notes:

1. moving truck *kinetic* truck waiting at stoplight *potential*.
2. stretched rubber band *potential* released rubber band *kinetic*.
3. speeding bullet *kinetic* bullet in a loaded rifle *potential*.
4. fresh dry cell *potential* lighted flashlight *kinetic*.
5. a tank of gasoline *potential* a gasoline fuel lawnmower cutting grass *kinetic*.
6. a river current *kinetic* water stored behind a dam *potential*.
7. a stick of dynamite *potential* a dynamite blast *kinetic*.
8. a piece of coal *potential* an operating coal furnace *kinetic*.
9. falling weight *kinetic* falling weight stopped halfway during its fall *potential*.
10. In number 3 what happens to the energy when the bullet is transferred to a target? *kinetic energy is changed to heat energy and is given off to the atmosphere in a useless form.*

FORMS OF ENERGY

Mechanical Energy

Mechanical energy is that form of energy which is acquired or released by moving objects. A rolling wheel, a turning windmill, and a rotating waterwheel are examples of objects with mechanical energy.

Mechanical energy can be easily changed into other useful energy forms. For example, falling water can spin the blades of a turbine. The mechanical energy of the spinning turbine can be converted into electrical energy if the turbine is connected to an electrical generator.

Other forms of energy can also be changed into mechanical energy. For example, gasoline or diesel fuel, which contains relatively large amounts of potential energy, undergoes controlled combustion in the engine of a bulldozer and produces motion in the pistons and other moving parts of the engine. The bulldozer can then do work.

By its very nature, mechanical energy is closely associated with kinetic energy.

Activity I-13

Objective:

The student will view pictures of how energy was used in the past and determine in what ways those activities produce mechanical energy.

What to do?

Using the transparencies prepared for Activity I-1, have the students examine each illustration and have them determine which examples involve the use and/or production of mechanical energy. What actions in each illustration represent the production of mechanical energy?

Teacher Notes:

Mechanical energy is particularly evident when the device depends upon the operation of a chine. Examples of simple machine are sheels, levers, and inclined plans. Each of these machines is utilized to make a work situation easier — that is, to gain some type of mechanical advantage so that work can take place under more favorable conditions.

Mechanical energy is essential in most of the illustrations, but is certainly less evident in the sailing ship, the kite experiment, and the boy drinking water. How is mechanical energy used in these three situations?

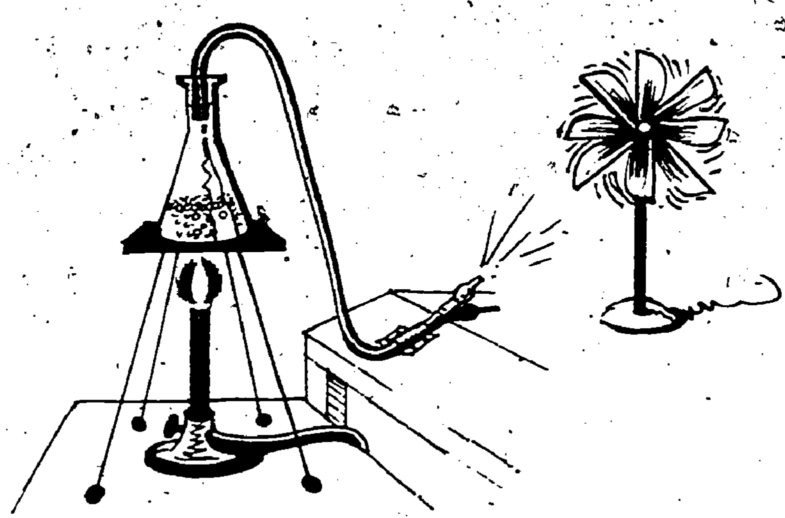
- The sailing ship is shaped like a wedge (inclined plane) to enable the ship to move more rapidly through the water. This is an application of a simple machine.
- The kite is pulled and is held in such a position as to represent an inclined plane so that the movement of air will lift the kite upward. The moving air currents (mechanical energy) lift the kite upward (mechanical energy).
- The boy drinking water: Mechanical energy is produced in lifting the water to his mouth. Also, mechanical energy is used in the swallowing mechanism where the downward movement of water is assisted by muscular contractions in transporting the water to the stomach.

Mechanical energy is apparent with almost every type of human and machine activity.

Activity I-14

Objective:

The student will be able to demonstrate how mechanical energy can be produced from steam in the same way that burning fuels can be used to turn generators for electrical production.



What to do?

Put about 100 ml of water into a 250 ml pyrex flask. Fit the flask with a one-hole rubber stopper, put a piece of glass tubing in the stopper, and connect a piece of rubber hose (about 1/2 meter in length) to the glass tube, Attach the glass portion of a medicine dropper to the other end in such a way as to enable the dropper end to be exposed. Heat the water in the flask to boiling. When enough steam has been generated through the tip of the hose mechanism, position the dropper in such a way as to spin the pinwheel. This simulates the action of turbines used to operate an electrical generator. What indicates the production of mechanical energy?

Teachers Notes:

The teacher should point out that the spinning pinwheel should be attached to another mechanical device in order to utilize the mechanical energy of the moving pinwheel to do some kind of useful work.

CAUTION: Do not heat the flask too rapidly! If you produce steam faster than it can escape through the tube, something will give! Be sure to add boiling chips to water! Insulate the part of the rubber tube you are holding with a paper towel.

Activity I-15

Objective:

The student will be able to demonstrate that mechanical energy can be changed to another form of energy.

What to do?

Materials Needed: quarter inch wood dowel, knife, hand drill, wooden block.

Sharpen a quarter-inch dowel to a point. Fasten the blunt end in a hand drill. Cut a small pit in a wooden block for the pointed end of the dowel to fit loosely. Have another student hold the block and turn the crank of the drill rapidly. What form of energy is produced when you turn the crank? After a few minutes feel the end of the dowel and the pit in the wooden block. What form of energy do you feel?

Teacher Notes:

Mechanical energy is the energy produced when objects, like machines, are moving. A moving automobile, a turning windmill, a rolling wheel, and in this case turning the crank of the hand drill all produce mechanical energy. Mechanical energy can be changed into other forms of energy. In a steam generating plant, the rotating generator produces electrical energy. In this demonstration, the turning crank produces heat energy as evidenced by the warm (sometimes hot) feel of the wooden dowel and block. Recall the illustration in Activity I-1 where the Indian actually started fires using this method of heat production, even though the devices were somewhat more crude than those used in this demonstration.

Gravitational Energy

One important form of potential energy is gravitational potential energy. This is the energy of a rock poised at the edge of a hill, or of droplets of water at the top of a waterfall. These are examples of gravitational potential energy because it is the earth's gravitational pull which will set them in motion.

The amount of gravitational potential energy depends on the heights and masses involved.

Figure 3 shows one use of gravitational energy: turning the turbines in a hydroelectric dam.

Activity I-16

Objective:

The student will observe changes in gravitational energy that is produced when an object rolls down inclined planes of different elevations and the effects that these changes have in doing work on other objects.

What to do?

Materials Needed: inclined plane (board 6 inches wide by 3 feet in length), a dozen books – each at least 1 inch in thickness, steel ball or marble, piece of velvet (1 foot by 3 feet)

The teacher will place the inclined plane board with one end elevated by a book. At the other end of the board, place a piece of velvet in such a way that it extends from just beneath the lower end of the board and stretches 3 feet beyond the end of the inclined plane. Then, release the ball at the top of the inclined plane, allowing it to roll onto the piece of velvet. Describe what happens. (If you have a stop watch available, try to determine the time involved for the ball to roll to the bottom of the inclined plane). Now, place a second book on top of the first book to elevate the inclined plane even higher. Again, observe what happens when the ball is released. Compare your results with the first instance. Continue to move the incline to various other heights using a different number of books. Record your results.

What kind of energy does the ball possess at the top of the ramp? When it is moving down the ramp? How do the different forms of energy relate to the nature of gravitational energy? What makes the ball roll down the ramp? How did the ball get the potential energy at the top of the ramp?

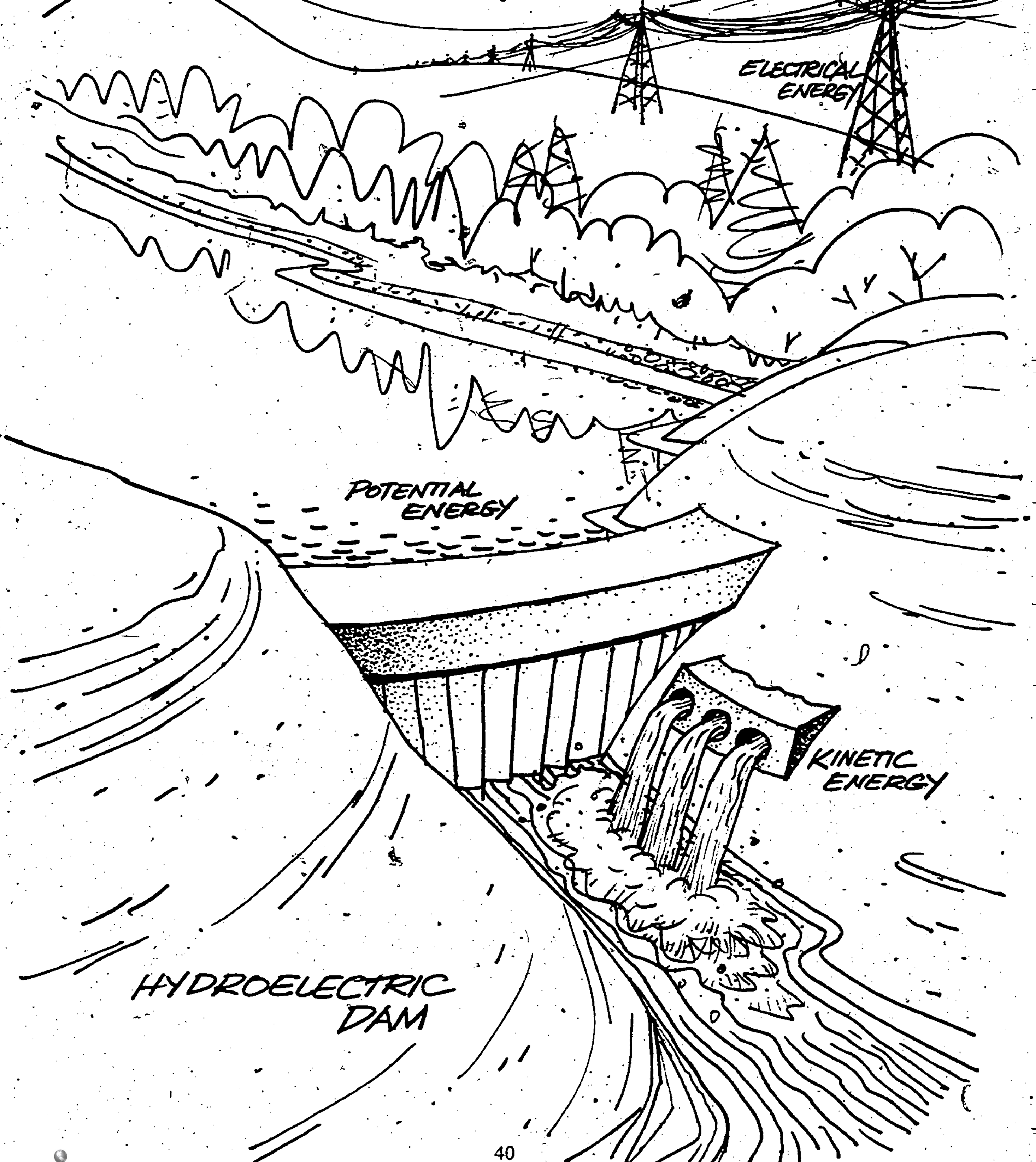
Finally, place a pencil on the cloth so that the ball hits it after it rolls down the ramp. How much work did the ball do on the pencil in striking it? (Remember, Work = Force x Distance) Now, change the elevation of the ramp. How did this change affect the amount of work that the ball does on the pencil? Record your results.

Teacher Notes:

The force of gravity is what makes the ball roll down the ramp. In getting the ball to the top of the ramp, work was done on it against this force of gravity. While resting at

GRAVITATIONAL ENERGY

Figure 3



the top of the ramp, the ball possessed potential energy. The rolling ball possesses kinetic energy. The potential energy is being converted to kinetic energy as it continues to roll down the incline. The kinetic energy reaches its maximum value at the bottom of the incline, or just at the impact with the pencil. If work is measured by force times distance, obviously the greater distance that the pencil travels upon impact indicates more work being done on the pencil. The more work that is done on the pencil, the greater is the amount of gravitation energy possessed by the rolling ball as a result of a higher elevation.

Chemical Energy

Chemical energy is that energy which is involved in chemical reactions. In most chemical reactions, energy is usually released or absorbed in the form of heat.

Photosynthesis and respiration, two biological processes, are basically chemical reactions. An explosion of gunpowder is obviously a chemical energy-releasing process. The rusting of iron is a chemical reaction which releases heat, but it generally occurs so slowly that the heat released is not detected. In a battery, chemical energy is stored for later release as electricity.

Chemical reactions that release heat are of particular importance as usable energy sources. The burning of fuels such as wood, coal, gas, and oil provides for release of stored chemical energy. Note that some initial energy is necessary to start these chemical reactions. For example, wood begins to burn only after it has been heated to its kindling temperature. The burning of coal, gas, and oil provides heat which can be used to boil water, creating steam which can then turn turbines to generate electricity. We again can see how one form of energy can be changed into many other forms.

Activity I-17

Objective:

The student will examine the relationship between the amount of fuel burned (a chemical change) and the amount of heat energy released as measured in a container of water heated by the burning process.

What to do?

Materials needed: small container of canned heat (2–2½ inch diameter Sterno can), Sterno stove or other suitable stove support for heating liquids, centigrade thermometer, 1 liter pyrex beaker or 32 oz. can with one end removed, water

Measure out 800 ml of water (or 1½ pints) into 1 liter beaker (or 32 oz. size can) that would be appropriate for heating. (The total amount of water used for heating should be accurately measured and recorded on the data table.) If a can is used, remove any label on the container before heating. Now, place the container with the measured amount of water on the stove support. Record the water temperature. Then remove the lid from the sterno can and light the fuel. Note the time and record it on the data table after you place the burning fuel in the appropriate spot for heating the water. Continue the heating and place the thermometer bulb in the water after 2½ minutes. At the 3 minute interval, note the water temperature and record it on the table. Continue the heating, repeating the temperature measurement every 3 minutes. The heating process should be discontinued after the temperature of the water reaches approximately 90°C.

Data Table:

A. Volume of water used for heating = ______________

B. Type and size of canned heat used = ______________

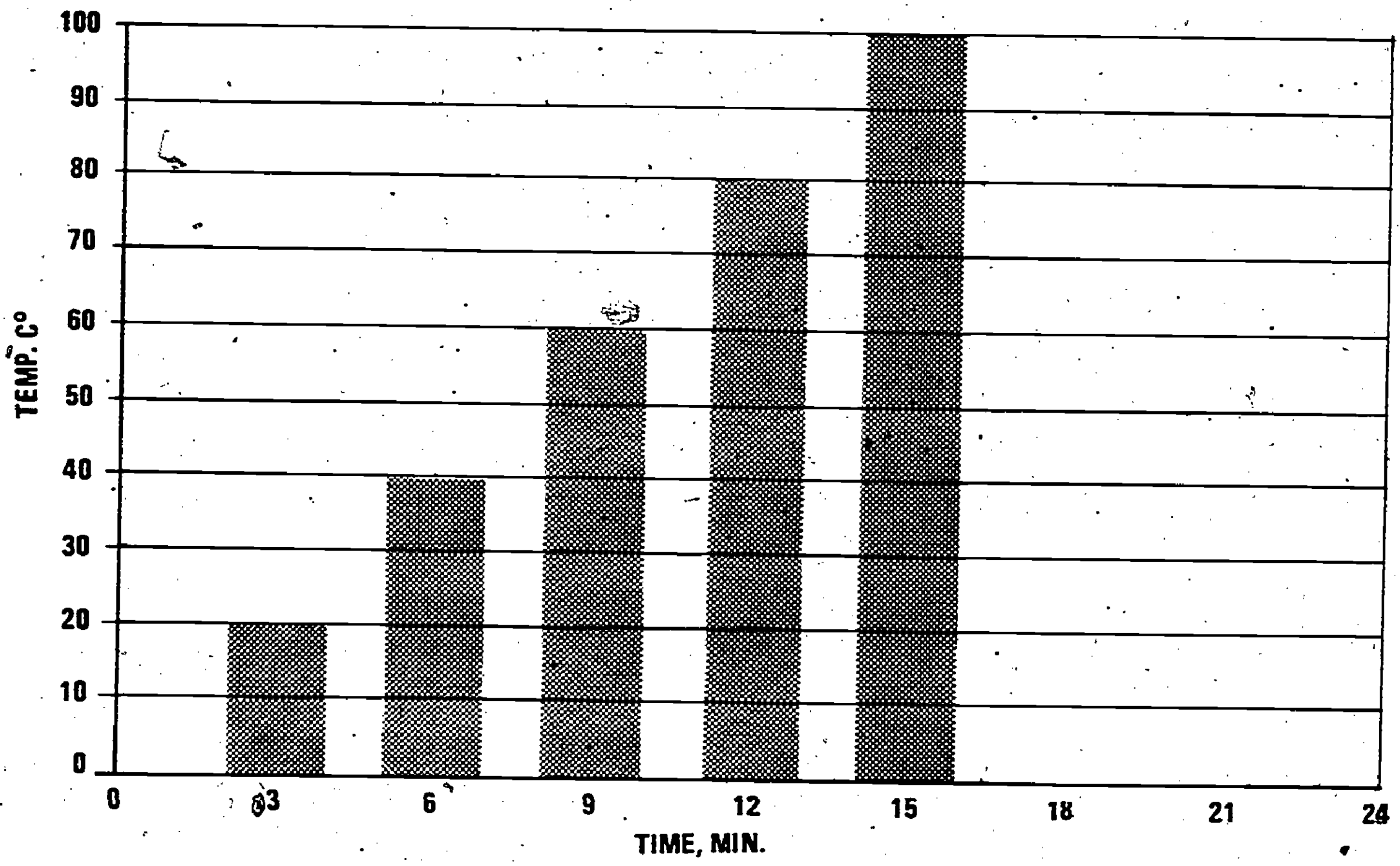
C. Type of container used = ______________

D. Table containing other information

Time, min.	Temperature, °C	Time, min.	Temperature, °C
0		21	
3		24	
6		27	
9		30	
12			
15			
18			

Prepare a bar graph: time vs. water temperature

Prepare a graph with time scale represented on the horizontal axis and temperature scale along the vertical axis. The following example is indicative of the type of graph to prepare from your data. It does not necessarily represent actual values obtained for this experiment.



Questions to consider:

1. What represents the chemical reaction in this experiment?
2. What forms of energy are produced when the burning process takes place?
3. After the flame is put out, observe the amount of fuel remaining in the container. How much longer would you predict it would take for all the fuel to be consumed? (Assuming the present burning rate and judging from the change in fuel level in the container.) How would you devise an experiment to make an accurate prediction based on actual information?
4. What does the graph show? What does it tell about the amount of energy produced from the burning fuel? Does the bar graph show an even heating rate? If it doesn't, why not?
5. Can you think of ways that energy was lost to the surroundings? This represents heat not used to raise the temperature of the water. Name at least three ways.
6. How could you redesign the apparatus used in the heating process to capture more of the "lost" heat energy?
7. Use these ideas to make changes in your heating system and repeat the experiment. What changes in your results would you expect to find in showing an improvement in the heating efficiency of your system?

Teacher Notes:

The fuel used was a flammable chemical mixture which is likely a solidified petroleum product. When this mixture burns, it gives off a relatively even heat. This even heating feature makes the fuel especially suitable for this type of experiment.

The forms of energy produced include primarily heat energy and some light energy.

The student can determine the relative amount of fuel used in this experiment by measuring the height of the fuel content in the can both before and after the burning takes place. A rough prediction can be made from this information. For example, if about 1/3 of the fuel burns in 30 minutes, then it can be estimated that 2/3 of the fuel remaining represents 60 more minutes of heating time.

The graph relationship shows that the burning fuel continues to heat the water at a regular rate (noted by the gradual increase in water temperature) until it approaches the boiling point at or near 100°C. Ask the students to estimate the water temperature from the graph after 10 minutes of heating. If time permits, allow the students to check their prediction time by again heating the same amount of water (volume should be accurately measured). It is important to note that when the water reaches higher temperatures, a greater amount of heat is lost to the surrounding air at a faster rate due to the large temperature differential.

How is heat lost in this system? (1) Some of the rising heat from the burning fuel escapes along the edges of the container. (2) The heated water tends to heat the air above it and some of the heat energy rises into the adjacent air above. (3) Metal containers readily conduct heat away from the warm water and in turn heat the surrounding air. (4) All warm objects tend to radiate heat from all surfaces to surrounding objects. (5) Air currents moving across the area of the flame tend to take with them some of the heat that would ordinarily reach the container of water.

How could this apparatus be redesigned for greater heating efficiency?

(1) Install a chimney between the heating source and the container of water – make provisions for air supply to reach the burning fuel.
(2) Surround the container with aluminum foil with the shiny surface toward the container to prevent radiant heat energy from escaping.
(3) Use a glass beaker (pyrex) instead of a metal container – glass is a much poorer conductor of heat and will provide less loss of heat through its better insulation qualities.
(4) Place a lid or loosely fitted cover over the top of the container. This will tend to cut down on the amount of heat rising to the atmosphere through convection currents.

What changes in the results can you expect from these improvements?

These changes should enable the water to reach the 90°C temperature in a shorter period of time. The bars in the bar graph should appear somewhat higher at each step.

Activity I-18

Objective:

The student will understand what happens when the body absorbs food in producing energy through chemical changes which occur in body cells.

What to do?

Discuss in class what happens when a body eats food (sugar gives off water and CO_2 and energy to the body. Fats tend to give off more energy because there are more carbon and hydrogen atoms in fats, and therefore they can produce more energy). Have the students draw a diagram of what happens to the food and the energy produced.

Teacher Notes:

This information can be found in any health, home economics, or biology text. Also, the encyclopedia is a good source of information.

Activity I-19

Objective:

The student will determine on the basis of weight measure which of the following fuels is better in terms of calories produced per gram.

What to do?

Examine a list of chemical reactions that represent the burning of various types of common fuels and calculate the amount of heat in calories per gram of fuel used.

(1) The burning of coal

Carbon (coal) + oxygen gas produces carbon dioxide gas + heat

$$C(s) + O_2(g) \rightarrow CO_2(g) + 94{,}000 \text{ cals}/12 \text{ gms}$$

Calculate the calories per gram of carbon burned

$$\frac{94{,}000 \text{ calories}}{12 \text{ gms}} = \underline{\qquad} \text{ per 1 gm of carbon}$$

(2) The burning of hydrogen

Hydrogen gas + oxygen gas produces water + heat

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(1) + 68{,}300 \text{ cal}/2 \text{ gms}$$

Calculate the calories per gram of hydrogen burned

$$\frac{68{,}300 \text{ calories}}{2 \text{ gms}} = \underline{\qquad} \text{ per 1 gm of hydrogen}$$

(3) The burning of octane (a petroleum product used in automobiles)

octane + oxygen gas produces water vapor + carbon dioxide + heat

$$C_8H_{18}(1) + \frac{25}{2}O_2(g) \rightarrow 9H_2O(g) + 8CO_2(g) + 1{,}305{,}000 \text{ cal per } 114 \text{ gms}$$

Calculate the calories per gram of octane

$$\frac{1{,}305{,}000 \text{ calories}}{114 \text{ grams}} = \underline{\qquad} \text{ calories per gm}$$

(4) The burning of methane (natural gas)

methane + oxygen gas produces water vapor + carbon dioxide + heat

$$CH_4(g) + 2O_2(g) \rightarrow 2H_2O(g) + CO_2(g) + 210{,}000 \text{ cal per } 16 \text{ gms}$$

Calculate the calories per gram of methane

$$\frac{210{,}000 \text{ calories}}{16 \text{ gms}} = \underline{\qquad} \text{ calories per gm.}$$

On the basis of calories per gram of fuel, which of these fuels is the best fuel?

Teacher Notes:

What are other factors to be considered in fuel selection? Discuss with the students such factors as the cost, availability, and environmental pollution of each fuel considered in their selection.

Electrical Energy

Have you ever run a comb through your hair and had your hair crackle and stand up? Or have you walked across a carpet, then touched a door handle, and felt a shock? These are examples of the action of electric charges. There are two kinds of electric charges: positive and negative.

We will see how these electric charges can become a usable form of energy. But first we must discuss some basic concepts. All matter is made up of very small particles called atoms. Every atom has a nucleus which consists of neutrons and protons. Neutrons have no electric charge; that is, they are electrically neutral. Protons are positively charged, and every proton has the same amount of charge, no matter what kind of atom it is from.

The nucleus of an atom is surrounded by negatively charged electrons. Every electron has the same amount of charge, and the magnitude of the negative charge of the electron is equal to that of the positive charge of the proton. Thus in an atom that is electrically neutral, the number of electrons surrounding the nucleus is equal to the number of protons in the nucleus, so that their charges exactly "neutralize" each other. If an atom has more electrons than protons, it is negatively charged; if it has more protons than electrons, it is positively charged.

In much the same way as magnetic forces operate, objects with opposite electric charges attract each other, while those with the same charge repel each other.

If a glass rod is held in the hand and rubbed by a wool cloth, the friction causes electrons to transfer from the wool to the glass. Thus the glass becomes negatively charged, and the cloth positively charged. When these two oppositely charged objects are brought close enough together, electrons will return to the cloth and each object will again be electrically neutral. This neutralizing action will create a spark in the small gap of air between the two objects.

However, if a metal rod is held in the hand and rubbed with a wool cloth, it will not become electrically charged. The charge which is created simply flows through the metal and through the hand of the person holding it. This is because metals are good electrical conductors. In a conductor, some of the electrons can move about freely, and thus move the electric charge through the conductor. If the metal rod is held by a piece of rubber, however, the rod can be charged. This is because rubber is an insulator or non-conductor. In an insulator, electrons are tightly held, and thus are not free to move through the system. So the electric charge cannot move through the rubber insulator and into the hand.

With this background, we can now think of electricity as the movement of electrons.

The examples of electricity that we have mentioned so far are all examples of static electricity. Static electricity involves electric charges on insulators, such as a glass rod and wool cloth, or a comb in dry air.

But of much more practical interest from an energy standpoint is an electric current — a continuous flow of electrons through a conductor. There are several ways of producing an electric current. One is by using a chemical wet cell. Two different metal strips such as copper and zinc are placed in a solution of sulfuric acid and water. When sulfuric acid is put into water, some of its molecules break up into separate parts called ions. These ions are electrically charged — some positive and some negative. The zinc strip begins to dissolve when it is put into the solution. As it dissolves, part of the zinc atoms leave the strip and mix with the water, but as each atom enters the water, it leaves behind two electrons. The zinc strip thus becomes more and more negatively charged. When the copper strip is placed in the solution, very few of its atoms dissolve, so the copper strip does not become negatively charged. If a wire is used to connect the two strips, the excess electrons on the zinc strip flow along the wire to the copper strip. At the copper strip, the electrons are neutralized by positive hydrogen atoms from the sulfuric acid, forming hydrogen gas. The electrons continue to flow through the wire until all the zinc is dissolved. If the two metal strips are connected by two wires to the terminal of a simple light bulb and socket, the electron flow will light the bulb.

Early experiments with electricity showed a close relationship between electricity and magnetism. It was found that electric charges in motion are always accompanied by magnetic effects. For example, a bar of iron placed in a coil through which a current is flowing becomes magnetized. In this way, it is possible to make electro-magnets, which are extremely useful in converting electrical energy into mechanical energy, being a major component of electric motors.

Conversely, it was discovered that when an electrical conductor is moved through a magnetic field — that is an area where magnetic forces are present — an electric current is produced in the wire. If a conductor wire is formed into a loop, and the loop is moved through the magnetic field which exists between the north and south poles of a magnet, an electric current will be produced in the loop. Note that the conductor or the magnet must be moving — there must be movement of one in relation to the other — for the current to be produced. The type of motion determines the direction in which the current flows. If, for example, the conductor loop is spun between the poles of the magnet, the electrons in the loop will move back and forth within the loop. Thus the current flows first in one direction and then in the reverse direction. Current produced in this way is called alternating current, and this is the kind of current we use when we plug something into an electrical outlet.

Activity I-20

Objective:

The student will be able to demonstrate the production and effects of static electricity using different types of non-conducting substances.

What to do?

Demonstrate static electricity by:

- having students comb their hair or rub a plastic comb on a wool sleeve.
- having students rub a piece of silk with any sort of hard rubber material.
- having students rub a piece of silk with a glass rod.
- having students hold tissue paper against the blackboard and rub it rapidly with a silk cloth.
- rubbing a filled balloon in students' hair and observing the sticking action to the wall. It will work only when hair is clean and dry, not oily.
- using a piece of glass, two books and some scraps of paper and a piece of silk cloth. Lay the two books on the table about 4 inches apart. Place pieces of paper underneath a sheet of glass resting on the two books. Rub the glass with the silk cloth. Watch what happens. Do this in the dark if possible.
- having students suggest more ways to illustrate static electricity.

Teacher Notes:

Atmospheric conditions are very important in successfully demonstrating static electricity. It works best on a dry day. On a humid day the water vapor in the air will enable the charge to leak away rapidly, returning the objects to a neutral charge.

The rubbing action will cause:

- the comb to attract electrons from the hair and wool, giving the comb an excess of electrons or overall negative charge and leaving the hair and wool with fewer electrons or overall positive charge.
- the silk to become positively charged and the rubber to become negatively charged.
- the silk to become negatively charged and the glass to become positively charged. (Note that a substance does not always have the same charge. The silk becomes positive in the first instance and negative in the second instance. It depends on the nature of the two materials which are rubbed together.)
- In the other two activities, the balloon will stick to the wall and the pieces of paper will begin to jump about in an amusing way due to static electricity.

Activity I-21

Objective:

The student will prepare a wet cell battery to show how chemical energy can be used to produce an electrical current.

What to do?

Materials needed: 1 copper strip (1 inch wide by 5 inches long), 1 zinc strip (1 inch wide by 5 inches long), 12 inches of insulated copper bell wire, 100 cc of dilute sulfuric acid (handle with care), beaker, knife.

Pour the acid carefully into the beaker. Use the knife to bare the wire 4 inches at one end, 1 inch at the other. Wrap the 4-inch bared end of wire around the top of the copper strip and stand the strip – by its unwired end – in the beaker. Stand the zinc in the beaker, making sure that it does not touch the copper. At this point examine the behavior of the metal strips in the jar. Does the copper react to the acid? Does the zinc? Finally, touch the 1-inch bared end of wire to the top of the zinc strip and hold it there for a few minutes. How does the copper strip behave now?

Teacher Note:

When the zinc is immersed in the acid, bubbles are given off from the strip. The copper strip, however, does not react with the acid, and no bubbles appear around it.

When you connect the two metals for an electric current flow, electrons flow from zinc – the more active metal – to copper. When these electrons come into contact with the acid ions around the copper strip, bubbles of hydrogen gas are given off at the surface of this strip. Thus the presence of bubbles around the copper shows that the cell is generating electricity.

Activity I-22

Objective:

The student will produce and detect an electric current from a simple wet cell using materials readily available from his home.

What to do?

Materials needed: Lemon, knife, copper strip (or penny), zinc strip (from old dry cell or zinc coated washer), galvanometer and pieces of connecting wire.

This experiment will demonstrate how to create electricity from a lemon. First, roll a lemon on the table, pushing on it with your hand to break up some of the tissue inside. Cut two slits an inch in length in the skin of the lemon. Push the strips of zinc and copper into the slits, making sure they do not touch. Connect a wire from the copper strip to the terminal of a galvanometer and a wire from the zinc strip to the other terminal. Watch the meter. Describe what happens and why. Note: If a commercially made galvanometer is not available, you can make one. See next activity.

Teacher Notes:

For best results, it will be necessary for you to clean the metal strips with steel wool or fine sand paper. Make sure that there are no loose connections. The major difference in this activity and the preceding one is that lemon contains citric acid in place of sulfuric acid. Actually, any electrolyte will work, including table salt dissolved in water. In general, an electric current can be produced from any two different metals immersed in an electrolyte. The amount of current flow or voltage is determined primary by the choice of metals used in producing the current.

Activity I-23

Objective:

The student will build a simple galvanometer for the purpose of detecting a small electric current.

What to do?

Materials needed: boy scout compass, a 4-ft. piece of insulated wire.

In building a galvanometer, wrap the insulated wire around the N-S axis of the compass, leaving the ends of the wire stripped of the insulation for an electrical attachment. Connect a dry cell to the coil and observe the compass needle. Current passing through the wire will cause the needle, which had been pointing north, to shift towards the E-W direction. Current passing through the wire creates a magnetic field stronger than the earth's magnetic field, and the needle shifts. This has become a simple instrument which can be used to detect a small electric current.

A more sensitive instrument can be made by building a little frame from cigar box wood just large enough to hold the compass. Place the compass in the tightly fitted frame and then wind about 20 turns of bell wire over the frame. Again, orient the compass so that the needle pointing toward the north is hidden by the wire.

Teacher Notes:

This galvanometer will not measure the amount of voltage produced by the energy sources. It will only detect whether or not a current is produced. Also, it is meant to be used only where a small direct current is produced, such as that which an ordinary 1.5 volt dry cell will develop.

Activity I-24

Objective:

The student will be able to identify the parts of an electric generator, describe its operation, and/or demonstrate a student-built device.

What to do?

Build, draw or diagram an electric generator, correctly labeling all its parts. Also, describe the use of each part.

Teacher Notes:

Labeled diagrams of a simple electric generator will appear in a number of general or physical science textbooks and lab manuals. Also, an encyclopedia is a good source for this kind of information.

Activity I-25

Objective:

The student will demonstrate the production of electricity using a student-made generator consisting of a bar magnet and coil of wire.

What to do?

Materials: mailing tube, copper wire, bar magnet

Electricity can be produced with a magnet and a coil. This simple generator can be made by winding about fifty to one hundred turns of wire around the hollow tube. Connect the ends of this wire to the two posts of a galvanometer such as the one prepared in Activity I-23. Push one end of the bar magnet through the center of the coil of wire, passing it completely through the hollow tube. Observe the galvanometer. Then pull the magnet through the coil in the opposite direction and observe the galvanometer again. In the return movement, be sure to orient the N-S magnetic poles of the magnet in the same direction as the first observation. Describe what happens.

Teacher Notes:

As the magnet is moved in and out of the coil, magnetic lines of force are broken by the coil and a current is set up in the coil.

Activity I-26

Objective:

The student will build and demonstrate the use of an electromagnet.

What to do?

Materials: 2-inch iron bolt with nut, 2 washers, roll of insultated wire, two dry cells, nails, and other small objects.

Place a washer at each end of the bolt and screw the nut just on to the bolt. Wind layers of insulated bell wire on the bolt between the washers, making certain to leave 1 foot of wire sticking out when you start winding the coil. When you have filled the bolt between the washers with several layers of turns of wire, cut the wire, again leaving about 1 foot sticking out. Twist the two ends of the wire close to the ends, then wind short lengths of tape at the ends of the bolt to keep the wire from unwinding. Remove the insulation from the two ends of wire. Connect two dry cells in series (connect the negative terminal of one battery with a short wire to the positive terminal of the other) and attach the electromagnet, prepared from the bolt, to them. Pick up some tacks and nails. Disconnect one wire from the battery while the tacks are still attached. What happens? Using the electromagnet, pick up other objects made of iron or steel. Try it with other materials. Explain what happens.

Teacher Notes:

It will become evident that an electromagnet will lose its magnetism quite readily after the circuit has been disconnected. Only objects containing iron and steel will be picked up with the electromagnet.

Activity I-27

Objective:

The student will construct a simple electric circuit and will test different solids for electrical conductivity using the prepared electrical circuit.

What to do?

Materials needed: a dry cell, knife switch, and electrical socket and light bulb, four-inch strips of rubber, cloth, aluminum, iron and other materials.

Make a simple electrical circuit by connecting a piece of wire from one terminal of the battery to one terminal of the knife switch. To the other terminal of the knife switch, connect another piece of wire to the terminal of the light socket. A third piece of wire is connected from the other terminal of the light socket to the open terminal of the battery. Connect the switch. The light should go on.

Open the switch and test the strip of rubber, cloth, aluminum, iron and other materials for conductivity by holding each one of them across the two poles of the switch. Which of the materials conducted the electric current and made the light go on?

Teacher Notes:

conductors	non-conductors
aluminum	rubber
iron	cloth

The conductors will enable the light to go on. The non-conductors will not complete the circuit.

Electromagnetic or Radiant Energy

We have already pointed out the close relationship between electrical fields and magnetic fields. Oscillations or vibrations of electrically charged particles of matter in magnetic fields produce energy in the form of electromagnetic waves which radiate from the source at the speed of light. This energy is often called radiant energy. Depending on the conditions under which they are generated, these electromagnetic waves may have a long wave length, which means they have low frequency and energy. They may be of the particular wave length that can be detected by the human eye, in which case they are visible light waves. Or they may be of shorter wave length and higher energy, such as x-rays. Thus a wide band or spectrum of electromagnetic waves exists.

The sun is the major source of radiant energy for the earth. Sunlight is that portion of the sun's total radiation that is visible to the human eye. Other electromagnetic waves radiated from the sun are infrared and ultraviolet radiation, gamma rays, x-rays, and radio waves.

Activity I-28

Objective:

The student will examine various ways of using reflected light to simulate the actual path and behavior of light in common laboratory and field instruments.

What to do?

Have the students bring into the classroom a collection of mirrors. Have them look at their own images in the mirrors at various angles. Record the results. Use a flashlight in a darkened room and have them record the results of where they see the reflected light from the flashlight on the mirror at various angles. Put chalk dust on the mirror and see what happens. Ask the students how these concepts are used in a telescope, optical instruments, microscopes and periscopes. If possible, have examples of these in the classroom for the students to look through and examine

Teacher Notes:

A telescope uses light that travels in straight lines. A microscope operates by light reflected in a perpendicular line. A periscope directs light by angular reflections.

Activity I-29

Objective:

The student will see the effect of refraction of light when it passes from one medium to another.

What to do?

In order to illustrate that light rays change direction when going from one kind of matter to another, begin by placing a coin in each of two cups and set the cups side by side. Move the cups until the coins are just out of sight over the edge of the cups without changing position of the eye. Have someone pour water slowly into the first cup. Record the results. Why did the coin continue to appear in the first cup?

Teacher Notes:

Be sure to explain to the students that this light phenomena is called refraction of light and that this characteristic of light is used in eyeglasses and cameras to change the direction of light.

Activity I-30

Objective:

The student will calculate the amount of radiant energy which falls on one square meter of the earth's surface.

What to do?

If the energy from the sun falling on a square meter of the earth's surface (per min) is 4.47×10^4 watts, have students calculate how much falls on a square meter of the earth's surface for a 10-hour period. How can we harness this energy?

Teacher Notes:

The amount of radiant energy striking one square meter of the earth's surface in a 10-hour period is:

$$\frac{4.47 \times 10^4 \text{ watts}}{1 \text{ min.}} \times \frac{60 \text{ min}}{1 \text{ hr.}} \times 10 \text{ hr} = \frac{2.68 \times 10^7 \text{ watts}}{10 \text{ hr.}}$$

Curved reflectors can be used to concentrate the sun's rays to one focal point, thus increasing the intensity and usefulness of the radiant energy.

Activity I-31

Objective:

The student will determine the location and function of each type of radiant energy group in the electromagnetic spectrum.

What to do?

Using the accompanying chart of various frequencies of the electromagnetic spectrum, find the location of each type of radiant energy wave group. Discuss with the students and illustrate in some way how radio waves are sent and received. How are infrared waves used? Where do we experience ultraviolet waves? X-Rays?

What do scientists fear about freon in terms of its effect on the ozone layer in the stratosphere?

Teacher Notes:

The function of each wave group can be obtained from any good encyclopedia or physical science textbook.

Nuclear Energy

Nuclear energy is the energy released or absorbed during alterations within the nucleus of an atom. We have already said that the building block for all matter is the atom, and that an atom can be considered to be a dense core of particles called protons and neutrons forming a positively charged nucleus, surrounded by a swarm of negatively charged electrons.

Any one of the more than 1300 known species of atoms characterized by the number of neutrons and protons in the nucleus and by energy levels is called a nuclide. For example, an atom of chlorine with 18 neutrons in its nucleus is one nuclide, while an atom of chlorine with 20 neutrons is another nuclide.

All nuclides can be placed into one of two categories: radioactive or stable. Radioactive nuclides (radionuclides) undergo spontaneous nuclear changes which transform them into other nuclides. This transformation is called radioactive decay, and through the decay, the radioactive nuclide is changed eventually into a stable nuclide.

There are some 265 stable nuclides and 66 radionuclides found in nature. All the rest of the nuclides are man-made radionuclides. Thus about 5/6 of all known nuclides are radioactive.

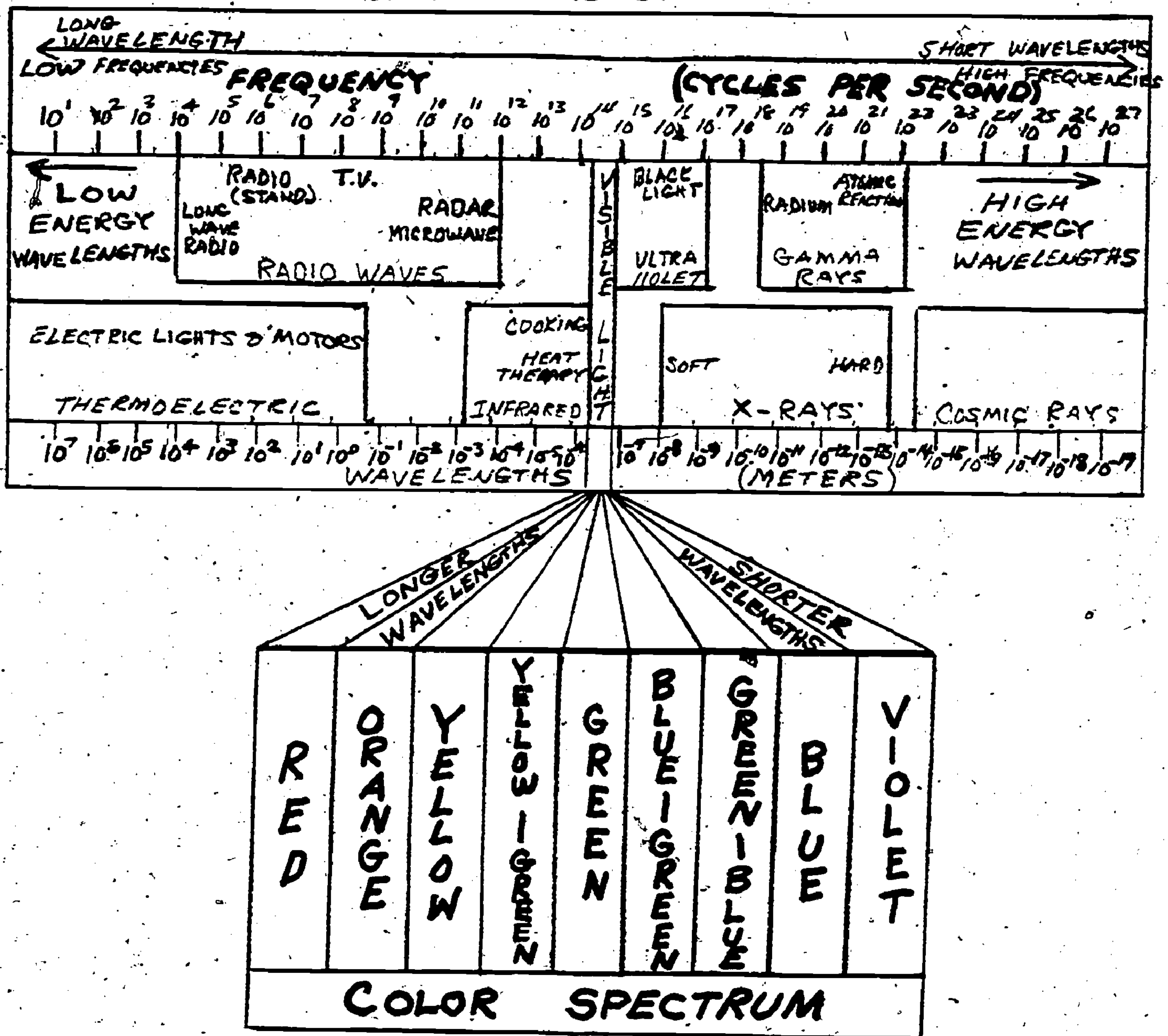
In changing to a stable state, the nucleus of a radioactive atom emits radiation. Radiation may be in the form of particles, or in the form of electromagnetic rays called photons. Some radionuclides decay by the emission of alpha particles, which are high energy helium nuclei. Others decay by the emission of beta particles, which can be either negatively charged electrons (negatrons) or positively charged electrons (positrons). Decay by the emission of these particles is usually followed by the emission of photons of two types: gamma rays, which are produced in the nucleus of the decaying atom, and x-rays, which are produced as a result of the rearrangement of orbital electrons. Except for their origin and the fact that x-rays are usually lower in energy and therefore less penetrating, x-rays and gamma rays are the same.

Loss of this radiation changes the atomic structure of the radioactive nuclide, a process which continues until a stable (nonradioactive) nuclide is reached. Uranium, for instance, is radioactive; it decays slowly into elements like radium, radon, and polonium, and finally stops at lead. The time required for one-half of the radioactive atoms of a nuclide to decay to its daughter nuclide is known as the half-life of that nuclide. An atom with a short half-life quickly decays. Half-lives vary from minute fractions of a second to billions of years.

As a source of useful energy at the present time, the most important nuclear reaction is the fission reaction. When atoms of certain heavy nuclides are bombarded by neutrons, the nuclei of some of these atoms will capture a neutron and become unstable so that they fission, or split, into two or more small atoms. Together the fission products weigh slightly less than the original atom and the bombarding neutron combined; this missing mass is converted into energy, as described by Einstein's formula: energy equals mass times the velocity of light squared ($E = mc^2$). It is this conversion of mass into energy that

RADIANT ENERGY

ELECTROMAGNETIC SPECTRUM



Adopted from "Exercises and Investigations for Modern Physical Science," Holt, Rinehart and Winston, Inc., page 154.

NUCLEAR FISSION CHAIN REACTION

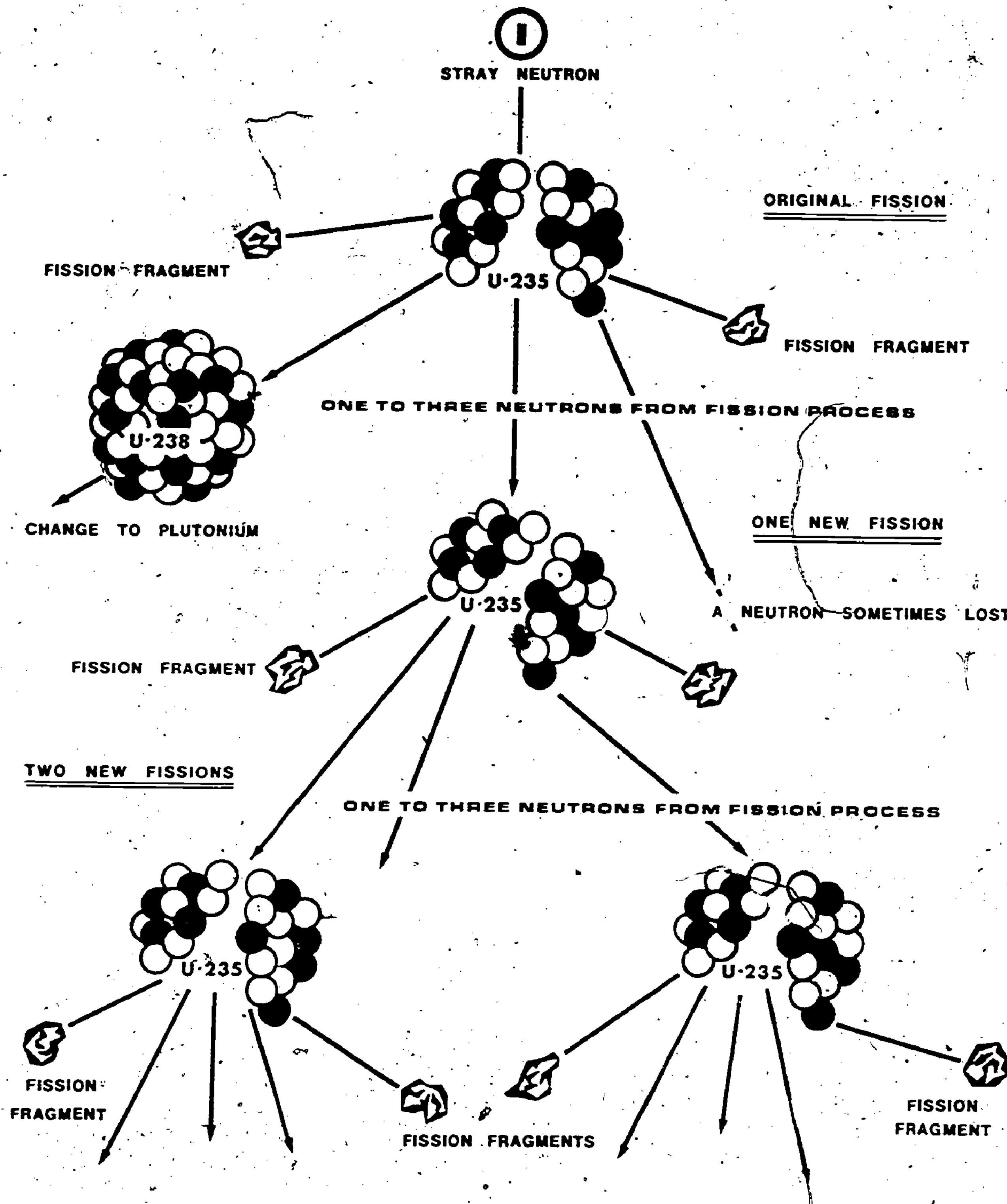


FIGURE 4

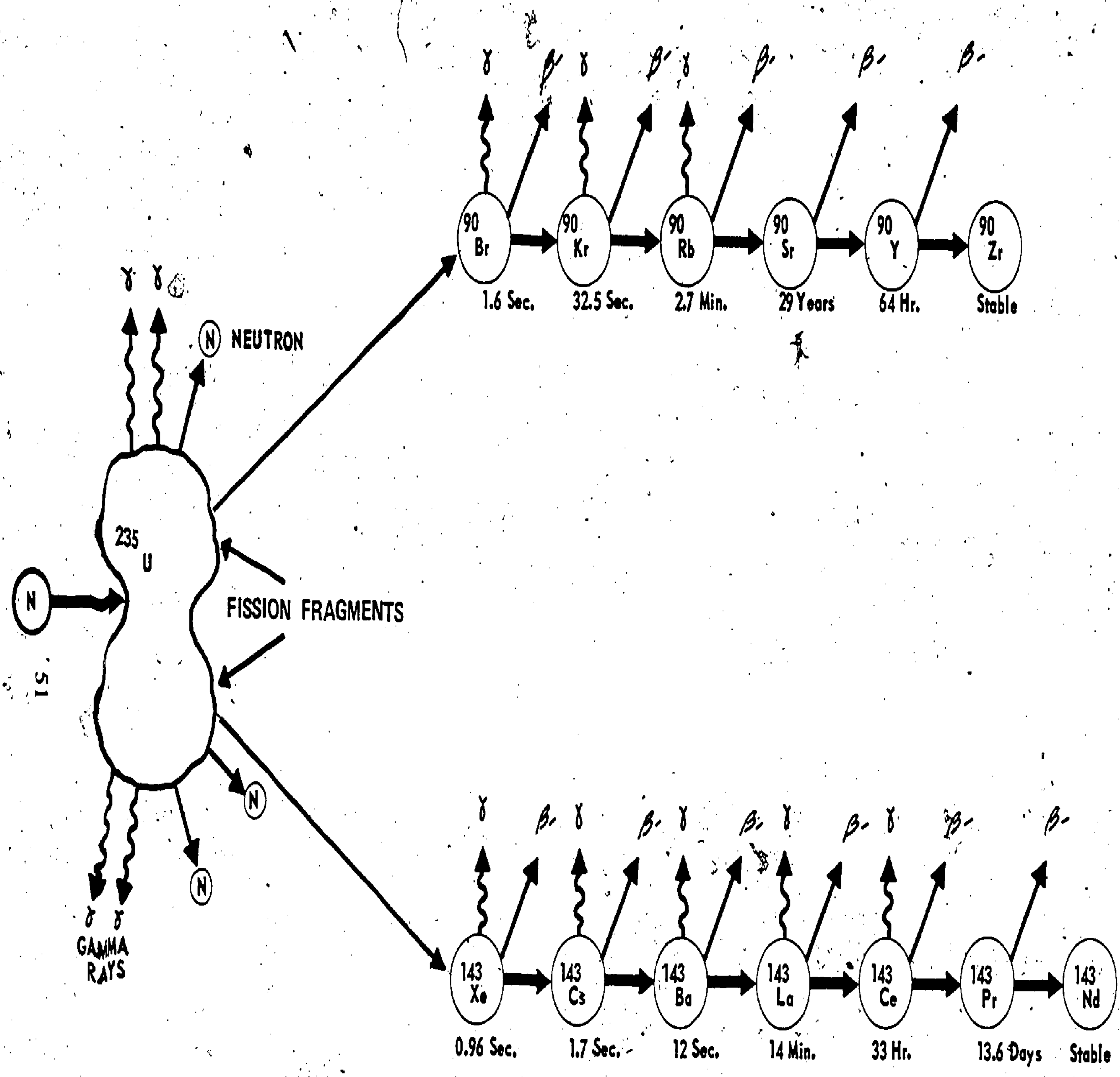


FIGURE 5

URANIUM FISSION AND BETA DECAY CHAINS

makes nuclear fission so powerful, and sets it apart from ordinary chemical reactions, where no such conversion occurs. As fission fragments fly apart, most of this energy appears almost instantaneously as heat as the fragments lose their energy of motion to the surrounding material. The heat from this fission reaction can then be used to boil water to make steam, which in turn spins turbines that generate electricity.

When an atom fissions, several free neutrons are released. These are available to strike other atoms, causing them to fission. This is the chain reaction (Figure 4). If a chain reaction is to continue, there must be enough fissionable atoms packed closely enough to insure the capture of enough neutrons to keep the rate of fission constant. The amount of material required for this is called the critical mass.

Generally, the smaller atoms produced by fission are radioactive. These fission fragments usually decay by negatron emission followed by gamma ray emission. Figure 5 shows one of more than 30 possible chains of decay following the fissioning of an atom of uranium-235. The fission fragments are atoms of radioactive bromine and xenon, and they each decay through many steps by emitting beta particles. The half-life for each part of the chain is shown. Note the diversity of half-life lengths.

Uranium is the basic nuclear fuel because it contains uranium-235, the only nuclide found in nature that readily undergoes fission. The natural concentration of uranium-235 in uranium is seven-tenths of one per cent; the balance is uranium-238, which does not readily undergo fission.

The process of nuclear fusion also releases a tremendous amount of energy, but we have not yet come to the point where we can make practical use of it. In fusion, two light nuclei are forced together to form a heavier nucleus. The fusion reaction will use forms of hydrogen called deuterium and tritium to make a single helium nucleus and a neutron, releasing a large amount of energy.

Activity I-32

Objective:

The students will use people to illustrate the particles and energy changes involved in nuclear reactions.

What to do?

In order to illustrate fission, ask two students to each hold one hand of the teacher. These students represent the uranium atom. If the teacher represents the energy, what important role does the teacher play in the uranium atom? Now ask the students to try to get away, but the teacher should hold them tightly so that they can't. Then, have a third student force them away from the teacher. What type of particle does the third student represent?

In illustrating fusion, the teacher tries to keep two students apart who are trying to get together. The third student makes every attempt to get the two students together and finally succeeds in doing so. What type of particles do the students represent? What does the teacher represent?

Teacher Notes:

In the illustration of fission, the teacher represents the energy that holds the atom together. The third student represents the neutron that bombards the nucleus of the fissionable atom.

In the illustration of fusion, the two students, who are being kept apart by the teacher, represents two heavy hydrogen atoms; namely, deuterium and tritium. When the two students eventually get together by the pushing effort of the third student, the teacher is squeezed out. The teacher represents the energy released from the nuclei of the two heavy hydrogen atoms as they are fused together.

This activity would likely be most effective for the upper elementary grades. The various roles and movements should be worked out in advance with the participating students so that the situation does not get out of hand.

Activity I-33

Objective:

The student will draw diagrams of some simple atomic structures and identify the different parts of the atom.

What to do?

The students will draw diagrams of atoms with colored chalk, colored pens, or colored pencils on paper. Label the different parts of the atom: electrons, protons and neutrons. Where is the nucleus of the atom located? Some suggestions for elements to illustrate are as follows:

- Hydrogen-1 (ordinary hydrogen)
- Hydrogen-2 (deuterium)
- Hydrogen-3 (tritium)
- Carbon-12
- Carbon-14 (used for radioactive carbon dating)
- Uranium-235 (better do a little planning for this one)

Teacher Notes:

Obtain a periodic table from a science or chemistry textbook. Using this periodic table, notice the numbers which increase by one as you move from left to right across the periodic table. These numbers are the atomic number or the number of protons contained in the nucleus of that atom. The number of neutrons can be obtained by subtracting the number of protons from the exact mass number. For example, carbon-14 has a mass number of 14. Its atomic number is found to be 6 from the periodic table. The difference in these two values is:

Mass Number – Atomic Number = Number of Neutrons
14 – 6 = 8 (No. of Neutrons in carbon-14)

What about carbon-12?

Mass Number – Atomic Number = Number of Neutrons
12 6 6 (No. of Neutrons in carbon-12)

Note that ordinary hydrogen has only one proton, no neutrons. Deuterium contains one proton and one neutron and tritium has one proton and two neutrons.

How many electrons should be represented in a neutral atom? The number of electrons should equal the number of protons (atomic number).

In the simple drawings, the center of the atom contains the neutron and protons and the electrons are located outside the nucleus.

Activity I-34

Objective:

The students will examine a rock collection and a number of other objects with the use of a geiger counter to determine which substances give off high energy rays resulting from radioactive decay.

What to do?

Obtain a geiger counter from your science equipment or borrow one from another laboratory. Test various objects for radioactivity, particularly someone's rock collection. Some wrist watches may contain radium in face parts which will cause the geiger counter to give off its characteristic clicks. Separate those substances which contain radioactive material from those that do not. What do those substances which cause the radioactive decay clicks have in common? What causes the clicks in each one? What relationship does the number of clicks have to radioactivity?

Teacher Notes:

One needs to be certain that the radiation which is recorded on the geiger counter is not coming from background radiation. Check the area before the object is brought within the vicinity of the geiger counter.

Activity I-35

Objective:

The students will make an on-site visit to a nuclear power plant to learn about and observe first hand a nuclear plant facility, its built-in safety features, and its potential for production of electrical energy.

What to do?

Visit a nuclear power plant and/or have a nuclear engineer speak to the class about controlled nuclear energy production.

Teacher Notes:

Such a visit to a nuclear power plant can be most meaningful if the students are prepared well in advance for the experience. There are a number of booklets which give excellent background preparation. Do not expect to go inside the reactor shell because of radiation hazards. Most plants have an education facility for visiting groups and the students can become well informed about the actual plant operation by observing model demonstrations.

Activity I-36

Objective:

The students will observe an oil drop model of a fissioning atom.

What to do?

Materials needed: a small water glass, 5 or 6 ounces of rubbing alcohol, an ounce or so of cooking oil, some water, a teaspoon, a butter knife, and a paper towel.

Fill the water glass about half full of rubbing alcohol, then add enough water to fill the glass two-thirds full. Stir the alcohol-water mixture with the teaspoon. Wipe the teaspoon dry and fill it with cooking oil.

Carefully bring the spoon close to the surface of the alcohol-water mixture, then gently tip the spoon over. A single blob of oil should slide into the glass.

If the blob of oil is floating on the surface, carefully add a bit more alcohol to the mixture with the teaspoon. If the blob has sunk to the bottom of the glass, spoon in some more water. The idea is to change the blob of oil into an oil drop that hovers somewhere in the middle of the glass.

Note how perfectly spherical the drop is. The forces that hold the oil drop together are analogous to the forces that hold an atom together.

Now, take the butter knife and carefully prod the drop apart. At first, the drop will bulge. Then, it will tear apart into two perfectly round oil drops. The oil-drop "atom" will have split into two smaller "atoms." Note that the drop did not split until it was deformed by the knife. Atoms behave in much the same way: They resist splitting until some action critically deforms them.

Activity I-37

Objective:

The students will observe a domino model of a chain reaction.

What do do?

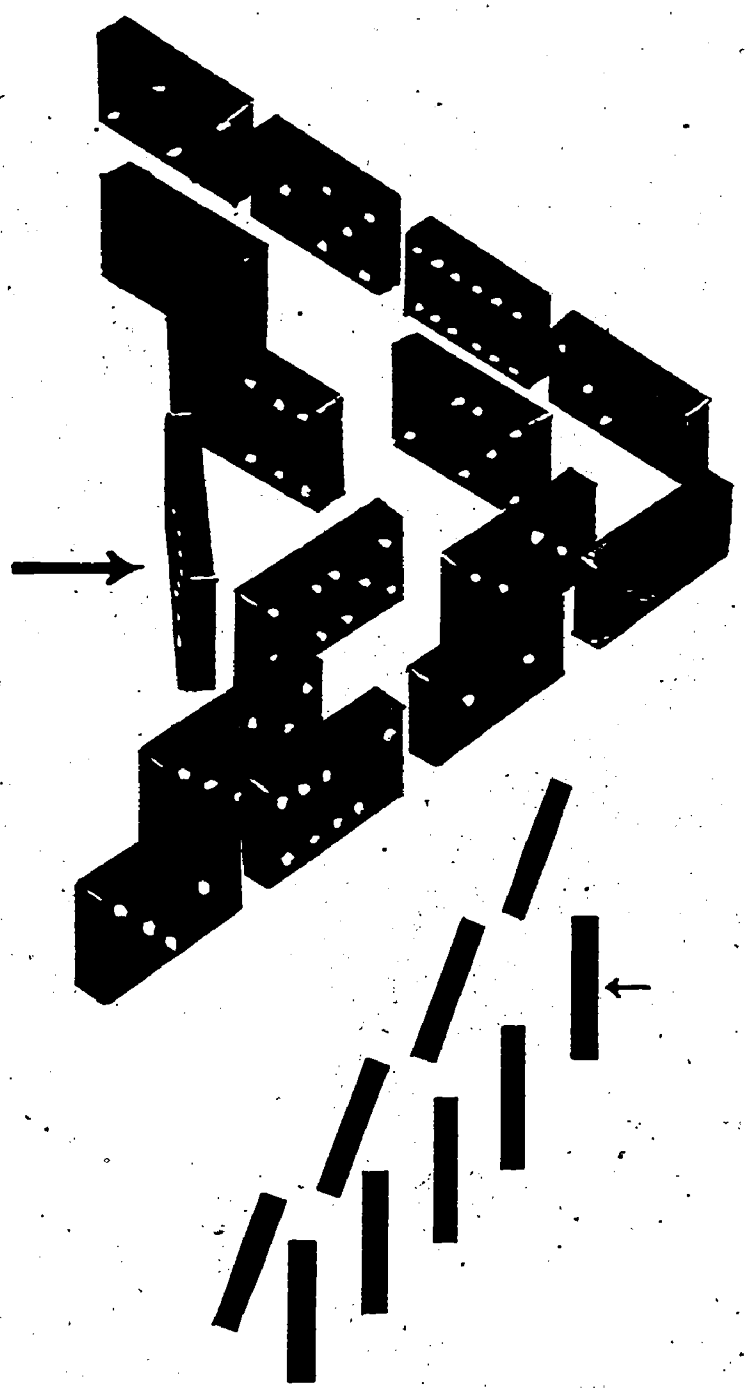
Materials needed: a set of dominoes

Set up the dominoes on their sides as illustrated in the first drawing. When you tip the leading domino over, as if shooting a neutron bullet into uranium, it tips two other dominoes over (releases two new neutrons). In turn, the two falling dominoes tip over four more. And the uncontrolled chain reaction goes to completion.

But in a nuclear reactor, the chain reaction lasts years instead of a fraction of a second. You can model this slow-moving kind of reaction by setting up the dominoes as shown in the second drawing. This type of chain reaction "wastes" some of the neutrons produced. Some dominoes fall without hitting other dominoes.

Teacher Notes:

Activities I-36 and I-37 were taken from an excellent booklet which contains other nuclear experiments, along with information for ordering inexpensive low-level radioactive sources. This booklet is "Nuclear Experiments You Can Do," a publication of Thomas Alva Edison Foundation, Suite 143, Cambridge Office Plaza, 18280 West Ten Mile Road, Southfield, Mich. 48075.



Heat Energy

Early experiments showed that heat had to be some form of motion. But obviously an object can be hot without any motion being visible. Thus the motion must be occurring in parts of the object which are too small to be seen. These small parts are called molecules. The speed of a molecule can be quite large, but the molecules of solid objects move through a very short distance. The higher the speed of the molecules in an object, the greater the amount of heat energy it contains.

The combustion of gasoline in an automobile engine produces heat energy, or high speed motion of the molecules in the cylinders. The motion of these molecules against the pistons make the engine run. Thus work is obtained from the heat energy of molecular motion.

Note that heat and temperature are not the same thing. Temperature measures the average kinetic energy of molecules in an object. When an object is heated, this average speed is increased, and the temperature increases. The amount of heat in an object, however, depends on the number of molecules present as well as their kinetic energy. Thus a cup of boiling water has the same temperature as a quart of boiling water, but the quart of boiling water has four times as much heat energy, since it has four times as many molecules.

Heat can be thought of as the simplest form of energy, since it is the form of energy into which all other forms can be most readily converted. It is also the form that is most difficult to convert into any other form.

Activity I-38

Objective:

The student will identify a variety of different sources of heat energy.

What to do?

Have the students list as many different sources of heat as possible and describe what heat does for them.

For example, they could make a table like the following:

Source of heat	Benefits
Stove burner	Cooking food
Immersion heater	Heating liquids
House furnace	Space heating
Hot water heater	Water heating

Activity I-39

Objective:

The student will construct and observe the operation of a thermometer.

What to do?

Materials needed: pyrex flask, one-holed stopper, 1½ ft. piece of glass tubing, red ink, water, piece of thread, bunsen burner, flask of hot water, one of cold water

Discuss with the students the construction of a thermometer and where they are used. Why are thermometers important? What do they do?

Then, fill the pyrex flask with water tinted with a few drops of red ink. Fit the glass tubing into the stopper. Place the tubing and stopper in the flask in such a way that a little water extends into the tube. Tie a piece of thread around the tube at the level of the water. Heat the flask with the bunsen burner, and watch the water level. Mark an arbitrary degree scale. Put the flask in a pan of hot water for ½ hour, then in a pan of cold water for ½ hour. Measure the difference. Why does the water rise in the tube?

Teacher Notes:

The water rises in the tube due to the fact that the particles of water move faster, much as a crowd of people who get out of control.

Be careful in placing the glass tubing in the rubber stopper. The teacher should give the student some assistance with this chore.

Activity I-40

Objective:

The student will examine the effects of the rubbing action of sand particles (friction) in changing the temperature level of a sand mixture.

What to do?

Materials needed: bottles, rubber stoppers to fit bottles (one holed), sand, thermometers

Make a sand shaker by inserting the thermometer into the stopper after you have added sand to the bottle to make it half full. The thermometer should extend into the sand when the stopper is in position. Record the temperature of the sand before the shaking action. Now, have the students shake the bottle for two minutes. Then read and record the temperature rise. What caused the temperature to rise? What happens in a machine when parts move together? How do you prevent heat energy build-up in a machine? What happens to the brakes of a bike when they are applied to the wheels?

Teacher Notes:

The temperature rises due to the particles of sand rubbing together to produce heat energy. In a machine, the moving parts will rub together producing heat energy. This heat energy formation can be reduced in a machine by using a lubricant such as oil. The brakes of a bicycle will have a tendency to heat up due to the resistance to motion in a bicycle wheel.

Activity I-41

Objective:

The student will determine the effects of heating different kinds of wire which have been suspended between two supports.

What to do?

Materials needed: two stands, piece of bare wire 2 ft. long, string, weight, bunsen burner or lighted candle, ruler

In order to see what heating does to metallic solids, place two stands 18 inches apart. Stretch a wire tightly between them. In the center of the wire, hang the weight, suspending it about 4 inches from the table. Carefully measure the distance. Now, heat the wire by moving the flame back and forth. Again measure the distance of the weight above the table top. See what happens when the wire cools. Try different kinds of wires. Explain what happens to bridges and roads in hot and cold weather. What happens to elastic in clothes during long periods of washing in hot water?

Teacher Notes:

This experiment shows that metal wires will expand upon being heated. The amount of expanding will depend upon the type of wire under investigation. Bridges and roads will expand during the hot summer months and contract during the relatively cold winter months. If a bridge is located near the school, take the class to its location and view the built-in expansion joint provided in its design.

Activity I-42

Objective:

The student will determine the ability of various materials (solids) to conduct heat energy.

What to do?

Materials needed: plywood (¼ inch) 2" by 8", pieces of copper, aluminum, brass, iron wire about 6 inches long, paraffin, bunsen burner or strong flame, tape

What materials will conduct heat energy best? Begin by dipping one end of each wire into melted paraffin until a large ball of paraffin forms. Then, tape each wire to a board as in a fan shape, so that all of the ends opposite the paraffin come to a point. Finally, heat the wires at the point where they join together. Which paraffin melts first? Record the results. Will a material which conducts heat slowly, lose heat slowly? Are all metals good conductors of heat?

Teachers Notes:

A material which conducts heat slowly will tend to lose heat more slowly, and metals are found to be good conductors of heat.

HEAT TRANSFER

An understanding of how heat moves from one object to another is essential in helping to reduce wasted heat energy. Heat is transferred from one object or place to another by conduction, convection, or radiation. We shall consider each of these in turn.

When the bowl of a metal spoon is held in a candle flame, the handle will begin to feel warm. This is heat transfer by conduction. If one end of an object is heated, the molecules in that end are speeded up. They strike the molecules next to them with harder blows, causing them to move more rapidly. This increased motion then progresses down the whole object. Metals are the best conductors of heat, while wood and cloth are poor conductors.

The movement of heat by the flow of molecules is called convection. It is the transfer of heat by the movement of the heated material itself. Convection occurs in liquids and gases, where the molecules move about more freely than in solids. For example, a hot stove in a room heats the air around it by conduction. The heated air becomes lighter than the colder air surrounding it. The warmer air thus rises and is replaced by cooler air. Then the cooler air is heated and rises. This continuous movement of heated air away from the stove, and cooler air toward the stove, creates a convection current. Eventually, all parts of the room are heated.

The movement of heat energy in the form of electromagnetic waves is called radiant heat transfer. Conduction and convection require the movement of molecules, but for radiant heat transfer, molecules are not necessary. The light and heat of the sun are transmitted to earth by waves which travel through the vacuum of space, where there are practically no molecules.

An open fireplace gives heat to a room mainly by radiation.

Activity I-43

Objective:

The student will demonstrate the effect of heat being passed through a solid medium by the method of conduction.

What to do?

Materials needed: several paper clips or needles, candle in a candle holder, steel rod or large knitting needle about 14 inches long, pot holder.

Tie a small piece of thread to each paper clip. Light the candle and let some wax drip onto the holder. Use the hot wax drippings to hang the clips, by their threads, from the steel rod. The clips should be an equal distance from each other and about 1½ inches in from the ends. Grasp the rod with the pot holder, and hold one end in the candle flame. Observe what happens to the clips.

Teacher Notes:

Heat is transferred from one end of the steel rod to the other and the clip nearest the flame will fall off first when the heat melts the wax. In turn, each succeeding clip further down the rod will fall as heat continues to be passed on its way. This action indicates heat transfer by conduction.

Activity I-44

Objective:

The student will observe the effect of heat movement in a liquid by convection.

What to do?

Materials needed: large beaker, wire gauze, alcohol burner or bunsen burner, thermometer, potassium permanganate crystals.

Fill a large beaker with cold water almost to the top. Set it on the wire gauze on a beaker support. Place the alcohol burner under it with the flame at the edge of the beaker. Allow it to heat for about a minute. Is the warmer water at the top or the bottom of the beaker? Check the water temperature with the thermometer. Empty the beaker and replace with a beaker full of cold water. Drop a small crystal of potassium permanganate into the water above the flame location. Observe what happens when the water is heated.

Teacher Notes:

As the potassium permanganate crystals dissolve, the purple color will rise in the solution when the beaker of water is heated. The upward movement of potassium permanganate color indicates the movement of the hot water by convection currents.

Activity I-45

Objective:

The student will demonstrate the effect of heating an object through radiant heat transfer.

What to do?

Materials needed: 200-watt light bulb, lamp socket with cord, masking tape, thermometer, aluminum foil, black plastic tape.

Place a 200-watt light bulb in a lamp socket and connect it to a power source. With some masking tape, tape the socket cord to a support rod which is high enough to permit the bulb to hang 2 ft. from the table. Place your hand directly under and about 2 inches from the lamp. Turn on the lamp. What effect does this have on your hand? Hold a tablet or book between your hand and the lamp. What change in the effect was noticeable on your hand? Next, place your hand about 4 inches above the lamp. Is the heating effect the same as it was previously? Again, move your hand below the lamp. Gradually lower your hand, increasing the distance from the lamp. What effect does distance have on heating by radiant heat transfer?

Using the thermometer, measure the normal room temperature. Then wrap a piece of aluminum foil tightly around the bulb of the thermometer. Hold the bulb about 2 inches below the lamp for about three minutes with the bulb turned on. Note the temperature. Repeat the experiment using a small piece of black plastic electrical tape around the bulb of the thermometer. In which case was more heat absorbed? What color clothing would be more comfortable during the summertime, black or white?

Teacher Notes:

The 200-watt light bulb gives off radiant heat energy in all directions. The radiant heat energy is absorbed by most objects located in the path of the rays. The further the object is located from the source of energy, the fewer rays will strike a given area of the object's surface. Thus, the heating effect is less intense at a greater distance.

The aluminum foil tends to reflect the radiant heat energy. The black tape tends to absorb a greater portion of the rays. One should observe a higher temperature on the thermometer with the black tape than with the wrapped aluminum foil. This experiment would indicate that light-colored clothing worn in the summertime would reflect more radiant energy than black and therefore would be more comfortable.

Activity I-46

Objective:

The student will identify the methods of heat transfer in various situations related to the saving of energy in the home.

What to do?

Recently a newspaper published an article concerning 50 ways to save energy in the home. Some of the suggestions pertaining to heat loss and heat loss prevention are listed below. Indicate the primary method of heat transfer which would be affected by each conservation measure. Briefly explain why you made each selection?

SUGGESTIONS	CONDUCTION	CONVECTION	RADIANT HEAT
1. Broil foods rather than fry or bake. Explain:			
2. Thaw frozen foods before cooking. Explain:			
3. Don't use the oven to quickly heat the kitchen. Explain:			
4. Set the refrigerator at 30 to 32 degrees Fahrenheit. Explain:			
5. Close the refrigerator on a dollar bill. If it slides out easily, you need a new gasket.			
6. Use warm, not hot water, in the clothes washer. Explain:			
7. Lower the thermostat two or three degrees extra in winter when entertaining a large group of people. Explain:			
8. Keep furniture and rugs from blocking heating and cooling outlets. Explain:			
9. Don't run window fans when the air-conditioner is on. Explain:			

SUGGESTIONS	CONDUCTION	CONVECTION	RADIANT HEAT
10. Seal spaces around attic stairway doors and pull-down stairways. Explain:			
11. Close draperies and shades to reduce incoming heat on summer days. Explain:			
12. Open draperies and shades on sunny winter days. Explain:			
13. Draw window shades and drapes at night in the winter time. Explain:			
14. Keep fireplace damper shut when not in use. Explain:			

Perhaps you can think of other suggestions not already included in this list. If so, please list your suggestions below.

15.

16.

17.

18.

19.

20.

21.

ENERGY TRANSFORMATIONS

We have already seen that energy can be converted from one form to another. But no one has ever found a way to create energy out of nothing. Furthermore, there is no known way of destroying energy – energy is never lost. Under special circumstances, energy can be converted into matter and matter into energy, but this is still transformation, not creation or destruction of energy.

One of the biggest problems with energy is the fact that when energy is converted from one form to another, some of the energy is wasted. It is not destroyed – it just changes into a form where it is no longer of practical use. This form is usually heat, which escapes and is eventually dispersed into space, never to be seen again.

Of course, heat energy can be converted into other types of energy, but a great deal of effort must go into the transformation. On the other hand, other forms of energy can be converted into heat much more easily. There thus seems to be a definite direction in which energy seeks to flow, and this direction is toward a dilute, scattered form of energy. Scientists call this form "entropy", and its precise definition need not concern us. In practical terms, it means energy that has become so dilute and scattered it cannot be used ever again to do work.

This inherent wasted heat energy represents a permanent challenge to energy conservationists. It is energy "down the drain" as far as providing useful work to meet energy needs. We must learn to reduce energy waste to acceptable levels, keeping in mind that complete elimination of energy waste is impossible.

Activity I-47

Objective:

The student will examine the interchangeable possibilities of energy, beginning with mechanical energy and ending up as low quality heat energy.

What to do?

Using the transparency entitled, "Energy changes from one form to another", follow the transforma[illegible] mechanical energy to heat energy.

Activity I-48

Objective:

The student will determine the energy transformation that take place when a bulldozer pushes a boulder to the top of a hill, and the boulder rolls back down to the bottom of the hill.

What to do?

The student will examine the energy transformations in the following situation: Suppose a boulder lies at the bottom of a hill and a bulldozer is used to push it to the top. What energy changes occur in getting the boulder to the top of the hill? What form of energy does the boulder possess at this elevated position? If the boulder is allowed to roll back down the slope, what energy changes are now taking place? What has happened to all the energy when the boulder reaches the bottom of the slope?

Teacher Notes:

In pushing the boulder up the slope, the bulldozer is gradually converting kinetic energy to potential energy as the boulder is elevated higher and higher. The engine of the bulldozer burns gasoline (potential energy) to create thermal or heat energy. The heat energy produced in the engine is converted into kinetic energy of the moving dozer and boulder in front of it. In moving the boulder, some of the energy is converted into low quality heat and noise energy. In going to the top of the slope, the energy of the boulder is converted into gravitational potential energy.

In rolling down the slope, the boulder is converting potential energy partly into kinetic energy and partly into heat energy (heat is produced by friction as the boulder rolls down the slope). Eventually, the boulder comes to rest when all of its kinetic energy has been converted into heat. In this entire process, the rolling boulder leaves a trail of heat that is soaked up in the surroundings as low quality heat energy.

Activity I-49

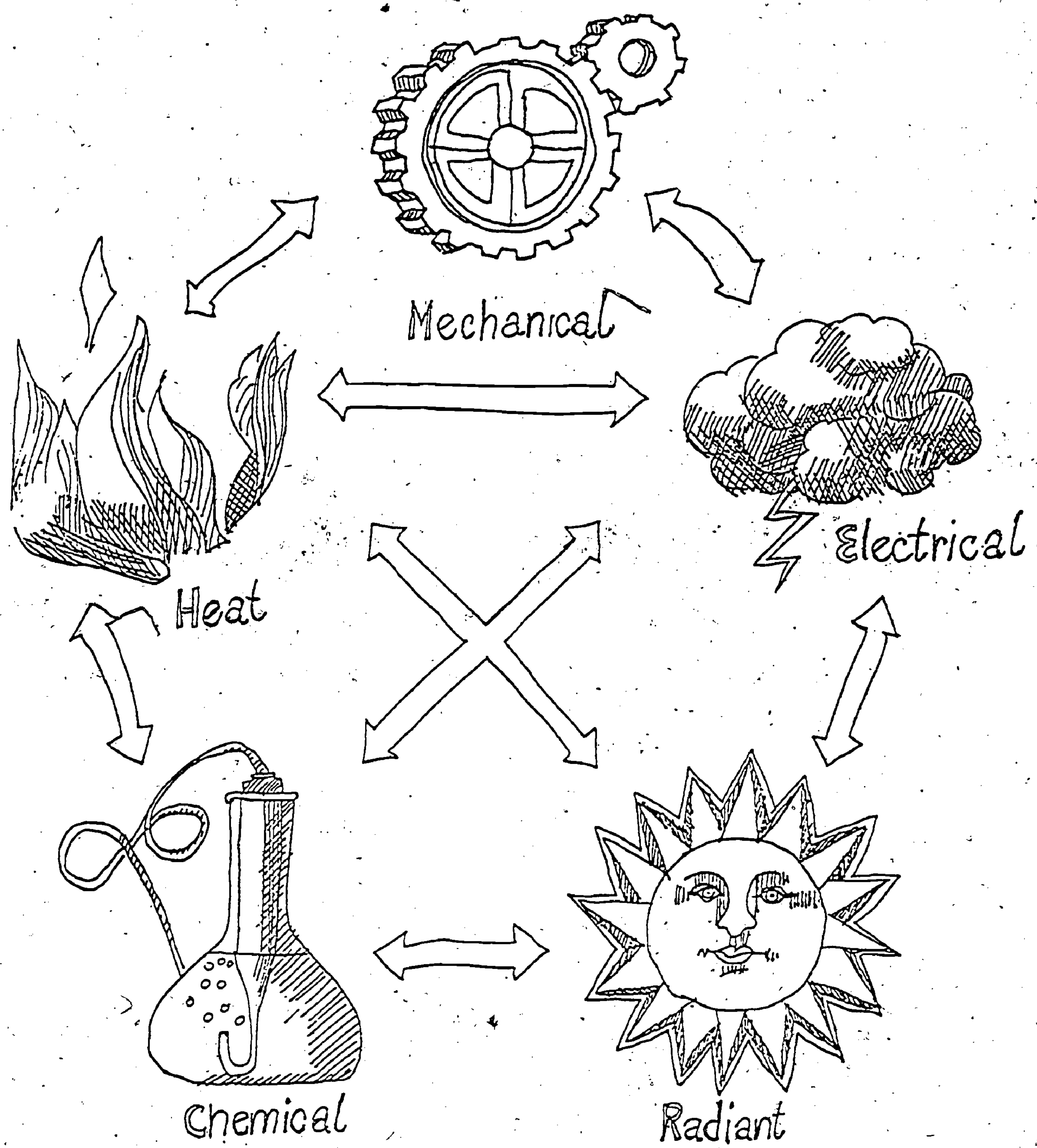
Objective:

The students will examine the loss of energy in energy transformations.

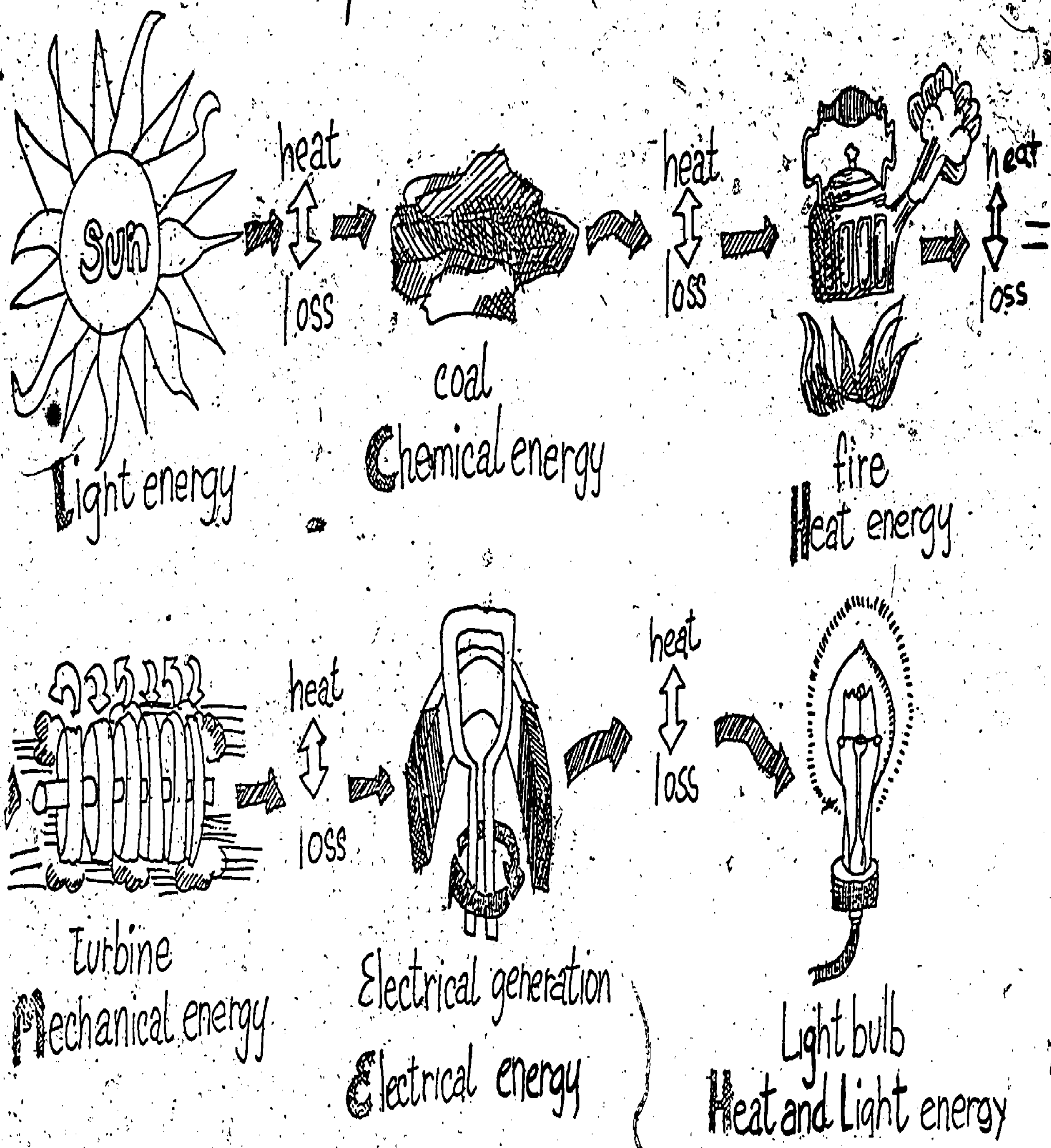
What to do?

Refer the students to a mimiographed copy or transparency of the chart entitled "Energy Transformation." Discuss with the students the loss of heat energy with each energy transformation. Assign one transformation step to each student for research. Questions for each student to consider: How does the actual loss of energy occur? What steps are or could be taken to minimize the heat loss? Is it possible to completely reduce energy loss at that step? What happens to the heat and light energy delivered by the light bulb? Where does all the energy "disappear" to?

Energy changes from one form to another



Energy Transformation



MEASUREMENTS OF ENERGY

We need not concern ourselves with many sophisticated terms in energy measurement, but we do need some basic definitions to serve as tools in talking about energy.

A basic unit of energy measurement is the British Thermal Unit, or BTU. One BTU is the amount of heat energy that must be supplied to one pound of water to raise its temperature one degree Fahrenheit.

Energy from all fuels can be converted to BTU's. Approximate conversion rates are as follows:

1-42 gallon barrel of oil	5.8 million BTU's
1-cubic foot of natural gas	1031 BTU's
1-kilowatt hour of electricity	3413 BTU's
1-ton of coal	25 million BTU's

The word power refers to the amount of energy used or produced in a given amount of time. One important unit of power is the watt. One watt is equal to .00948 BTU per second. One kilowatt is 1000 watts, while one megawatt is 1,000,000 watts.

The kilowatt-hour is the familiar measurement of electricity. A kilowatt-hour (KWH) is 1000 watts of power used for one hour.

All electric appliances and light bulbs are rated in watts. For example, a 100 watt light bulb will light for 10 hours with one KWH of electricity. An appliance with a rating of 1000 watts will run for one hour on one KWH of electricity.

In biological processes, the unit of energy is the calorie. One calorie is the heat required to raise the temperature of one gram of water one degree Centigrade. The Calorie (note upper case "C") is called the kilocalorie, and is equal to 1000 calories. One Calorie is about 4 BTU.

Activity I-50

Objective:

The students will match various energy equivalents.

What to do?

What equals what?

Try to find a match for each of these. Be careful: they may surprise you!

1. Energy equivalent of 1 barrel of oil.
2. Energy used for the manufacture of 20 aluminum cans using recycled aluminum.
3. 3 months' worth of electricity for a frost-free refrigerator.
4. Total energy use of 800 million Chinese in one year.
5. 350 degrees in your oven.
6. Paper needed to package food in 1 American fast food chain in 1 year.
7. Heat given by the burning of one cord of oak wood.

* * *

1. Energy used by the air conditioners of 200 million Americans in one year.
2. 325 degrees in your oven if you use stainless steel, ceramic, or glass dish.
3. Energy equivalent of a man at hard labor for 2 years.
4. Energy used in the manufacture of aluminum can using only virgin aluminum.
5. 174 million pounds of paper.
6. 1 months' worth of electricity for non-frost-free refrigerator.
7. Heat given by the burning of one ton of coal.

Teacher Notes:

Answers:

- 1-3 A human being requires 341 BTU's of energy for one hour of normal activity.
- 2-4 If you failed to recycle 2 aluminum cans, you would waste more energy than is used daily by a person in poorer lands.
- 3-6 A frost-free refrigerator uses much more energy than a manual model.
- 4-1 The U.S. level of energy consumption is 6 times as high as the world average.
- 5-2 These types of dishes conduct heat more effectively and thus do not require as hot an oven.
- 6-5 This amount, 174 million pounds, requires a substantial yield of 315 square miles of forest for one year.
- 7-7 The heat potential of one cord of wood (80 cubic feet) equals the heat potential of one ton of coal.

Courtesy of Park Project on Energy Interpretation, National Recreation and Park Association.

ENERGY AND THE LIVING WORLD

We have discussed various forms of energy, and their transformations. Later modules will deal with how people use these forms of energy to do work for them. But before we leave the general topic of energy, we will see some aspects of energy as it pertains to the world around us.

As we have said before, the sun provides the energy that sustains life on earth. The sun has probably existed for some 5 or 6 billion years. It is really just an average temperature, middle-sized star when compared with the rest of the stars in the universe. What is so special is the earth's location in relation to the sun. The earth is just the right distance from the sun to support life as we know it.

The exact source of the sun's energy is not really known. It has been theorized that the sun is a giant fusion reactor, fusing hydrogen into helium and converting the mass difference into energy. It is believed that the sun produces more energy in one second than has been used by all people throughout human history.

The tremendous energy produced by the sun radiates out in all directions. Only a very small fraction (one two-billionth) ever reaches the earth's atmosphere. Not all of this energy reaches the earth's surface. In fact, 40 per cent of the solar radiation is reflected back to space (mainly by clouds); 17 per cent is directly absorbed by the atmosphere, including water vapor, clouds, and dust. The remaining 43 per cent is absorbed by the earth, and is used to power the winds, water cycle, and ocean currents, and to support life. Actually, only about one per cent of the incoming solar radiation is used to support life through photosynthesis. Figure 6 shows the distribution of the various proportions of solar radiation.

The earth's atmosphere plays an important part in regulating the temperatures here on the earth. Because of our atmosphere, we do not have the large temperature fluctuations that are found on the moon, which is, of course, the same distance from the sun as we are.

Another benefit provided by the atmosphere is what is called the "greenhouse effect." We have said that 43 per cent of the radiation from the sun, mostly visible light, passes through the atmosphere and is absorbed by the earth. This is transformed into heat (infrared radiation) and is radiated back toward space. The water vapor and carbon dioxide found in the atmosphere are good absorbers of heat. They then trap much of this heat energy and prevent it from immediately escaping back into space. This keeps the average temperature of the earth higher than it would be without the atmosphere (Figure 7).

The greenhouse effect is also the center of one of our modern-day controversies. One group of scientists is proclaiming that, because of all the smoke we are generating by burning fuels, we are going to block off enough incoming sunlight to lower the earth's temperature several degrees, which would be disastrous. Another group of scientists argues that because of the large amount of carbon dioxide we are generating, also through burning fuels, we will trap more heat in the atmosphere, which would raise the temperature of the earth several degrees and also prove disastrous. Might the production of energy prove in some way to be the downfall of the human race?

Only green plants can directly use the incoming solar radiation. All other organisms must then depend on the green plants for their life support.

Green plants use solar energy in the process of photosynthesis, where the sun's energy is transformed into chemical energy and stored as food. As the sun beams down on a green plant, the plant is taking molecules of water, minerals from the soil, and carbon dioxide from the atmosphere, and is using the sun's energy to combine these molecules into various new arrangements to form sugars, starches, proteins and vitamins. These new molecules contain the chemical energy that other organisms will then use to sustain their life. Figure 8 illustrates the process of photosynthesis.

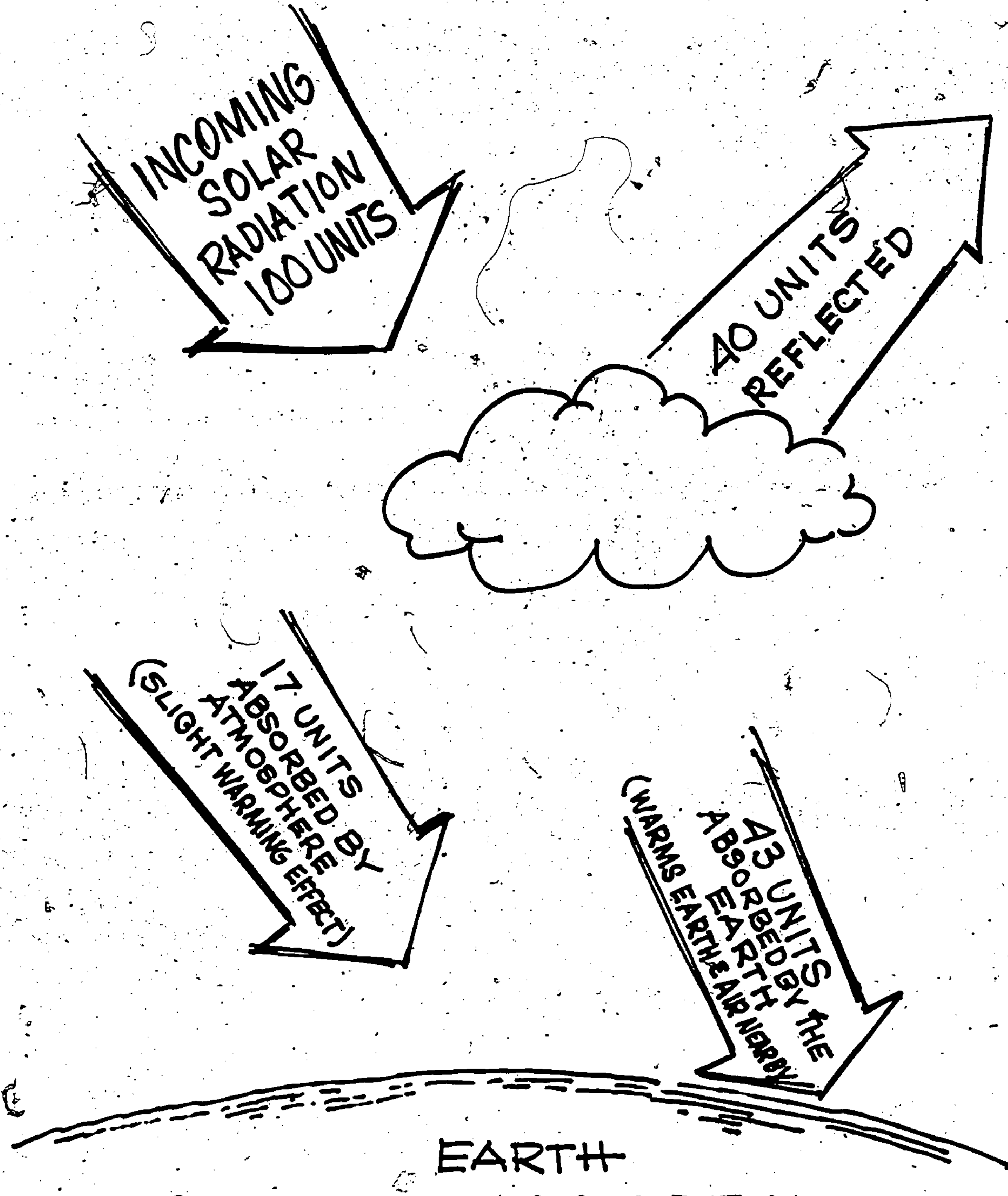
The process whereby animals use the energy stored by plants is called cellular respiration, and is really just the opposite of the process of photosynthesis. In cellular respiration, the food molecules (sugar, starch, and protein) are torn apart and energy is released, while carbon dioxide and water are produced. The energy released is then used by the animal for motion, growth, and other life processes.

Some of the energy from the plants is also stored again in the tissues and fat of the animal. Thus if an animal is eaten by another, the first animal is providing energy for the next animal – energy that actually originated in the sun.

This process of passing on the sun's energy can continue for only a limited time, because as in most energy transformations, energy is being lost at each step of conversion. As the energy is passed from one organism to the next, most of it (80 to 90 per cent) is lost through respiration and heat, and only 10 to 20 per cent is available to the next organism. Because of this loss, a country that eats much meat, like the U.S., has to produce many times more plants (grains) to supply everyone with food than a country such as India or China that eats more of the plants directly. In other words, eating meat is really a waste of energy because so much of the energy is lost as the corn and wheat are transformed into the meat of the animal. Figures 9 and 10 help illustrate this fact.

The sun provides the energy for many other phenomena besides life support. Wind is caused by the uneven heating and cooling of different parts of the earth by the sun. As the temperatures of two different regions of the earth differ, the air pressures over these regions also differ, and winds are produced (Figure 11). The energy in these winds may then be used for various purposes, including steering weather systems, driving ocean currents, shifting desert sands, and powering some machines.

The sun's energy also drives what is known as the water cycle (Figure 12). It all begins with the sun causing evaporation of water from the land and oceans. The water vapor later condenses and falls back to the land in the form of rain or snow. Gravity causes the water to run from the land back to the ocean.



SOLAR RADIATION DISTRIBUTION

FIGURE #6

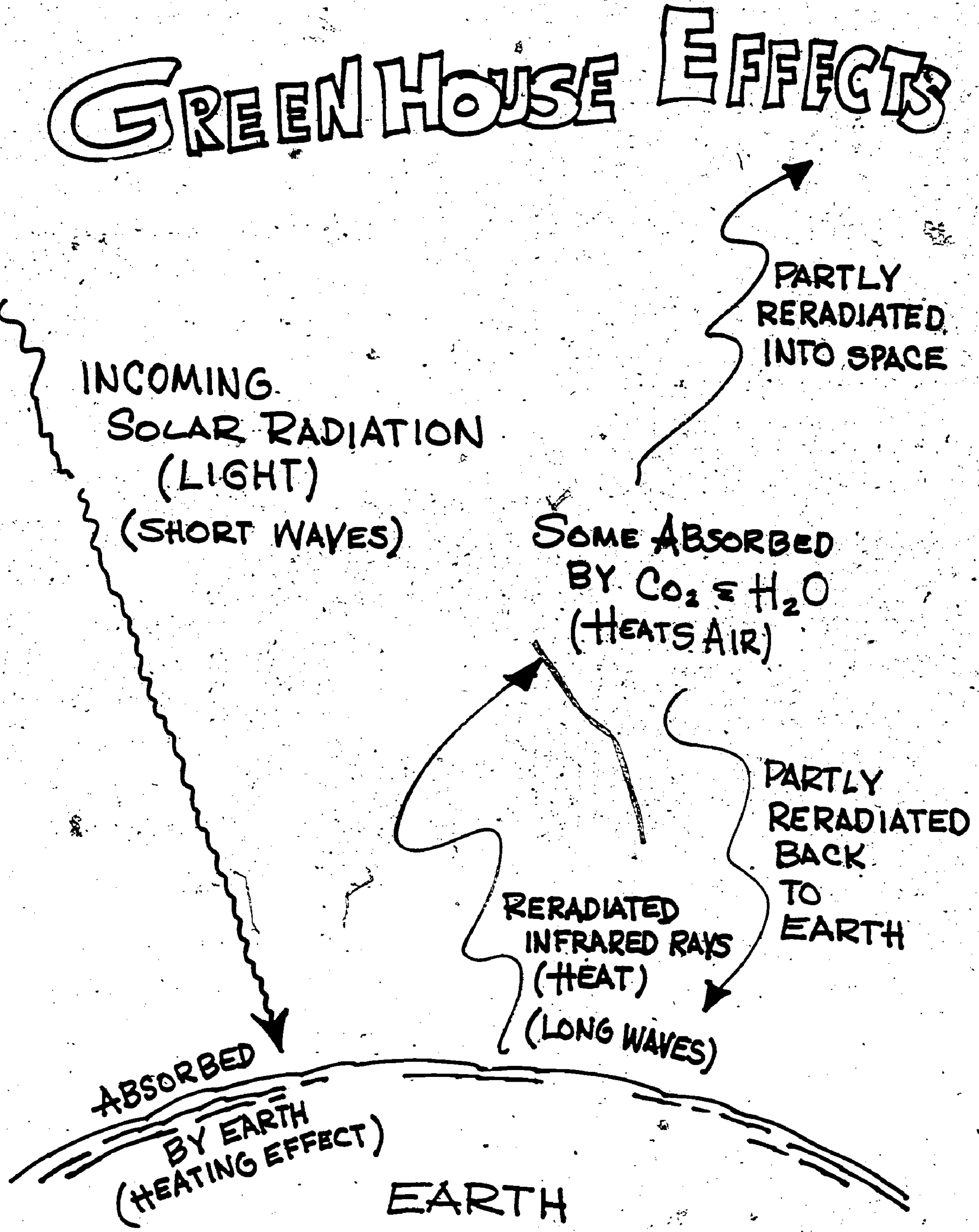
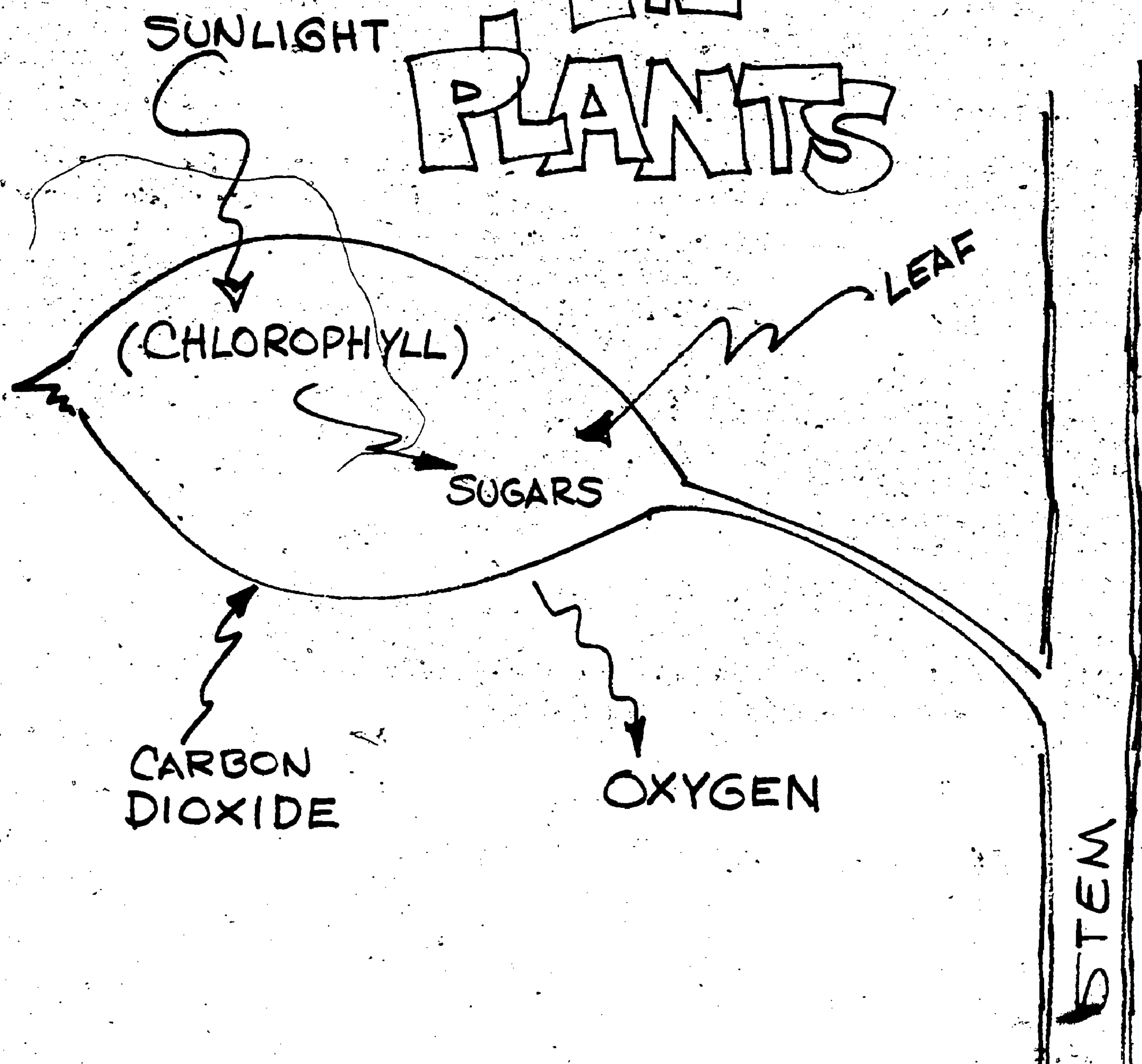

GREEN HOUSE EFFECTS
INCOMING SOLAR RADIATION (LIGHT) (SHORT WAVES)
PARTLY RERADIATED INTO SPACE
SOME ABSORBED BY CO_2 & H_2O (HEATS AIR)
PARTLY RERADIATED BACK TO EARTH
RERADIATED INFRARED RAYS (HEAT) (LONG WAVES)
ABSORBED BY EARTH (HEATING EFFECT)
EARTH

FIGURE #7

PHOTOSYNTHESIS IN PLANTS



CARBON DIOXIDE + WATER + ENERGY → SUGARS + OXYGEN

$CO_2 + H_2O + \text{SUNLIGHT} \rightarrow C_6H_{12}O_6 + O_2$

FIGURE #8

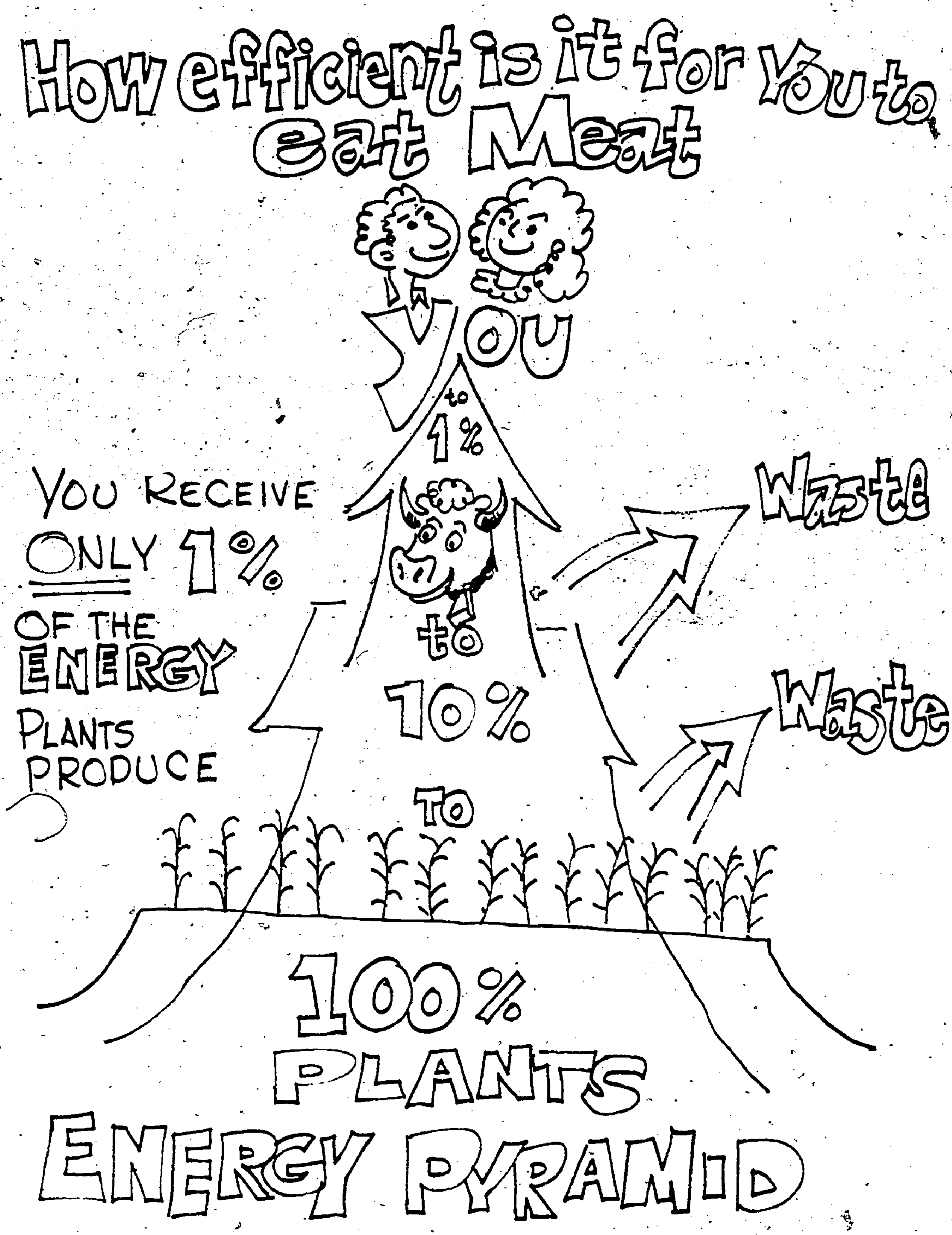

How efficient is it for You to eat Meat
YOU
to
1%
YOU RECEIVE ONLY 1% OF THE ENERGY PLANTS PRODUCE
Waste
to
10%
Waste
TO
100%
PLANTS
ENERGY PYRAMID

FIGURE #9

ENERGY FLOW THROUGH A FOOD CHAIN

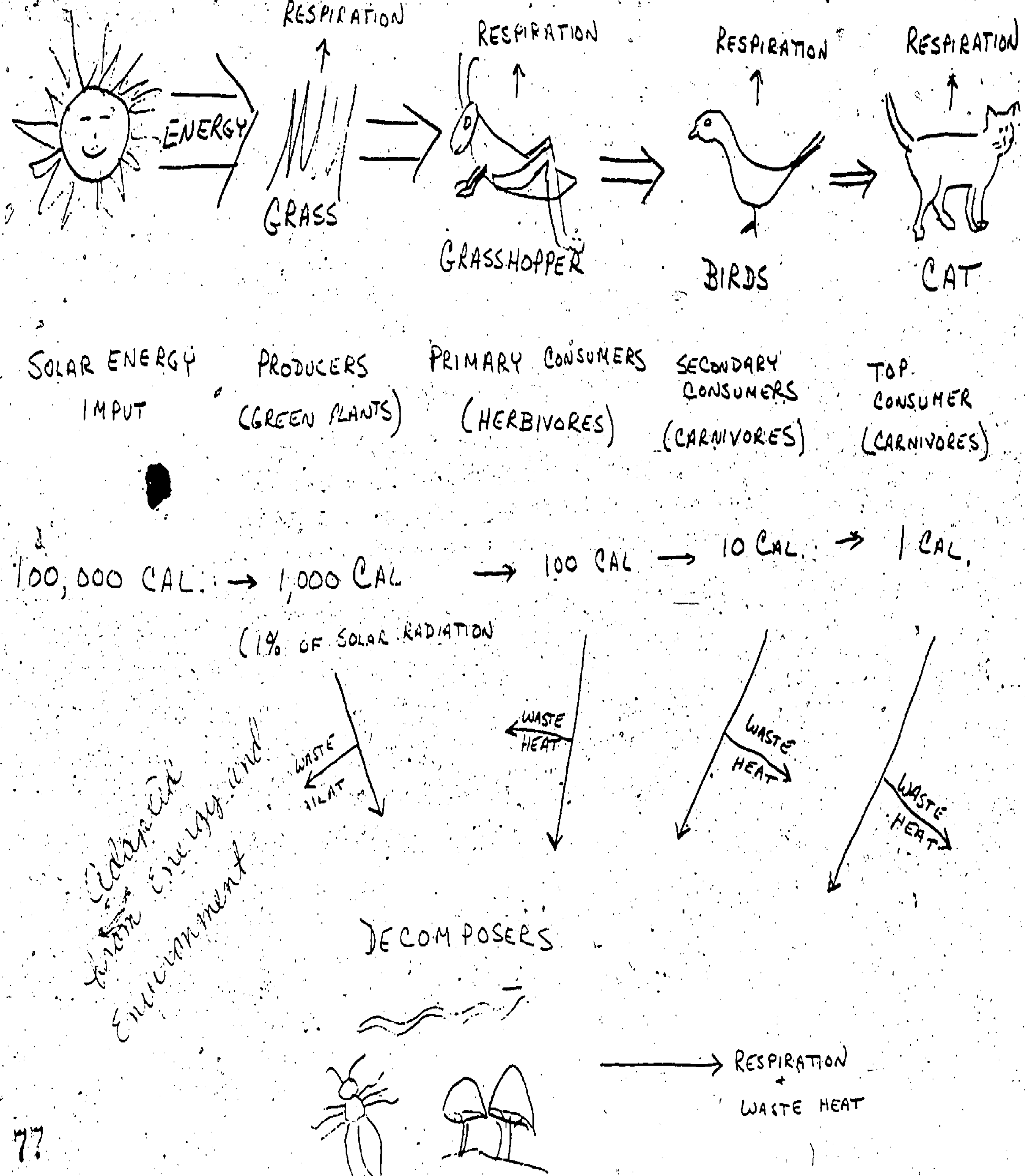


FIG. #10

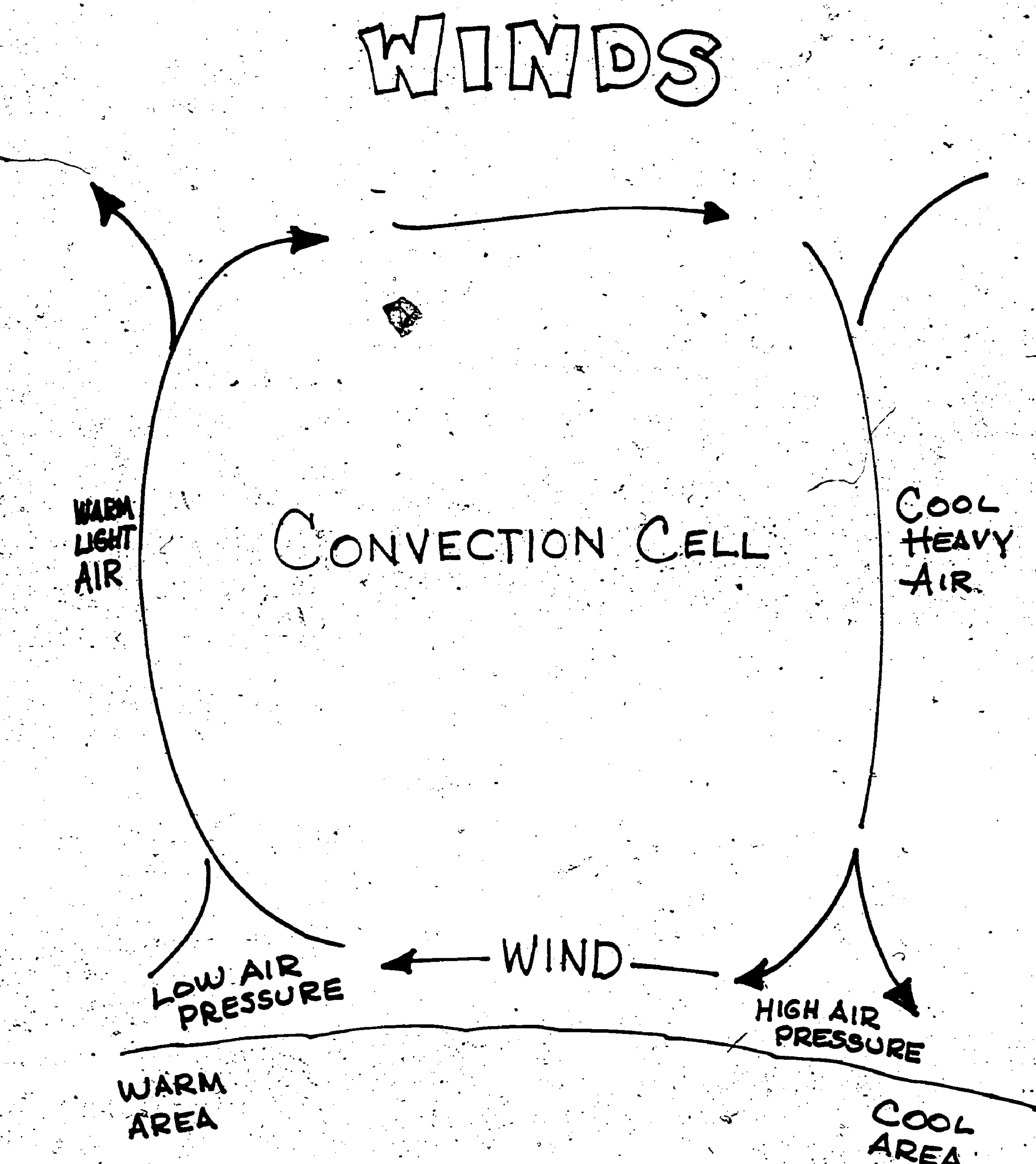

WINDS
WARM LIGHT AIR
CONVECTION CELL
COOL HEAVY AIR
WIND
LOW AIR PRESSURE
HIGH AIR PRESSURE
WARM AREA
COOL AREA

FIGURE 11

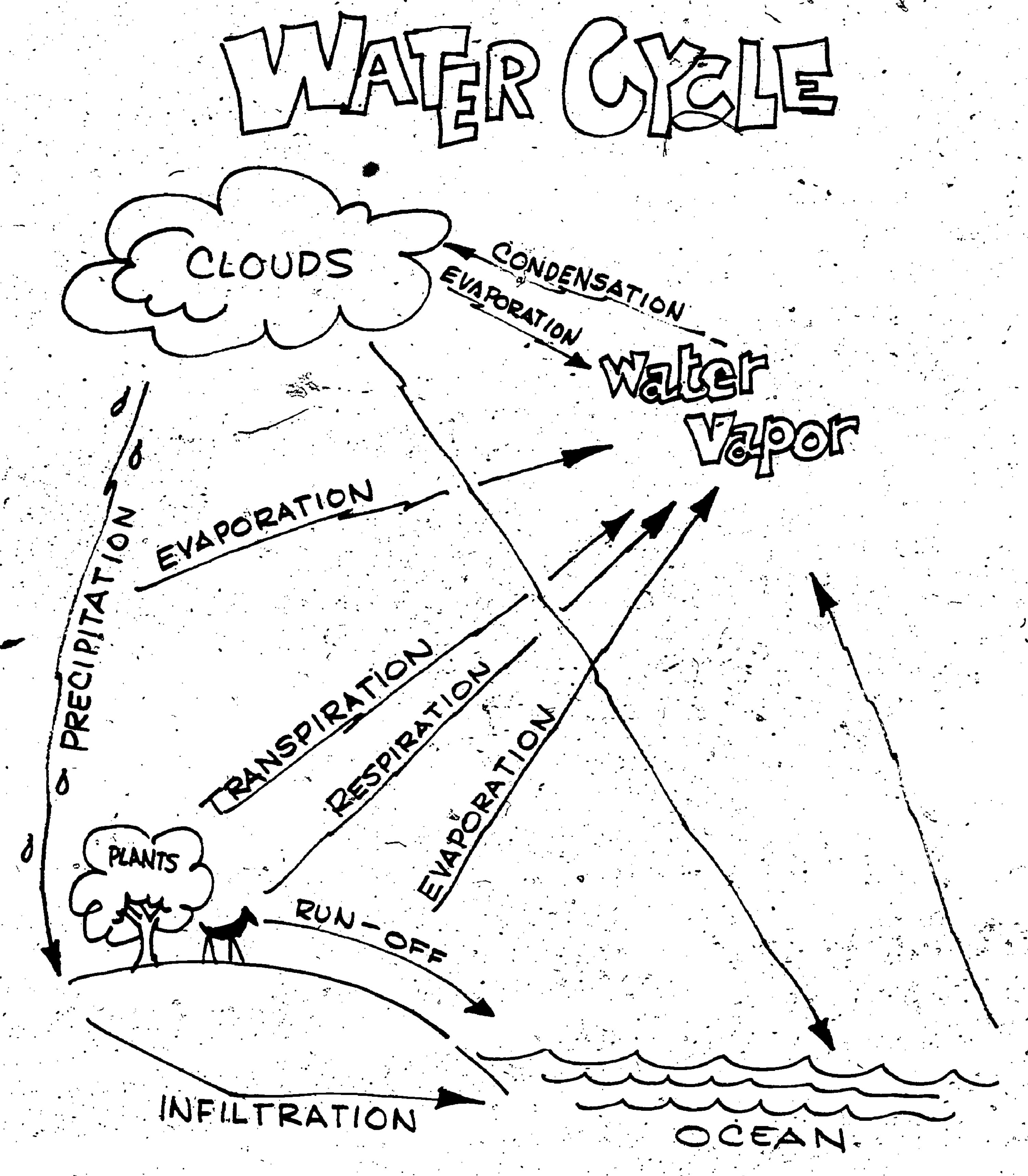

WATER CYCLE
CLOUDS
CONDENSATION
EVAPORATION
Water Vapor
PRECIPITATION
EVAPORATION
TRANSPIRATION
RESPIRATION
EVAPORATION
PLANTS
RUN-OFF
INFILTRATION
OCEAN

FIGURE #12

Activity I-51

Objective:

The student will be able to observe how the angle of the sun's rays on a surface controls the concentration of energy on that surface.

What to do?

Materials needed: Stiff paper, source of light

Shine a light through a square hole in a piece of stiff paper onto another piece of stiff paper. What happens when you hold the two pieces of paper parallel? What happens with the second paper at an angle? What happens when you move the second paper farther from the light? What does this show about sunlight on a slope as compared to sunlight on a flat field? Compare the sunlight when the sun is straight overhead to when it is low in the sky.

Teacher Notes:

Sunlight on a slope is more spread out (less concentrated) than sunlight on a flat field. When the sun is low in the sky, its light is less concentrated than when it is overhead.

Activity I-52

Objective:

The student, with the aid of a light meter, will detect various concentrations of sunlight.

What to do?

Have the students measure the light available to different plants by measuring different outdoor areas (around trees, open areas, etc.) with a light meter. Compare the results in a chart and discuss.

Activity I-53

Objective:

The students will dramatize how energy is distributed through a food web.

What to do?

Using pupils to represent the components, construct models of two or three simple food chains and then convert them into a food web.

Prepare cards lettered with such labels as sun, soil, green plants, mouse, grasshopper, earthworm, snail, frog, shrew, robin, garter snake, rabbit, owl, goldfinch, sparrowhawk, beetle, fungi, bacteria. Prepare enough cards to supply about half the class; let the other half serve as an audience. You will also need a ball of string which can be cut to convenient lengths and used to connect the links in the food chains and web.

Assign the cards to pupils. Have the two pupils representing the sun and green plants hold a length of cord between them. It is important to place these students in the center and allow the remainder of the web to develop around them. Now connect one of the herbivores (plant eaters) to the plants; follow this with carnivore (meat eater) linked to the herbivore. At first the components will depict simple food chains, but as more and more components are added, cross-links between the herbivores and carnivores begin to be evident and the food web concept is developed. Questions to ask in discussion:

1. Why is the sun necessary for all life?
2. What is the source of food used by animals?
3. In a natural environment, if all the members of a particular species such as grasshoppers were removed from the food web, what would be the effect? (This point can be emphasized by removing the appropriate pupil from the model.)
4. As a part of a food web, how does a human differ from all other organisms?

Teacher Notes:

The sun is necessary because it is the source of energy that plants use to produce food. If a species is removed from the food chain, the animals that feed on that species would have to find another food source, migrate, or starve. Since the elimination of a species means that there is less total energy (food) available in the system, some members of the system will have to be eliminated in some manner. Humans are unique in that they can consciously manipulate the components of a food web. This manipulation often endangers other species. Humans alone have the ability to understand the complex interactions of nature, and also the obligation and responsibility to preserve the balance of the food web.

Activity I-54

Objective:

The student will demonstrate that a green plant needs sunlight to produce food.

What to do?

Materials needed: A geranium plant, black paper, paper clips, alcohol, pyrex container, hot plate, iodine solution.

Cover two leaves of a geranium plant with black paper and paper clips — one should be partially covered and one completely covered. Leave a third leaf completely exposed. Put the plant in a sunny window for three days. Remove the paper and put each leaf in a separate hot alcohol bath and shake for 20 minutes. (Do not use an open flame around alcohol. Use a hot plate and be careful!) Remove and test each leaf with a few drops of iodine solution. Observe the color changes in each leaf. Where did the color changes appear?

Teacher Notes:

A purple color indicates the presence of starch which is made during the process of photosynthesis. Where sunlight was able to reach the leaf, photosynthesis was able to take place, and it is there that starch exists.

Activity I-55

Objective:

The student will determine how varying amounts of light affect the growth of green plants.

What to do?

Materials needed: Seeds, potting soil, pots, fluorescent lamp, light-tight box.

Grow three plants (beans or peas are a good choice) in potting soil. Place one of the plants in a window where it will receive light throughout the day. Each day turn the pot around so that the plant gets equal light on all sides. Keep another plant under a fluorescent lamp that is on 24 hours a day. Place the third plant in a box that is light-tight. Remove the plant from the box for only five hours daily, and during that time place the plant under the lamp. Give each plant enough water to keep the soil slightly moist.

Compare the growth of the plants.

Teacher Notes:

The plant under the lamp will grow faster because it is receiving the most energy. The one in the window will be the second fastest grower, and the one getting the least energy will grow the slowest.

Activity I-56

Objective:

The student will make a model of how winds are caused on the earth.

What to do?

Materials needed: Cardboard or wooden box, pane of glass or clear cellophane to fit over the largest side of the box, 2 lamp chimneys or mailing tubes or tubes from a roll of paper towels, candle.

Cut out the largest side of the box and cover it with the clear material. Cut two holes in the long side of the box. Secure the tubes or chimneys over the holes. Place a short candle under one of the openings. Light the candle. Observe what happens. Trace the air currents by holding a smoking paper over the chimney without the candle.

Teacher Notes:

The candle represents a warm region of the earth's surface. The smoke goes into the box through the hole where there is no candle, and then back out of the box through the hole where the candle is. This happens because the warm air is lighter than the cold air and is being pushed up by the cold air.

Activity I-57

Objective:

The student will demonstrate one way in which unequal temperatures can occur on the earth's surface.

What to do?

Materials needed: Two 500 ml (or larger) containers, four 0 to 100 degree C thermometers, soil, water, graph paper, 200 watt lamp (with reflector if possible), ring stand and clamp.

Fill one container half full of soil and the other half full of water. Arrange the thermometers so that one is 1 cm under the soil surface, the second is 1 cm above the soil, the third is 1 cm under the water, and the fourth is 1 cm above the water. Suspend the light 20 to 40 cm directly above the containers. Turn the light on and record the temperatures on each thermometer every minute for 10 minutes. Turn the light off and record the temperatures each minute for 10 minutes.

Put your data on a graph.

Questions to answer:

1. Did the soil or the water heat faster?
2. Which heated faster — the air over the soil or the air over the water? Why?
3. Which received more energy — the soil or the water? Why?
4. Which cooled faster — soil or water?
5. Which one might be considered a heat source in winter? Why?
6. Would land or water be a source of high air pressure during the summer? Why?

Teacher Notes:

The general shape of the graph is shown on the following page.

The soil heats faster than the water, and the air over the soil heats faster as a result. Both containers should have received the same amount of energy, since they were the same distance from the light. The soil also cooled faster than the water. Since water cools more slowly than land, it would probably be warmer than adjacent land during the winter. Water would also be a source of high pressure during the summer because the air over it is cooler, and therefore heavier.

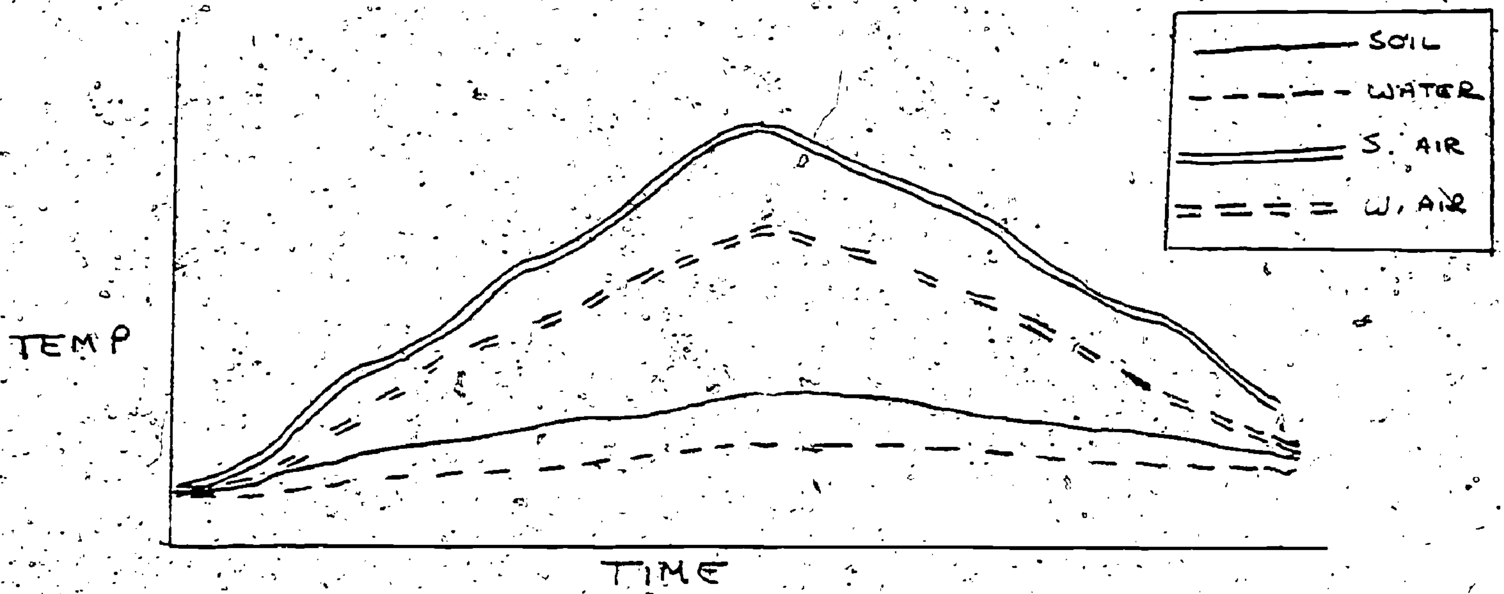
Activity I-58

Objective:

The student will examine a pictorial representative of the role energy plays in the world, and the inevitable destination of energy — low quality heat.

What to do?

Refer students to a mimeographed copy or transparency of "Energy Maze: Human 'Tourist' Version" which follows. This illustrates the "downhill" movement of energy through our ecosystem. The teacher may wish to describe for the students how the cycles represented in the diagram give off wasted heat energy with each transformation process. This diagram does not intend to be a detailed description of what takes place, but is a tool to help students understand the general concepts involved.

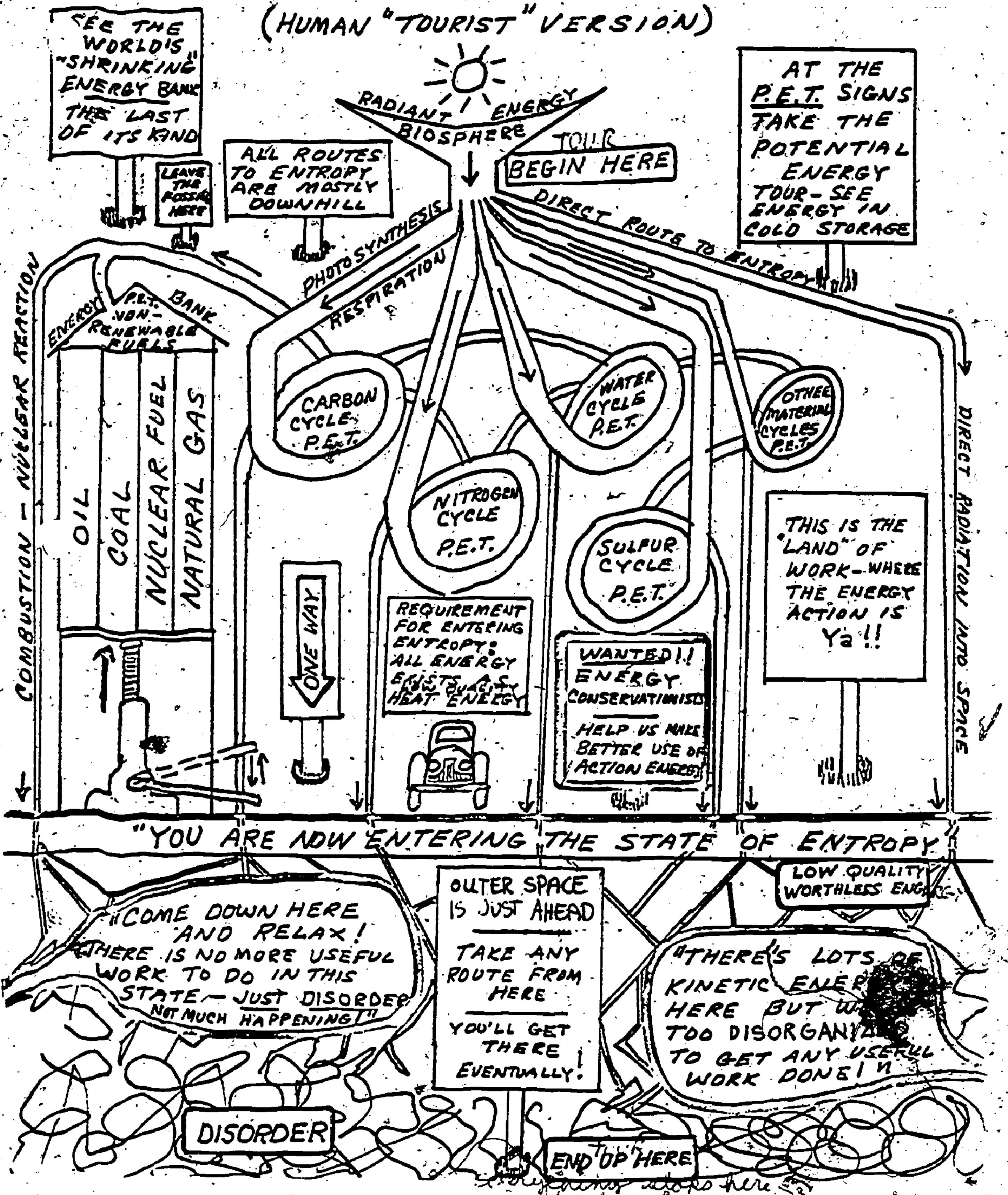


Graph for Activity I-57

83

By Samuel Wenger
Manheim Central School District
Manheim, Pa 17545

ENERGY MAZE
(HUMAN "TOURIST" VERSION)



75-76

ENERGY

WHERE DOES IT GO?

MODULE 2

AN ENERGY CURRICULUM MODULE #2

Governor's Energy Council

Pennsylvania Department of Education 1977

From their earliest history, human beings have sought to minimize their labor through the use of tools. Early hunters used tools to kill animals, and thereby stretched their own biological energy, derived from sunlight in the form of food, to get more energy from the bison and mammoth.

The most vital discovery during the stone age was how to make fire.

During the later Neolithic period, humans used stone tools for agriculture, and were able to produce renewable crops. The first stable communities began to develop, and various forms of housing were built. These primitive dwellings were all designed to meet the climatic needs of the area in which they were located. Thus communities could flourish, since the population did not have to migrate with the seasons to escape unfavorable weather conditions.

Further technological progress brought the ability to mine metals and use fire to forge them into tools and weapons. First came copper, then bronze, which is a mixture of copper and tin. Following the Copper and Bronze Ages came the Iron Age, which may have begun in Africa or the Orient about 2400 years ago.

Before the time of the Greek and Roman civilization, the only significant energy sources were natural ones. The power of falling water was used in basic industry, agriculture, and grinding grain. The power of the wind was used for ships, and fire from the burning of wood was the major energy source for industry. Much of the mining and mechanization in early cultures--and certainly in Greece and Rome--was for the purpose of improving weapons for war.

The major source of energy in both Greece and Rome was the energy of human bodies--particularly slaves. From the Greek and Roman era to the beginning of the Industrial Revolution, sophisticated tools were developed, but they were powered by humans or animals. Yet the idea of a heat engine--a device that would use heat to do work--had been envisioned as early as 75 A.D. by the Greek inventor Hero. He made a toy which would spin as steam was expelled through vents.

Toolmaking and architecture were the primary developments between the fall of the Roman Empire and the last few years of the 17th century. Many significant inventions were developed during this time. This was the time of Leonardo da Vinci, but the application of his mechanical discoveries was limited by the absence of energy sources. Technical advances during this time included the printing press and the mechanical clock.

These years in European history were an era of great intellectual and scientific advancement. This was the dawn of Galileo's physics, Kepler's astronomy, and the mathematics and philosophy of Spinoza, Descartes, and Newton. Some of the great laws of nature were conceived. The spirit of the era was discovery--of the world and of applied science.

But to bring about the era of modern technology, an engine was necessary that could use an energy source and produce useful work. The water mills and windmills were limited to specific sites, and there was no way known to transport their energy to where it was needed. By the end of the 17th century, this engine appeared. In 1698, Englishman Thomas Savery obtained a patent for a machine which used fire to boil water, generating steam in a boiler for use in draining water from mines. His steam engine pump was soon improved upon, and these engines made possible the deep mining of coal, which had previously been hampered because of the buildup of underground water in the mines.

Englishman James Watt patented a vastly improved engine in 1782, and by this time the steam engine had become the forerunner of mechanized civilization. They were used for pumping water and supplying power to textile mills, rolling mills, and flour mills. A later breakthrough came with the development of engines that could use high pressure steam, making the engines much more efficient. With Robert Fulton's successful operation of the steamboat Clermont on the Hudson River in 1807, and Richard Trevithick's use of a steam locomotive to transport coal in Wales, the modern era of mechanized transportation began.

Little was actually understood about the theory of these engines, until the rise of the science of thermodynamics. When these scientific principles came to be understood, bigger and better engines could be built.

Up until the second half of the 19th century, the United States' energy sources were primarily muscle power of humans and animals, along with wind, wood, and falling water. Ninety percent of the fuel burned in 1850 was wood. Coal accounted for only 10 percent, despite the presence of plenty of coal and the technology to use it. The extensive cutting of forests in the east raised the price of wood and increased the distance that it had to be transported to the growing cities. So the demand for coal sky-rocketed until in 1885 coal surpassed wood as the dominant fuel. In 1885, coal was used to fuel the railroads, to make coke for the steel industry, to power miscellaneous industries, and to provide residential fuel. Coal was to remain the dominant fuel well into the 20th century.

During the 1800's, pressure increased for better and cheaper lighting methods. The various oils burned to produce light were expensive, explosive, or otherwise unsatisfactory. England had developed a coal gas pipeline network for lighting, but the scattered population and undeveloped coal industry in the United States made such a network generally impractical. Finally, an Englishman devised a method of producing oil from coal, which he called coal oil or kerosine. By the late 1850's, there were many kerosine plants in the Eastern U.S. Then some people began to notice a resemblance between the kerosine and the largely useless "rock oil" that came out of springs and wells in western Pennsylvania. In 1857, a Yale chemistry professor, hired by a group of Pennsylvania entrepreneurs called the Pennsylvania Rock Oil Company, gave his report on some of this oil. He concluded that some "very valuable products" might be manufactured from it. Drilling, rather than digging, turned out to be the best way of getting to the oil, and so in September 1859, in Titusville, Pennsylvania, oil was struck at a depth of 69 feet. This was not the first oil well in history--the potential value of oil had been recognized centuries before. But it was only in the Western industrial world of the time that science, technology, and society all came together at a point necessary for oil to be exploited as the concentrated fuel that would eventually replace coal.

The crude oil was made mostly into kerosine. Some of the other products were lubricants, necessary for increasing mechanization; and fuel oil, whose use grew as it began to replace coal for firing boilers for steam generation.

The use of steam for railroads and ships was a great step for transportation, but coal was too bulky and inefficient for use in any smaller scale vehicles. What was needed was a smaller engine. In 1870, inventors began testing an engine using gasoline in a compressed air-gas mixture. Up until this time, gasoline had been a generally useless by-product of kerosine refining. In 1887, a gasoline-fueled engine was adapted to vehicles and the first Benz automobile was patented. This engine was the forerunner of all internal combustion engines in operation today. By 1900, many automobiles had been built in the United States, most of them steam-driven or electrically powered. But the increasing availability of both fuel and lubricants for gasoline-powered automobiles speeded their development. They were light, maneuverable, fast, and competitive in cost. In 1900, the Oldsmobile switched from steam to gasoline, and three years later, Henry Ford introduced his gasoline-powered automobile. His mass-production techniques revolutionized industry.

A milestone in energy history occurred in 1879, with Thomas A. Edison's electric light. Edison himself, however, saw his own greatest achievement not as the light itself, but as the world's first electrical power-generating and distribution system. In 1882, he supervised the building of this system to light 1200 lamps in a one-half square mile area in New York City. Edison's generating station consisted of four boilers—which produced steam to power six generators.

Electricity made it possible to deliver energy to distant sites cheaply and cleanly. It essentially put the steam engine at the disposal of every home, business, and industry in America and much of the Western world.

Shortly after Edison's station began to generate electricity, water wheels began generating the nation's first hydroelectric power in Appleton, Wisconsin.

As electricity became more widely available, the number of electrical devices grew dramatically. Work that was previously done by muscle power could now be done by the new "labor-saving devices," and mechanization of the home was underway.

The latter half of the 19th century also saw a series of inventions which led to farm mechanization. These inventions included the reaper, the harvester, and the twine binder. Such inventions were necessary to develop the agricultural base to support the high-energy society that was rapidly evolving.

Energy use in the United States grew dramatically in the first decades of the 20th century. The number of automobiles increased at a remarkable pace—from 8,000 in 1900, to 194,000 in 1908, to more than 8 million in 1920. Electrical power generation increased at an amazing pace—by 1917 electric consumption was more than seven times what it had been in 1900. Factories had found electric power especially suited to the concept of the assembly line; and the number of electric motors soared. Electricity thus made practical the mass production of appliances, which were themselves electrically powered.

Total energy use in the United States grew much more slowly after World War I, and the shift toward oil continued. Oil overtook coal as the dominant fuel just after World War II, and has continued to claim an increasing share of the market. This shift to oil was brought about by the growing use of the automobile, and the switch from coal to fuel oil for residential heating and powering trains. Gasoline's share of the petroleum market increased very quickly. Two other uses of fuel also increased sharply during the years from the 30's to the 50's: aviation and farm equipment. The major petroleum product being produced was thus changing from kerosine to fuel oil to gasoline to accomodate the changing patterns in consumption. There was also a large increase in the use of asphalt, another petroleum product, to pave roads.

Geographic areas of oil production were also changing, from Pennsylvania and neighboring Ohio and West Virginia, to California and Oklahoma, and then to Texas and Louisiana.

Natural gas, which is often found in conjunction with oil, was mostly wasted until the late 1920's, when it became technologically feasible to lay the pipeline to transport it. Natural gas was clean-burning, convenient, and cheap, and it thus became the nation's primary household fuel by 1960. Gas also found use in industry, and for electrical power generation.

After World War I, as the number of electrical appliances multiplied, growth in electrical consumption accelerated, although overall energy growth was slower. From the beginning of World War I, total electric power demand has been doubling every 10 years. In the 1920's and 1930's, coal was the fuel for about two-thirds of the electric power generated, with hydroelectric power providing the rest. The shift to oil and natural gas had changed this ratio significantly, until by 1970, coal had dropped to about 45 percent; hydroelectric power provided 17 percent; natural gas accounted for almost 25 percent; oil, about 12 percent; and a newcomer to the fuel scene, nuclear power, provided about one percent.

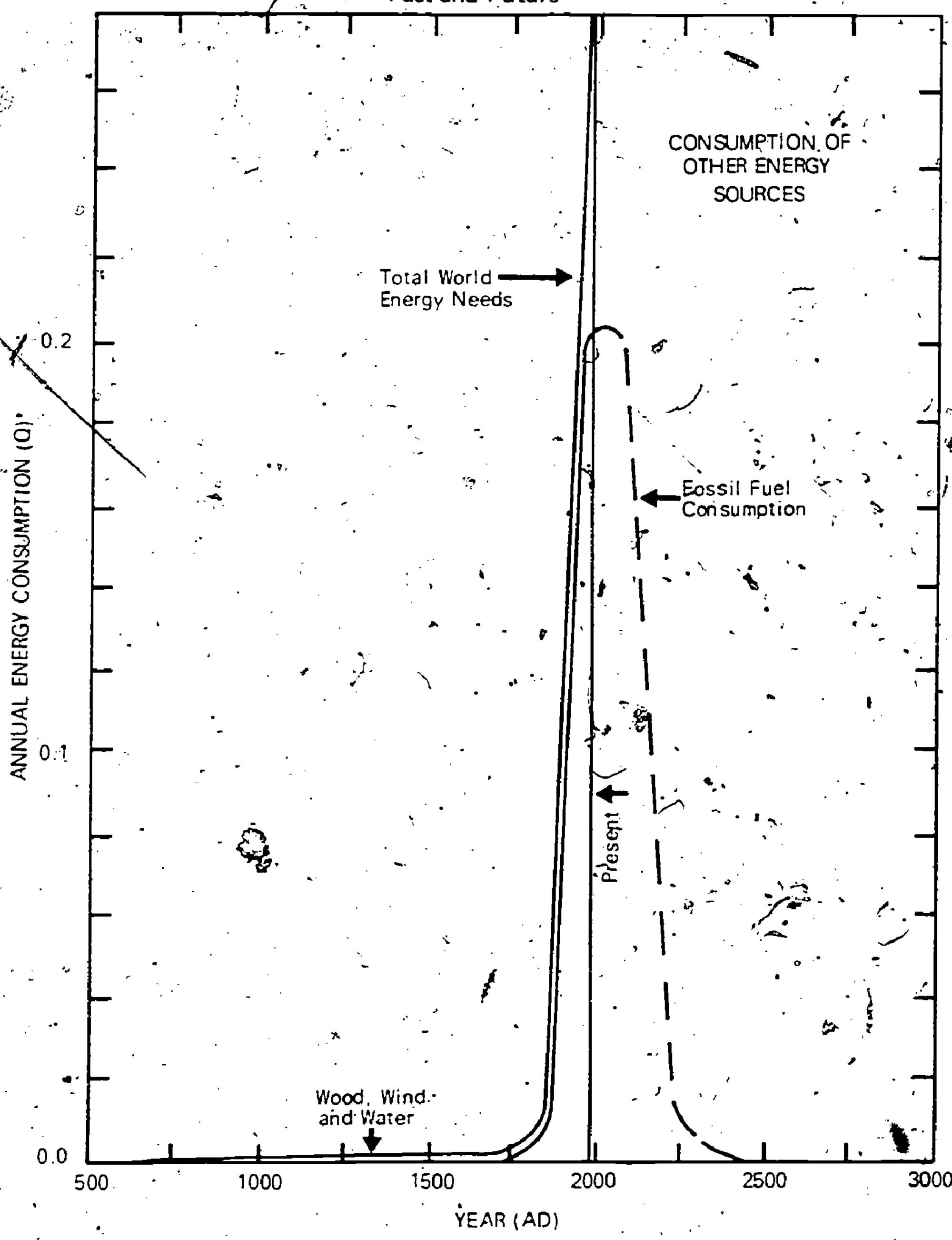
At the beginning of the 20th century, scientists were investigating the rays given off by radium. In 1905, Albert Einstein demonstrated mathematically the relationship between mass and energy, although it was decades before this theory could be proved. On December 2, 1942, a group of scientists headed by Dr. Enrico Fermi gathered under a squash court at the University of Chicago, where the first controlled nuclear reaction occurred. Scientists have since been working to safely harness that tremendous nuclear energy for the generation of electricity. The nation's first prototype nuclear power plant was built at Shippingport, Pennsylvania, in 1957.

In the years since World War II, energy consuming technology has appeared everywhere. During this period, a huge fleet of passenger airplanes has developed; there has been an automobile "population explosion." Air conditioning, central heating, television, clothes washers and dryers are generally thought of as necessities, not luxuries. A mechanized agricultural industry uses tremendous amounts of energy. The various engines that perform America's work produced 7.5 times the number of horsepower in 1971 as they did in 1940, while the number of people in the country increased by only 54 percent. Even with the slowing population growth, more and more energy is being used.

Our country now has a fossil fuel economy. We use these fuels not only to produce energy, but also as a basic raw material for plastics, pesticides, and synthetic organic chemicals. Everyone alive today was born years after this fossil fuel epoch began, and we have tended to act as if we expect it to go on forever. But Dr. M. K. Hubbert of the U.S. Geological Survey estimates that in a period of only 1300 years from beginning to end, humans will have consumed the world's entire available supply of fossil fuels. This is illustrated in Figure 1. Thus the world today is on the brink of transition from the fossil fuel age to some future energy era. As we have seen from this discussion of energy history, humans have moved from one fuel epoch to another, not because the old source was depleted, but because something better had been found to take its place. Discovery of the new preceded depletion of the old. People did not run out of muscle or wind or animals–they simply found something better. But this time there must be a change to some other energy form, and in the meantime, until the transition is made, we must conserve the fossil fuel resources we have by cutting down wasteful uses and increasing the efficiency of what we do need to use. This important topic of conservation–what each of us can do personally–is dealt with in Module VI.

WORLD ENERGY CONSUMPTION

Past and Future



*1Q = 10^{18} BTU

Activity II-1

Objective:

Students will perform simple research to complete statements on a timeline covering 200 years of energy development.

What to do?

Students should gather facts from encyclopedias and other reference materials to complete the statements on the energy timeline which follows. They will then have a comprehensive introduction to the modern energy story.

Teacher Notes:

A completed timeline follows the blank one which you may copy for your students' use. This activity and some others in this text are taken from an excellent booklet called "The Energy Challenge" which contains ditto masters of many energy-related activities. This booklet is a publication of the Federal Energy Administration and may be ordered without charge from The Energy Challenge, Box 14306, Dayton, Ohio.

Activity II-2

Objective:

The student will consider the difference in lifestyles caused by modern energy-consuming devices.

What to do?

Ask students to bring in household implements (or pictures of such implements) which use only mechanical energy or human energy. Include those used today, as well as examples of those used years ago–for example, washboards, egg beaters, can openers, butter churns, apple peelers, etc. Each student could also try to bring in a sample or picture of the modern equivalent of each older article–for example, the modern equivalent of an egg beater would be an electric mixer. A comparison of early automobiles with current models would be appropriate, along with modern "extras"–self-starters, automatic windshield wipers, air conditioning, etc.

Questions for discussion and research:

In the days before electricity, what were the equivalent of our present-day irons? toasters? televisions? electric lights? ranges? stereos? dishwashers? hot water heaters? freezers? washers? dryers?

Why the changes? What brought them about? Why do people purchase modern energy-consuming appliances rather than those which use only mechanical energy? Are there any that we could do without?

What effect has the automobile had on life styles, politics, business, and education? What about television, household electrical appliances?

Activity II-3

Objective:

The student will consider the pros and cons of the "good old days" and today's high energy use.

What to do?

Have the students list reasons why they would have enjoyed living before electricity was in use in homes and before the automobile. Have them list reasons why they would not have enjoyed it.

Activity II-4

Objective:

The student will consider our dependency on energy sources.

What to do?

Have students consider these questions:

What in your opinion would happen today if electricity were permanently shut off? What about gasoline? Would we survive as well as our ancestors? Why or why not?

Activity II-5

Objective:

Students will discover how petroleum and natural gas have changed American lifestyles during the past fifty years.

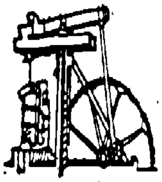
What to do?

Have students interview older members of the community and fill out the question sheet that follows. If some students do not have a grandparent or older adult living close by, they may want to make a visit to a local nursing home or senior citizens' center. Encourage class members to think up additional questions of their own. When the interviews are complete, discuss the answers together and tally the results. Ask students if they would like to have lived fifty years ago.

Finish the Energy Timeline

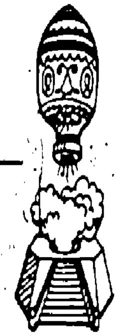
cut

1780 | 1785 | 1790 | 1795

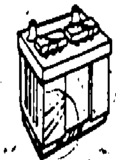


1776
In England James Watt puts two engines to work in factories & starts an energy revolution. The energy is ______.

1783
Two men fly in a balloon at ______. The energy used is ______



Most people burn wood for heating and cooking and travel by horse or on foot.

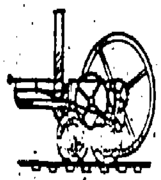


1800
In Italy, ______ invents the battery and gives his name to the volt. The energy produced is ______

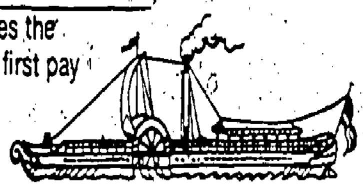
cut

1800 | 1805 | 1810 | 1815 | 1820 | 1825

1804
An Englishman, Richard ______, puts James Watt's engine on wheels and rails. He is the father of the railroad locomotive.



1807
Robert Fulton doesn't build the very first ______, but he makes the one people first pay to ride on.



Wood continues to supply most household energy needs. But coal begins to do more in factories and railroad engines.

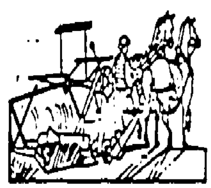
1821
First attempt to develop and market natural gas near Fredonia, N.Y.

cut

1830 | 1835 | 1840 | 1845

1829 An American named ______ and an Englishman named ______ each invents a generator. Who is first? ______. The energy produced? ______

1837 Americans put new inventions to work. First comes McCormick's ______, then the steam shovel by ______ and the telegraph by ______.

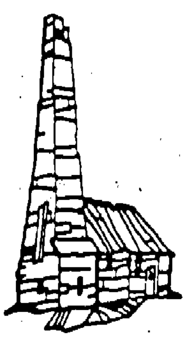


Railroads expand rapidly, hauling freight and passengers brave enough to stand the jolts and to risk hot cinders that often fly from the engine into their cars. England is first and America second in railroad locomotive production.

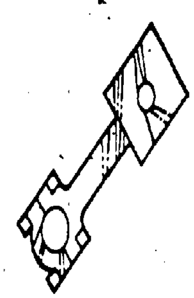
cut

1850 | 1855 | 1860 | 1865 | 1870 | 1875

1859
Edwin Drake strikes oil in Pennsylvania beginning the ______ industry.



1860
Lenoir of France invents the ______ combustion engine.



An explosion inside a cylinder paves the way for the later invention of the automobile. An oil strike hastens the discovery of the fuel that will run it.

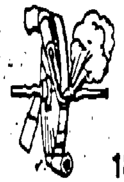
cut

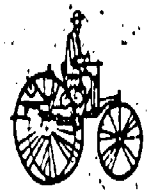
cut

1880 1885 1890 1895

Coal and wood still furnish most of the energy in homes. "Iron horses" and real ones continue to take most people places. Although the electric bulb has been invented most people still use kerosene or gaslights to read by.

1884
In England, Charles Parsons perfects the steam ________ and advances the development of electrical energy.





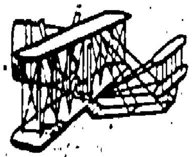
1886
Karl ________ builds the 1st successful automobile.

1892
The oil-burning engine is invented by ________. Eventually, this engine will replace steam-powered ones.

1895
The power of Niagara Fall is harnessed to make ________.

cut

1900 1905 1910 1915 1920 1925



1903
The engine in the Wright brothers' plane is powered by ________

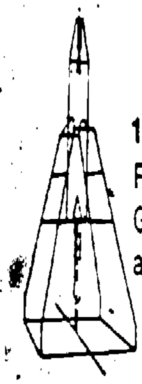
1905 Albert Einstein develops a theory for measuring energy and prepares the way for the ________ age.

1910
Ford makes the first Model ________ car.

By the end of this period, many new homes have coal furnaces in the basement. And more and more cars appear in garages.

cut

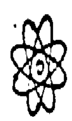
1930 1935 1940 1945



1926
Robert Goddard tests a ________.

1936
Hoover Dam on the Colorado River is built to generate ________ power.

1940
________, a fiber made from oil, coal, and water makes its first public appearance.



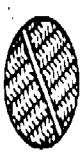
1942
In Chicago, Enrico Fermi sets off the first ________ chain reaction.

Many homes convert from coal to natural gas for heating. Most families own at least one car and some have two.

cut

1950 1955 1960 1965 1970 1975

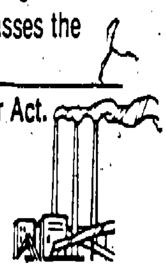
1952
Bell scientists raise hope for our energy future with the ________ battery.



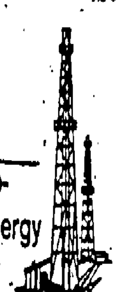
1957
The U.S. gets its first big ________ electric power plant at Shippingport, Pa.

Demands for energy grow. America gets more people, more homes, more factories and businesses, more cars, more trucks, more buses, more planes. Demand grows faster than supply.

1970
Congress passes the ________ Air Act.



1973
OPEC nations ________ oil and produce an energy crisis.



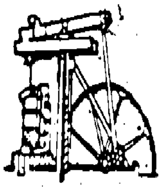
1976 Americans continue to look for ways to ________ the energy we have and find new ________ sources.

cut

Finish the Energy Timeline

cut

1780 1785 1790 1795

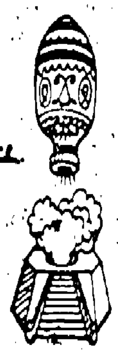


1776

In England James Watt puts two engines to work in factories & starts an energy revolution. The energy is steam

1783

Two men fly in a balloon at Paris, France. The energy used is hot air



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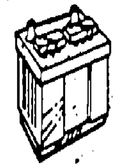


1800

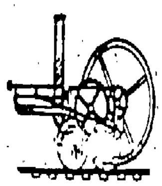
In Italy, Volta invents the battery and gives his name to the volt. The energy produced is electricity

cut

1800 1805 1810 1815 1820 1825

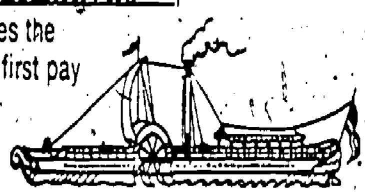
1804

An Englishman, Richard Trevithick puts James Watt's engine on wheels and rails. He is the father of the railroad locomotive.



1807

Robert Fulton doesn't build the very first steamboat, but he makes the one people first pay to ride on.



Wood continues to supply most household energy needs. But coal begins to do more in factories and railroad engines.

1821

First attempt to develop and market natural gas near Fredonia, N.Y.

cut

1830 1835 1840 1845

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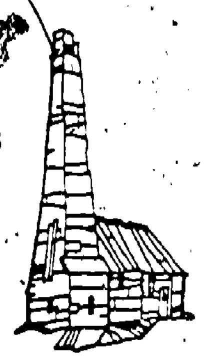
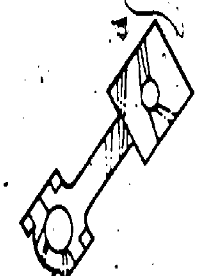


1860

Lenoir of France invents the internal combustion engine.



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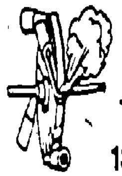

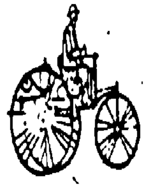

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1892 The oil-burning engine is invented by *Rudolf Diesel*. Eventually, this engine will replace steam-powered ones.

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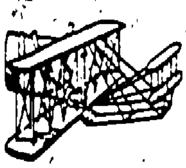
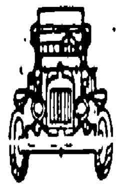
cut

1900 1905 1910 1915 1920 1925



1903 The engine in the Wright brothers' plane is powered by *gasoline*

1905 Albert Einstein develops a theory for measuring energy and prepares the way for the *atomic* age.



1910 Ford makes the first Model *T* car.

By the end of this period, many new homes have coal furnaces in the basement. And more and more cars appear in garages.

cut

1930 1935 1940 1945

1926 Robert Goddard tests a *rocket*

1936 Hoover Dam on the Colorado River is built to generate *hydroelectric* power.

1940 *Nylon*, a fiber made from oil, coal, and water makes its first public appearance.

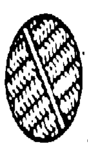
1942 In Chicago, Enrico Fermi sets off the first *nuclear* chain reaction.

Many homes convert from coal to natural gas for heating. Most families own at least one car and some have two.

cut

1950 1955 1960 1965 1970 1975

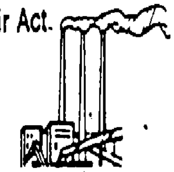
1952 Bell scientists raise hope for our energy future with the *solar* battery.



1957 The U.S. gets its first big *nuclear* electric power plant at Shippingport, Pa.

Demands for energy grow. America gets more people, more homes, more factories and businesses, more cars, more trucks, more buses, more planes. Demand grows faster than supply.

1970 Congress passes the *Clean* Air Act.



1973 OPEC nations *embargo* oil and produce an energy crisis.

1976 Americans continue to look for ways to *conserve* the energy we have and find new *energy* sources.

cut

The Good Old Days?

Interview someone who is old enough to remember what life was like before the days of great usage of oil and natural gas. Ask him or her the questions that follow and others that you think of yourself.

1. What kind of lights did you use in your home? ________________ How was it heated? ________________
2. What fabrics were clothes made of? Was clothing harder or easier to take care of? ________________
3. What sort of washing machine did you have? ________________
4. What kind of stove (and what kind of fuel) did your family use for cooking? ________________
5. Did you have a refrigerator? How did you keep your food fresh? ________________
6. How was food packaged when it came from the store? ________________ What did milk come in? ________________ Was your milk delivered? ________ How? ________________
7. What sort of soap did you use? Did it clean as well as the cleaners we have now? ________________
8. How was your water heated for bathing and laundry? ________________
9. Did your family have a car? ________ If not, how did you travel? How did you get to school? ________________
10. Did you have a radio? What did it look like? ________________ Did you go to the movies? ________ What kinds of entertainment did you enjoy? ________________

(Think up as many more questions of your own as you can. Ask them during the interview. Put the answers on the back of this paper.)

To close the interview, ask these questions and write the answers on the back of this paper.

In what ways is life for you more enjoyable now that we have electricity, plastics, detergents, and other oil and natural gas products?

In what ways did you like the "good old days" better?

Activity II-6

Objective:

The student will find words pertaining to the nation's energy past.

Activity:

Seek and find sources of energy in our nation's past.

m	l	d	e	f	p	u
u	e	w	a	t	e	r
e	f	o	i	b	a	m
l	e	o	a	l	t	y
o	b	d	r	g	a	s
r	t	s	k	u	y	c
t	s	t	e	a	m	l
e	l	f	i	r	e	p
p	a	c	o	a	l	t
e	l	a	m	i	n	a

Answers:
wood
water
wind
peat
oil
muscle
steam
petroleum
gas
coal
fire
animal

Activity II-7

Objective:

Students will read an article on colonial lighting, and unscramble words and play a game related to the article. The activity should give the students some feeling for the differences between colonial lighting and our method of flicking a light switch.

What to do?

Have students read the following article. They may then unscramble the words and play the *Bright Light* game.

BRIGHT LIGHT – A COLONIAL VIEWPOINT

The first way of lighting the house of Colonial America was by use of Pine-Knots. These were gathered from the fat pitch-pine which grew in abundance thoughout the Colonies. These knots were referred to as candle wood and were the main source of illumination from New England to Virginia in the 1600's. When burned, candlewood emitted bright light, smoke and pitchy tar drippings. Because of this, the candlewood was usually burned on a flat stone in the corner of the fire place. The pitchy tar that dripped from the pine knots became a valuable trade product of the colonists.

Until people began to raise domestic animals, candles were costly luxuries selling at four pence apiece. As animals were domesticated, frugal farm wives saved every ounce of tallow. Wicks were spun from hemp, cotton, or milkweed. Making candles was an autumn task, and a hard one, for the entire winter's stock of candles was made at one time. Two large kettles were placed on the fire and each was filled with half boiling water, half tallow. At the cooler end of the kitchen, two long poles were laid across the backs of two chairs. Across these poles were placed smaller sticks called candle rods. To each candle rod was attached 6 to 8 wicks. A rod with its row of wicks was dipped into the melted tallow and then returned to its place across the poles. Each rod was dipped in turn, cooling between dips. The candles "grew" until after about 30 dips they were the thickness desired.

Wax candles were also made. They were often shaped by hand, by pressing bits of heated wax around a wick. Farmers kept bee hives as much for the wax as the honey.

Rush lights were made by stripping part of the outer layer from common rushes, thus leaving the pith bare, then dipping them in tallow or grease and letting them harden.

Colonists found that the oil from whales was a vast and cheap supply of oil for their metal and glasslamps. Toothed whales have a valuable material stored in their heads, Sperma-Coeti. Sperma-Coeti was used for making candles and it is said that these candles gave out three times the light of a tallow candle and had four times as big a flame.

Betty lamps were small shallow receptacles, either oval, round, or rectangular, with a spout an inch or two long. They usually had a chain by which they could be hung on the back of a chair. Betty lamps were filled with grease or oil, and a piece of a cotton rag or wick which ran down the spout into the oil. From this wick, dripping grease, came a dull, smoky flame.

For many years, simply striking a light was very primitive. Nearly all families had some form of steel and flint. By striking these two together over a piece of tinder (linen or vegetable matter), a spark would be emitted and would fall on the tinder. The spark was then carefully blown into a flame. The flint, steel, and tinder were usually kept together in a tinder box.

Charles Dickens said that if you had good luck, you could get a light from the tinder box in a half an hour.

Because the process of producing a flame was so difficult, fires in fireplaces were carefully banked during the night in the hope that cinders would still be "alive" by morning. If by ill fortune the fire in the fireplace totally "died" during the night, someone was sent to the nearest neighbor carrying a shovel or covered pan in which to bring back live coals for rekindling the fire.

The first practical matches were "Congreves" invented in England in 1827. Eighty-four of these matches were sold in a box for twenty-five cents.

Unscramble these words that relate to methods of colonial lighting.

1.	neknstoip ____________	dowo lecnac ____________
2.	neldacs ____________	lowtal ____________
3.	sicwk ____________	odr cdalne ____________
4.	xeeswab ____________	hurs tighls ____________
5.	ealhw lio ____________	amserp-tocie ____________
6.	sapmll ytetb ____________	tinlf ____________
7.	elets ____________	tiredn ____________
8.	dlinkireng ____________	Songcever ____________

Use the unscrambled words to help you remember some important facts about lighting. The number beside each blank is a clue to tell you in which row it may be found.

(1) ____________ were the first way of lighting Colonial Houses.

Pine knots were called (1) ____________.

(6) ____________ held oil and wicks for lighting.

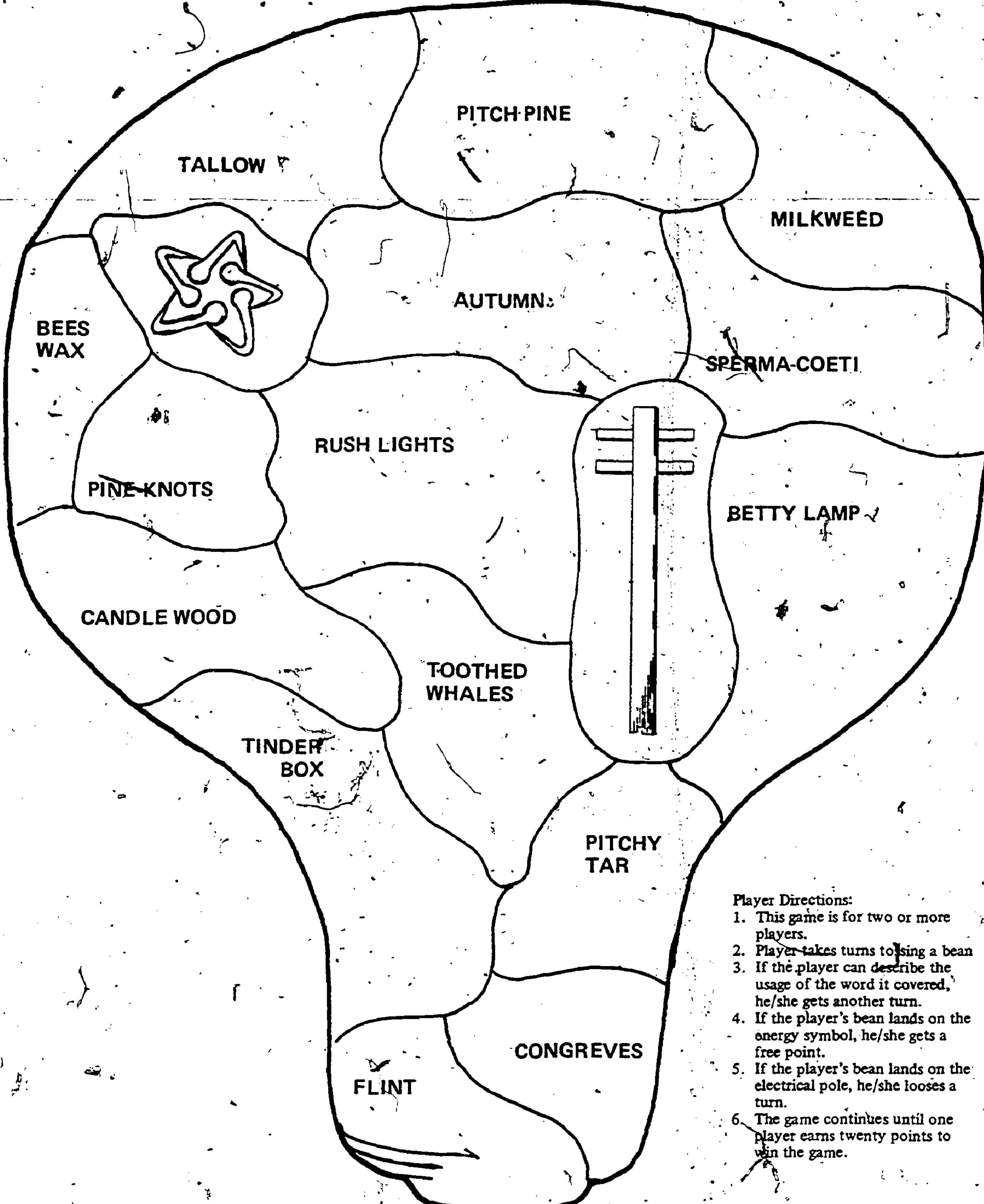
Taken from a whales head (5) ____________ produced excellent candles.

It was not until 1827 that (8) ____________ invented matches.

The (3) ____________ held many wicks that were dipped into a tallow pot.

1.	pineknots	candle wood
2.	candles	tallow
3.	wicks	candle rod
4.	beeswax	rush lights
5.	whale oil	Sperma-Coeti
6.	Betty lamp	flint
7.	steel	tinder
8.	rekindling	Congreves

BRIGHT LIGHT



Player Directions:

1. This game is for two or more players.
2. Player takes turns tossing a bean
3. If the player can describe the usage of the word it covered, he/she gets another turn.
4. If the player's bean lands on the energy symbol, he/she gets a free point.
5. If the player's bean lands on the electrical pole, he/she looses a turn.
6. The game continues until one player earns twenty points to win the game.

ENERGY

ITS PRESENT SOURCES

MODULE 3

AN ENERGY CURRICULUM MODULE #3

Governor's Energy Council

Pennsylvania Department of Education 1977

INTRODUCTION

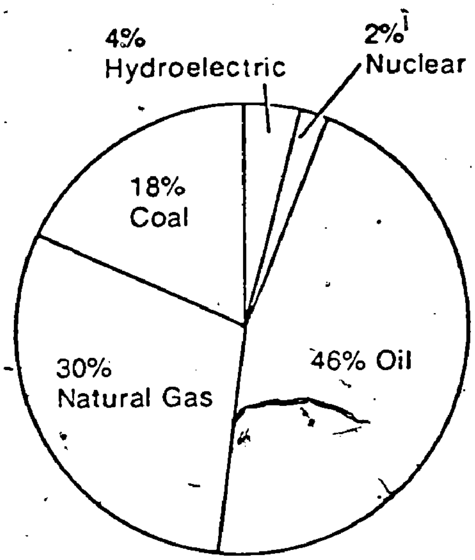
Energy, in its basic scientific sense, is the capacity to do work. Throughout human history, people have relied on an increasing number of energy resources to work for them. Originally, of course, people relied only on their own muscle power, and later that of animals, to do their work. They sought to expand their resources by using the energy in wood, water, and wind. In the 18th century, people began to use the energy of coal, the first fossil fuel to be discovered. Later came the use of petroleum and natural gas. In this century, we have begun to tap nuclear energy. We are also looking closely at other energy sources in an attempt to provide sufficient energy while living compatably with the environment.

Energy sources which are most familiar to us are really secondary sources of energy–that is, energy in some other form has already been expended to produce the secondary source. A prime example of a secondary energy source is electricity. In order to generate electricity, some primary energy source, such as coal, oil, or nuclear power, must be used.

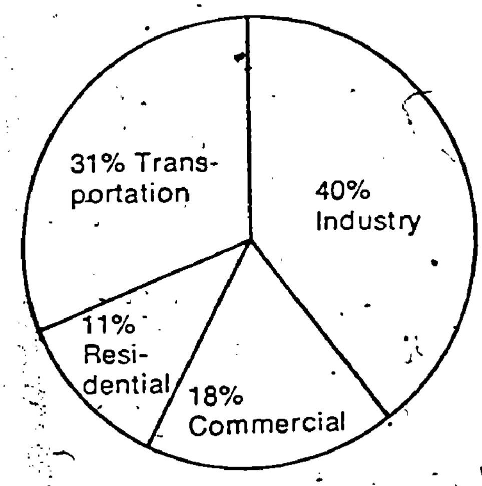
What sources are supplying our energy needs today? Figure 1 shows the five primary sources of energy that supply Americans with most of their energy needs. In this chapter, we will discuss each of these primary sources, as well as one secondary source, electricity.

How are these energy sources used by various parts of our society? Energy experts generally divide energy consumers into four sectors. These sectors are transportation (trucks, trains, planes, cars, buses, motorcycles, ships, etc.); industrial (factories); commercial (stores, offices, schools, hospitals, theaters, churches, etc.); and residential (homes and apartments). Figure 2 shows how these sectors divide the energy pie generated by the five primary sources.

1976 Figures from Federal Energy Administration



ENERGY SOURCES
FIGURE 1



ENERGY CONSUMPTION
FIGURE 2

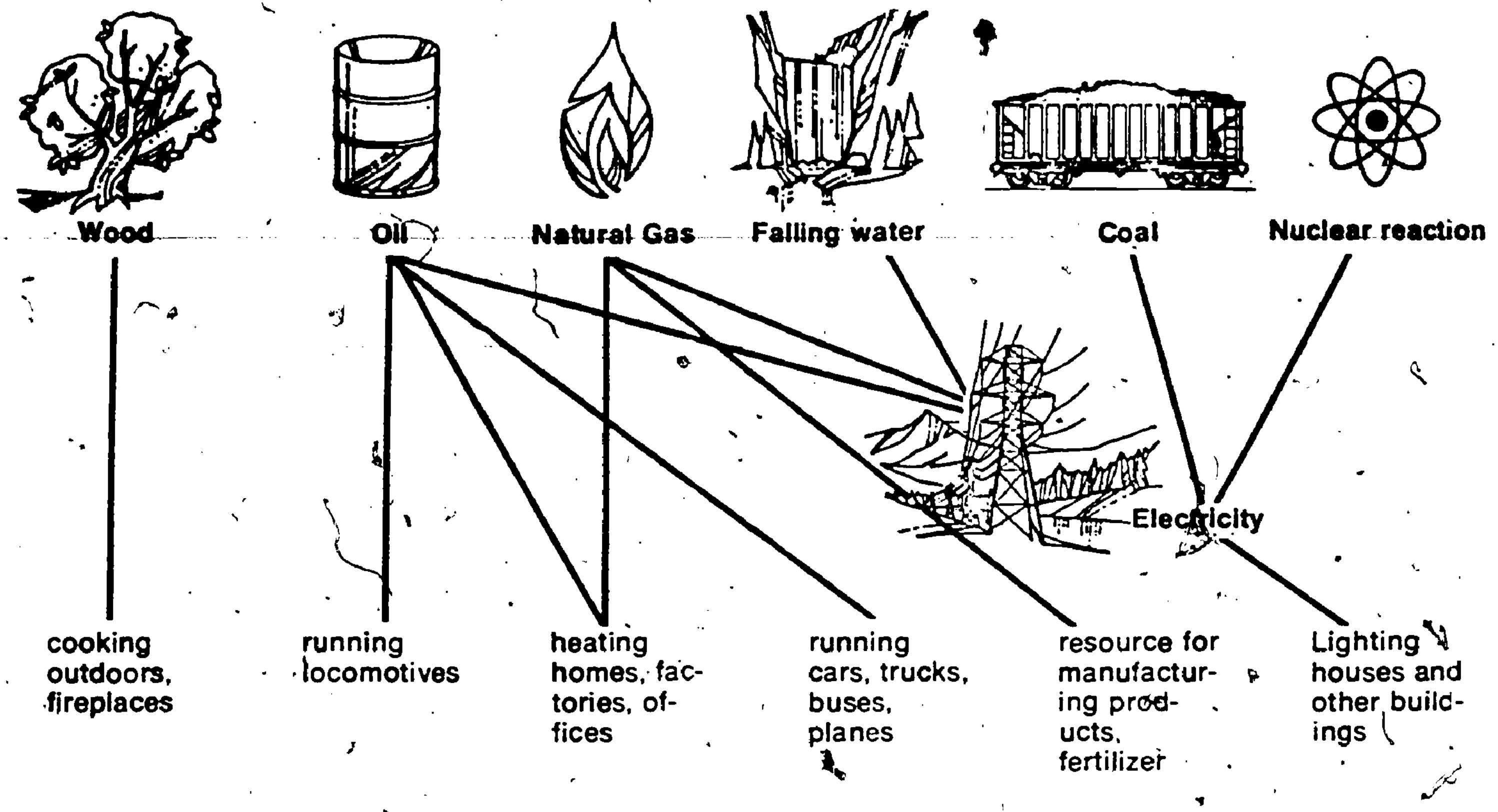
Activity III-1

Objective: Students will recognize the difference between a primary source of energy and a secondary source such as electricity.

What to do?
Have students complete and discuss the items that follow on "Primary Energy Sources."

Primary Energy Sources

ACTIVITY III-1



The diagram above shows six primary sources of energy. Lines connect each primary energy source to the most important work it does. Which energy source is seldom used today? Which two do not involve burning to produce power? Which ones are used to make electricity?

Use the information on the chart and on the energy timeline to help you complete these four stories about the Spritz family.

1. In 1901, Great-grandma and Great-grandpa Spritz went by train to Niagara Falls for their honeymoon. The train engine burned ______________ to boil the water that made the ______________ that drove it. The *primary* source of energy was ______________. Not long ago their great-grandchildren flew by jet to California. The primary energy source that got them there was ______________

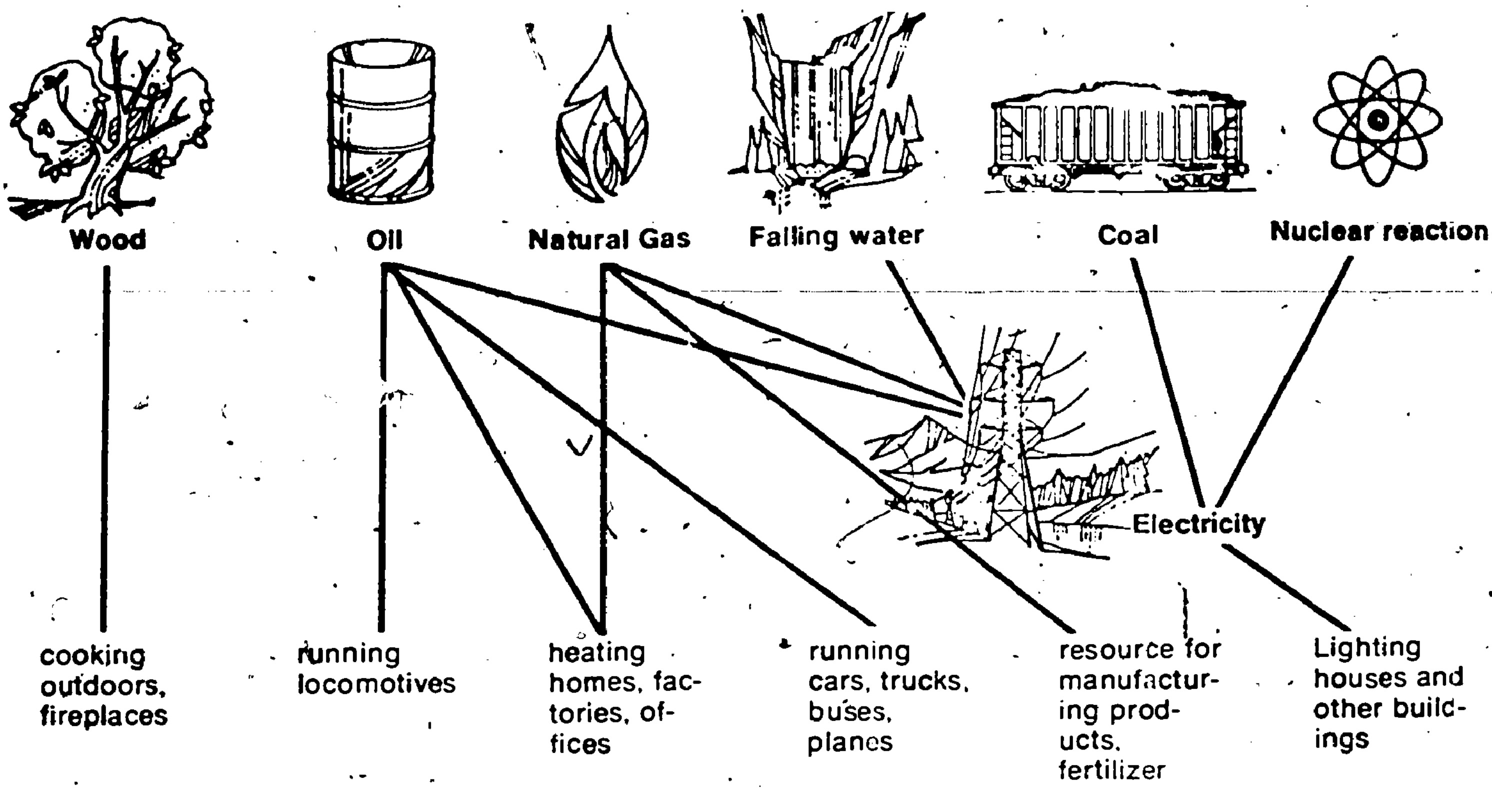
2. Great-grandpa Spritz was one of the first in town to drive an automobile. His Model T burned ______________. The primary source of this fuel is ______________. A Spritz great-grandson earns his living driving a big diesel truck. The primary source of this fuel is ______________.

3. Four generations of Spritzes have lived in the old family home. At the turn of the century, the family huddled around a stove in the parlor for warmth. Probably the primary energy source was ______________. In 1928 the family put in central heating by installing a furnace in the basement. The primary energy source was ______________

Since 1952 the Spritzes, like most Americans, have heated their homes with a primary energy source that is clean and convenient to use. It is ______________.

4. Recently a young Spritz asked how the electricity that lights the house and runs the appliances is made. His dad drew a picture of a giant wheel with blades. "This is a ______________ engine," he said. "There are a number of these at our city's power plant. These giant wheels turn to make electric energy. Falling ______________ or powerful blasts of ______________ turn the wheels. You can't get steam, of course, without boiling water. And so a primary energy source furnishes heat to boil the water." The primary energy source that makes most of our electricity is coal. Other sources might be ______________ or ______________ or ______________.

Primary Energy Sources



The diagram above shows six *primary sources* of energy. Lines connect each primary energy source to the most important work it does. Which energy source is seldom used today? *wood* Which two do not involve burning to produce power? *falling water; nuclear reaction* Which ones are used to make electricity? *oil; natural gas; water; coal; nuclear.*

Use the information on the chart and on the energy timeline to help you complete these four stories about the Spritz family.

1. In 1901, Great-grandma and Great-grandpa Spritz went by train to Niagara Falls for their honeymoon. The train engine burned *coal* to boil the water that made the *steam* that drove it. The *primary* source of energy was *coal*. Not long ago their great-grandchildren flew by jet to California. The primary energy source that got them there was *oil*.

2. Great-grandpa Spritz was one of the first in town to drive an automobile. His Model T burned *gasoline*. The primary source of this fuel is *oil*. A Spritz great-grandson earns his living driving a big diesel truck. The primary source of this fuel is *oil*.

3. Four generations of Spritzes have lived in the old family home. At the turn of the century, the family huddled around a stove in the parlor for warmth. Probably the primary energy source was *coal or wood*. In 1928 the family put in central heating by installing a furnace in the basement. The primary energy source was *coal*. Since 1952 the Spritzes, like most Americans, have heated their homes with a primary energy source that is clean and convenient to use. It is *natural gas*.

4. Recently a young Spritz asked how the electricity that lights the house and runs the appliances is made. His dad drew a picture of a giant wheel with blades. "This is a *turbine* engine," he said. "There are a number of these at our city's power plant. These giant wheels turn to make electric energy. Falling *water* or powerful blasts of *steam* turn the wheels. You can't get steam, of course, without boiling water. And so a primary energy source furnishes heat to boil the water." The primary energy source that makes most of our electricity is coal. Other sources might be *oil* or *natural gas* or *nuclear fuel*.

Activity III-2

Objective: Students will recognize the four sectors of energy users and how these groups consume the major primary energy resources.

What to do?

Have students complete and discuss the items that follow on "Where we get our energy, How we use it,"

COAL

Coal represents over 90 per cent of U.S. fossil fuel reserves, so it is a fuel of major importance.

The starting point for coal is the formation of peat. Peat is a fuel in its own right, but it is not really ancient enough to be considered a fossil fuel. It can be classified as "geologically young coal." Peat is essentially an accumulation of plant remains in early stages of decomposition. Peat is usually formed in areas where water covers dead vegetation that has accumulated on the ground. The water blocks the action of bacteria from the air, greatly slowing the rate of decay. Thus most of the carbon of the plant matter is retained, and peat is formed. Peat beds are probably laid down in a period of about 10,000 years. Peat is not of major importance in meeting world energy needs, but it is of considerable local significance in many areas of the world.

Coal began to be formed some 350 million years ago. The conversion of peat to coal occurred as peat beds became covered with layers of rock and soil. Thus buried below the surface, increasing temperature and pressure began the process of converting the peat to coal. (See Figure 3)

Coal is graded according to its carbon content: the more carbon, the more energy and less smoke produced by burning.

Anthracite is the top grade of coal. It is hard, easy to handle, burns cleanly, and has a high energy content. It is also superior in that it contains very little sulfur. This is significant, since sulfur dioxide, a major air pollutant, results from the burning of fuels with high sulfur content.

Bituminous coal is the most widely used. It is relatively easy to handle, burns with only moderate production of smoke, and has an energy content about 25 per cent lower than anthracite. Unfortunately, it often has a very high sulfur content. In fact, the sulfur content of some bituminous coal makes its use illegal for many applications.

Lignite coal is of relatively low quality, with an energy content around 30 to 50 per cent lower than anthracite. It is relatively free of sulfur, but produces other pollutants. Lignite dries out on exposure to air and crumbles. It therefore requires careful handling in shipping and storage.

Coal's use for industrial and residential purposes began in England about the middle of the 18th century. In Pennsylvania, Captain Adam Stephen found coal along the Allegheny River in 1754. In western Pennsylvania, coal was first used industrially to make glass in the early part of the 19th century. Coal later became the chief source of residential heating. About 1890, coal began to be used for the manufacture of coke for the developing steel industry.

An accident of geology has provided the United States with almost a third of the world's coal reserves. (The term "reserves" refers to energy resources which have actually been discovered and can be recovered under present methods and economic conditions.) The U.S.S.R., western Europe, and China have most of the rest of the world's coal reserves.

Within the United States, four major areas–Rocky Mountains, Northern Great Plains, Interior, and Eastern–contain more than 90 per cent of the coal reserves. (See Figure 4.) Two of these areas–Northern Great Plains and Rocky Mountains–contain approximately 70 per cent of the coal resources in the United States, and most of the nation's low sulfur coal. The coal in these areas generally lies close to the surface and is thus easier to mine. Also, the population density in these areas is low, so using the amount of land necessary for the mines is not a problem. On the other hand, this coal is often far away from the industrial centers where it is needed, so transportation becomes a problem. Coal from these two areas is usually of the type lowest in energy content. And these areas do not have the water resources necessary in coal production.

Much of the coal in the Eastern area has a high sulfur content. This is not true of anthracite, which is found principally in Pennsylvania, but unfortunately anthracite makes up only a small fraction of U.S. coal reserves. Eastern coal is often in deeper beds, making mining more difficult. Also, the population density is much higher, causing competition for the land area. But Eastern coal generally has a higher energy content, and water supplies are better in Eastern coal regions.

Thus many factors interact when we consider coal reserves.

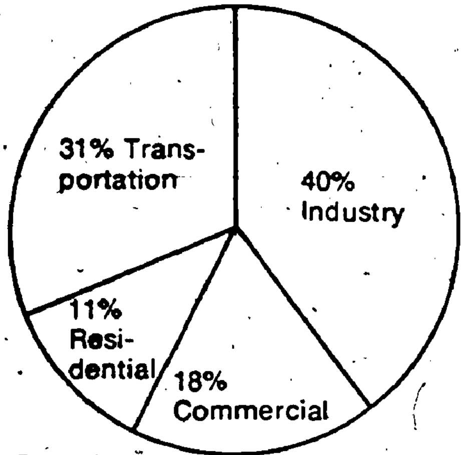
Coal can be recovered by deep mining, strip or surface mining, or augur mining. Much of the coal in the Eastern coal area must be deep-mined–shafts must be sunk deep underground to where the coal lies. In the Western areas, the coal lies closer to the surface. In such cases, the layer of soil covering the coal, called the overburden, can be scraped away, exposing the coal. Augur mining may be used when coal is exposed on the side of a hill; the coal is removed from the side by boring into the coal. Augur-mined sites are found in some Eastern states.

The chief uses of coal are producing heat for industrial processes and heating buildings, generating electricity, and providing coke for making steel.

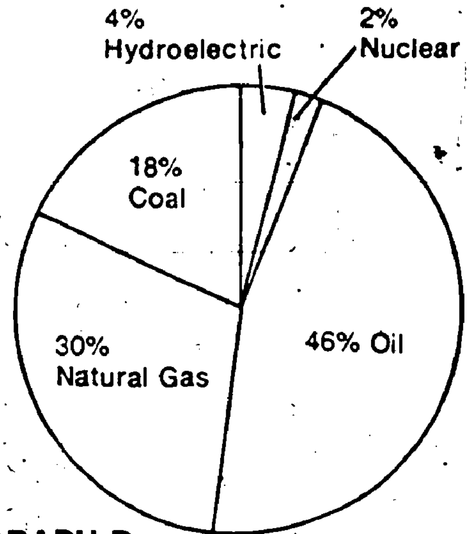
In electrical power plants, the heat energy of coal is

Where We Get Our Energy How We Use It

Activity III-2



GRAPH A



GRAPH B

Graph A divides our energy use into four groups. In what group do we use the most energy? ______________________.
What ranks second? ____________________.
In what ways do you use energy in each of these two groups? What group(s) gives you the most opportunity to cut down on your energy consumption?

Which groups use energy when you do each of the following. Check the box or boxes in the appropriate columns.

(The first one is done for you.)

	Industry	Transportation	Commercial	Residential
1. Take a hot bath				✓
2. Drive to a hamburger stand				
3. Fly in an airplane				
4. Switch on air-conditioning				
5. Buy a new baseball				
6. Ride a school bus				
7. Blow dry your hair at home				
8. Buy a frozen pizza				
9. Ride a motor-bike				
10. Manufacture a motor-bike				

Graph B shows five primary sources of energy. These five sources supply Americans with most of their energy needs. They light and heat the buildings in which we live, work, and play. They fuel our vehicles. They run the machines that work for us and manufacture and process the goods we use and the foods we eat. Look at Graph B and answer these questions.

1. What energy source do we use most?
____

2. Which do we use mostly for heating our homes?
____

3. What energy source provides most of the fuel for our transportation?
____

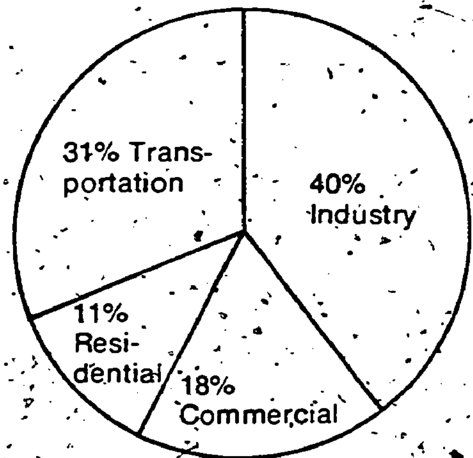
4. Which one makes most of our electricity?
____

5. What is a possible reason why we use so little hydroelectric energy?
____

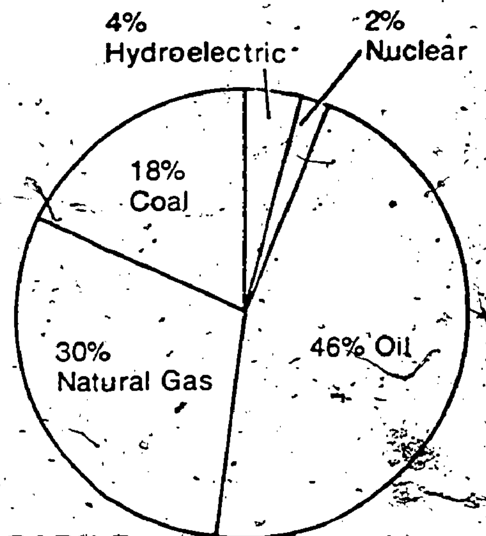
6. Why is electricity not shown on this chart?
____

Where We Get Our Energy How We Use It

Activity III-2



GRAPH A



GRAPH B

Graph A divides our energy use into four groups. In what group do we use the most energy? industry
What ranks second? transportation
In what ways do you use energy in each of these two groups? What group(s) gives you the most opportunity to cut down on your energy consumption?

Which groups use energy when you do each of the following. Check the box or boxes in the appropriate columns.

(The first one is done for you.)

Every item that includes a product could also be checked under "Industry."

	Industry	Transportation	Commercial	Residential
1. Take a hot bath				✓
2. Drive to a hamburger stand		✓	(✓)	
3. Fly in an airplane		✓		
4. Switch on air-conditioning	✓			✓
5. Buy a new baseball			✓	
6. Ride a school bus		✓		
7. Blow dry your hair at home				✓
8. Buy a frozen pizza			✓	
9. Ride a motor-bike		✓		
10. Manufacture a motor-bike	✓			

Graph B shows five primary sources of energy. These five sources supply Americans with most of their energy needs. They light and heat the buildings in which we live, work, and play. They fuel our vehicles. They run the machines that work for us and manufacture and process the goods we use and the foods we eat. Look at Graph B and answer these questions.

1. What energy source do we use most? oil

2. Which do we use mostly for heating our homes? natural gas

3. What energy source provides most of the fuel for our transportation? oil

4. Which one makes most of our electricity? coal

5. What is a possible reason why we use so little hydroelectric energy? not very much falling water

6. Why is electricity not shown on this chart? it is a secondary source

THE GENESIS OF COAL

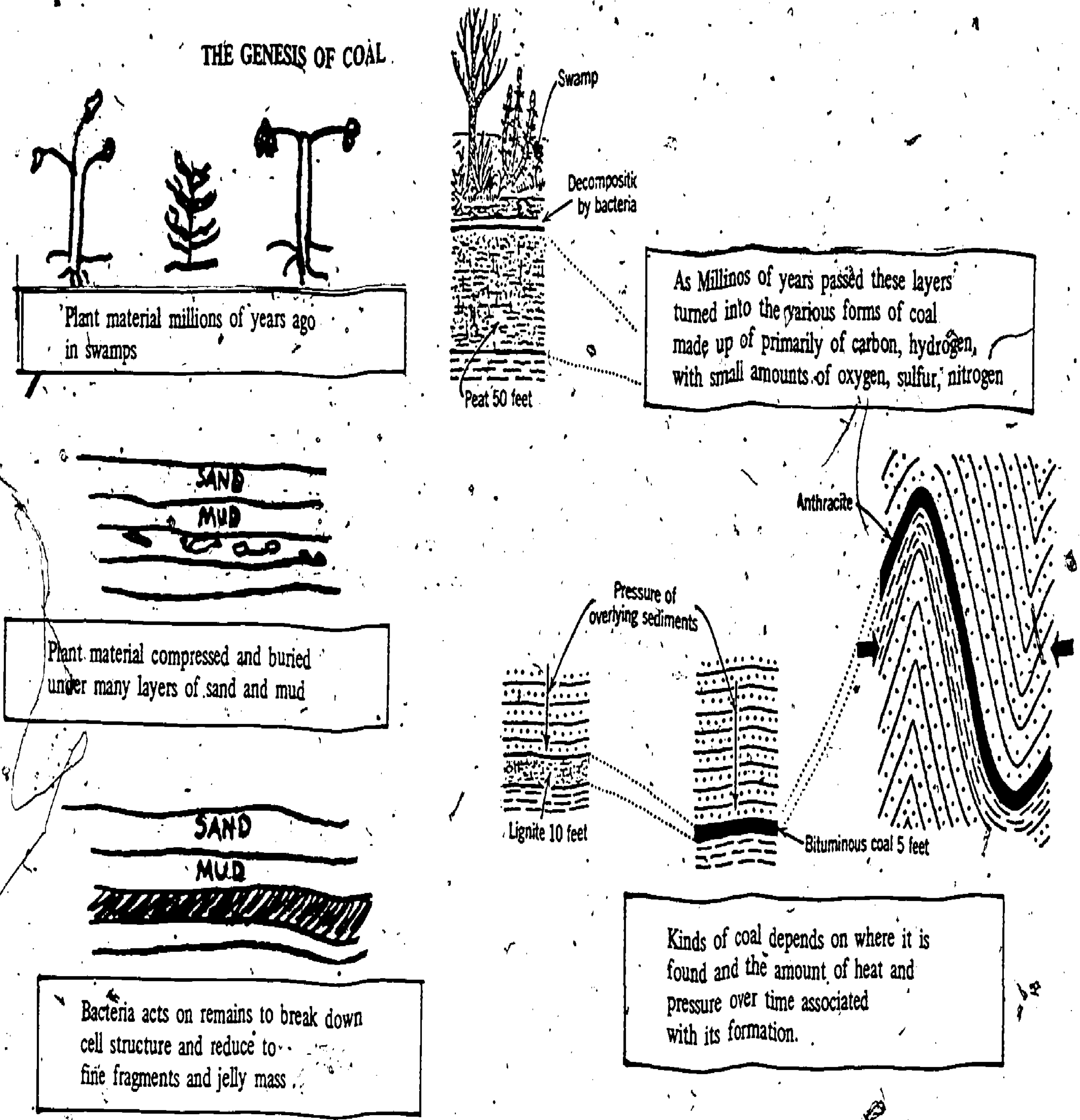
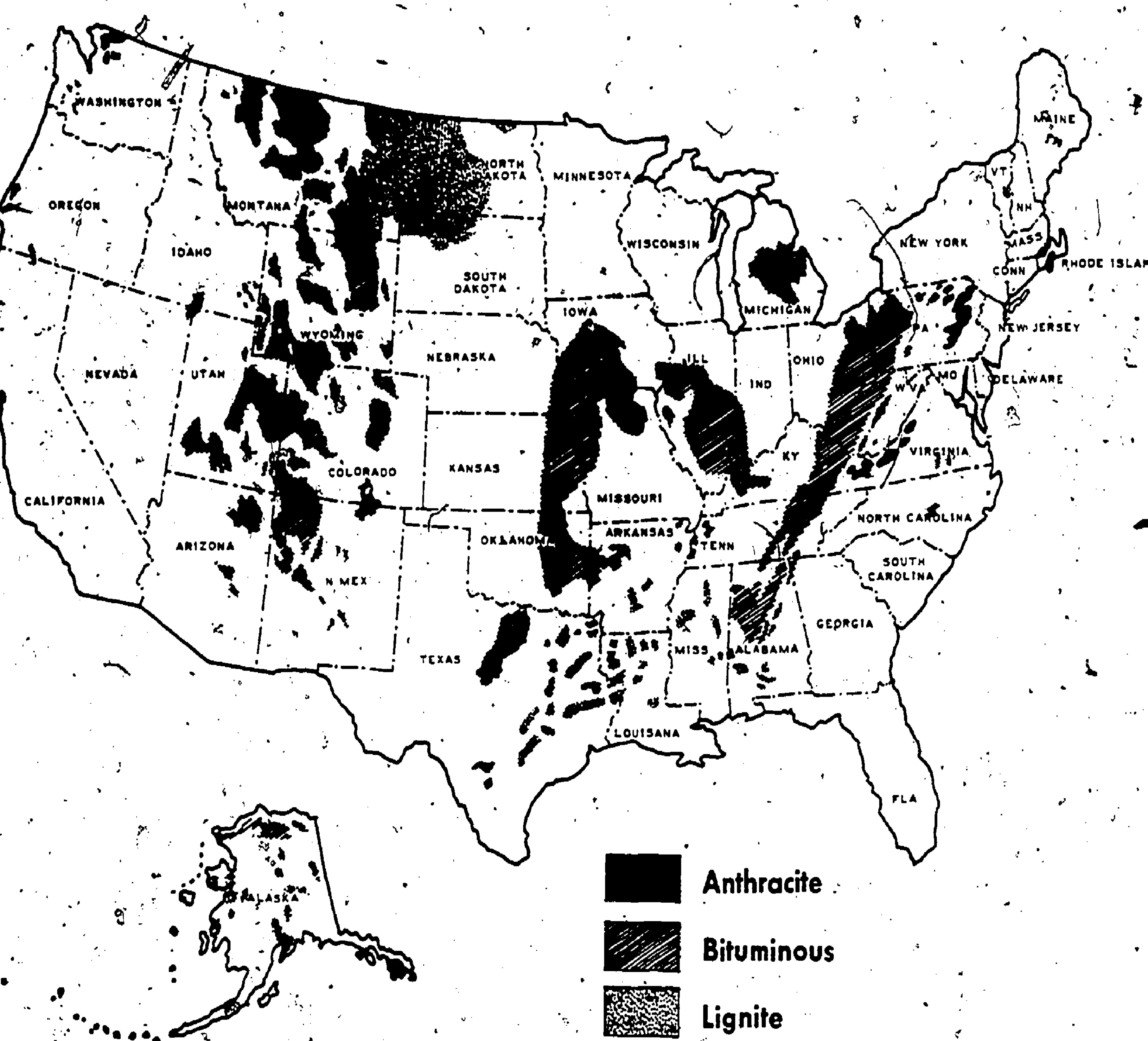


FIGURE 3

COAL FIELDS OF THE UNITED STATES
(FROM UNITED STATES GEOLOGICAL SURVEY)



used to make steam, which in turn is passed into turbines and generators to produce electricity.

Coal is a mainstay of the steel industry, where it is used to make coke. Coke is a hard mass of carbon material produced by heating certain grades of bituminous coal in enclosed ovens. The coke is used in the process of turning iron into steel.

Environmental impacts from the use of coal are evident in the mining process and in its use as a fuel. Getting coal out of the ground without major damage to the environment presents a challenge. Underground coal mines have polluted the water table, harbored fires, and caused millions of acres of surface land to subside, breaking roads and sewers and collapsing buildings. Underground mining is a hazardous industry in terms of mine accidents and disabling black lung disease.

Strip mining is safer and much cheaper than underground mining. In 1976, more than 60 per cent of the nation's coal production came from surface mining. In mid-1977, more than 1000 acres a week were being strip mined. Strip mining has been notorious for destroying landscapes and polluting rivers and water supplies with silt and acid mine drainage. In the past, legislation governing strip mines was left up to each state, and Pennsylvania and some other states enacted strip mining reclamation legislation. In 1977 a strict federal strip mine reclamation law was passed. It requires that land must be restored to "a condition capable of supporting the uses it was capable of supporting prior to any mining." There is some question as to whether strip-mined land should be restored to its original condition and use, or restored to a different condition and better use. At any rate, an operator cannot strip mine the land unless he can provide definitive plans for its reclamation.

Another environmental impact from coal is one that is shared by any fuel used to generate electricity. Electrical generating plants are not very efficient–that is, a large portion of the energy produced cannot be used to generate electricity, and goes into the environment as waste heat. This heat has definite environmental impacts.

The waste heat is dissipated through the use of cooling water. This cooling water is taken from a nearby river, lake, or other large body of water. Its temperature is raised slightly by the waste heat from the generating plant, and it is then returned to its source. The body of cooling water eventually loses the added heat to the atmosphere. If the temperature change in the cooling water is too great, it may upset the ecological balance of the body of water, perhaps killing some types of the aquatic life and favoring the growth of others. The use of cooling towers or cooling ponds is sometimes required, where part of the waste heat is transferred to the air. We must keep in mind that this discussion of waste heat applies to any type of electrical generating plant, not just a coal-burning plant.

If a power plant is located near an industry which can use the low-grade steam as process heat, or near a community which can use it for residential heating, some of this heat becomes a useful resource instead of a waste to be disposed of.

The burning of coal produces air pollution which can have serious environmental consequences. The worst pollutant is sulfur dioxide, which is a colorless gas produced when fuels containing sulfur are burned. Sulfur dioxide affects the respiratory system, which includes the lining of the nose, throat, and lungs. Statistical studies have shown that many people die each year as a direct or indirect consequence of breathing sulfur dioxide from coal burning plants.

There are three approaches to reducing sulfur emissions that are already feasible or under development: burning low-sulfur coal, cleaning the coal ~~before~~ burning, or using scrubbers to remove sulfur from the flue gas after the coal is burned.

Low-sulfur coal, primarily from the west, can be used to meet the Environmental Protection Agency standards. Many Eastern and Midwestern utilities are bringing in low-sulfur western coal to avoid the problems of flue gas scrubbers. Use of this western coal presents its own problems, however. Among them are reclaiming strip-mined areas where there is a scanty water supply and transporting the coal from the western areas. The pressure is on for development of the vast coal resources in western Pennsylvania and the rest of Appalachia, which are near places where coal needs to be used.

Coal is normally cleaned before use in order to remove extraneous mineral matter and improve its quality as a fuel. Such cleaning may also remove some sulfur, but usually far from enough to meet present air pollution standards. A commercially successful method of removing much of the sulfur content before coal is burned has yet to be demonstrated.

One cleaning method under development is solvent refining of coal. Pulverized coal is mixed with a solvent and reacted with hydrogen gas at high temperatures and pressures. This dissolves the coal and separates it from its ash and sulfur, producing a clean burning, high heat value fuel. This process is now under critical study at the Gulf Research Laboratories at Harmarsville, near Pittsburgh.

The third option for sulfur control is to use scrubbers to remove the sulfur dioxide from the flue gas prior to its discharge to the atmosphere. In such scrubbers, the hot gas is passed through a mixture of limestone and water, which chemically removes most of the sulfur dioxide. There have been many problems with the operation of such scrubbers, and a disposal problem for the large quantities of wet sludge they generate. Research continues on other scrubbing techniques, and on new systems for burning coal, such as fluidized bed combustion, which is described in Module VI.

Coal-burning power plants must also control the emission of particulates, which are primarily mineral ash. Very fine particulates, which may be retained in the lungs, are a potential health hazard. Some evidence suggests that sulfur compounds in combination with these particulates may be responsible for some of the adverse health effects previously attributed to sulfur dioxide alone. Electrostatic precipitators are generally used to reduce particulate emission to an acceptable level.

Nitrogen oxides are another pollutant from coal-burning plants. This is especially a problem in urban areas where it is combined with nitrogen oxides from auto emissions. Techniques based on modifications of the combustion process are being explored to reduce the production of nitrogen oxides.

The use of coal produces a tremendous amount of waste in the form of ash and slag. About 30 million tons of these materials are collected each year.

Another byproduct of the burning of any fossil fuel is carbon dioxide. A study has recently been completed by the National Research Council's Geophysics Study Committee. This study centered on the effect of carbon dioxide on climatic conditions. Carbon dioxide reflects part of the earth's radiated heat back to the ground; thus, any significant rise in the amount of carbon dioxide in the atmosphere will increase the greenhouse effect mentioned in Module I. The study concluded that if the world continues to rely heavily on fossil fuels for its energy, within 200 years the earth's average temperature could rise as much as 6 degrees C. The impact on sea levels, agriculture, and the polar ice caps could be profound and possibly disastrous.

Carbon dioxide results from burning any fossil fuel, but in light of our probable increasing dependence on coal, it is of special concern. The study concludes that we have to be prepared to switch from fossil fuels in about 50 years to avoid apparent climatic changes. However, experts do not agree on this point.

Activity III-3

Objective:

The student will observe the difference between the types of coal.

What to do?

Materials Needed: Small samples of peat, lignite, bituminous coal, anthracite coal, crucible tongs, Bunsen Burner, hand lens.

Examine the samples carefully, using a hand lens if necessary. Answer the following questions:

1. Which sample looks most like plants?
2. Which sample looks least like plants?
3. Arrange the samples in order of hardness.
4. Arrange the samples in order of luster.
5. Which sample looks like it has the most carbon in it?
6. Which sample looks like it has very little carbon in it?

Now hold each sample with the crucible tongs and light it with the Bunsen burner. Note how long each takes to ignite. Also, note any odors or smoke, and how rapidly each burns.

Activity III-4

Objective:

The students will research the mining and extraction of coal, and use their findings to make a model of a coal mine.

What to do?

Have students find pictures and diagrams of coal mines, and using any available materials, make a model of a coal mine.

Activity III-5

Objective:

The student will test the gases coming off a sample of burning coal.

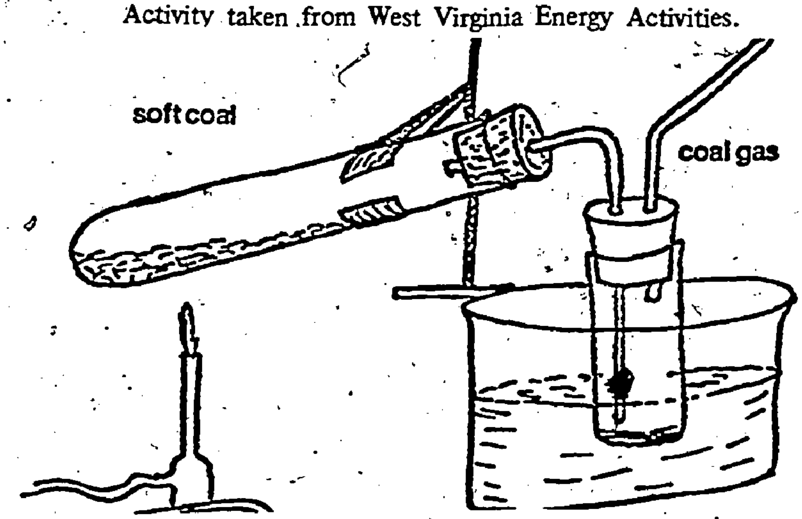
What to do?

Materials needed: Bunsen burner, glass or plastic container, 2 test tubes, 2 stoppers (one 1-hole and one 2-hole), 2 glass tubes, (1-curved 8", 1-3"), test tube holder, soft coal, water, matches, red litmus paper, lead acetate paper.

This activity involves the destructive distillation of coal. It *must* be done in a well-ventilated part of the classroom or outdoors. Set up the apparatus as shown in the diagram below. Fill the distillation tube one-third full with pieces of soft coal and heat the tube. Test the gas which comes off to see if it burns. Then test for hydrogen sulfide by holding moistened lead acetate paper in the gas. (If paper turns black, hydrogen sulfide is present.) Test for ammonia by holding wet red litmus in the gas. (If ammonia is present, the paper will turn blue.) Continue heating the coal until all the gases are driven off. The material remainining is coke.

Burn coke and soft coal. Which produces a better fire? Which material would be better for a fireplace?

Activity taken from West Virginia Energy Activities.



Coal Tar

Activity III-6

Objective:

The students will research the mining of coal, the use of coal in making steel, and the environmental and health effects of burning coal.

What to do?

Divide students into groups and ask one group to find out how coal is converted into electricity. Have them illustrate the journey of the energy from coal from the mine to the home or classroom. Have another group illustrate the environmental and health effects related to the mining and burning of coal and what is being done to solve these problems. Have another group prepare a display of how coal is used in making steel. (The World Book article on coal is an excellent reference for this activity.)

Activity III-7

Objective:

The students will write letters to coal companies to find out about reclamation.

What to do?

Have the students write letters to local coal companies (or coal companies in other areas). Ask what the company is doing to relcaim the land after mining.

Activity III-8

Objective:

The students' will debate the positive and negative aspects of strip mining.

What to do?

Divide the class into two teams. Debate the following:

Coal should be strip mined instead of deep mined. Land can be reclaimed after strip mining.

Activity III-9

Objective:

Students will describe how coal was formed and how it is mined. They will develop an awareness of the current controversy over mining methods.

What to do?

Have students complete and discuss the items following on *Fossil Fuels: Coal, Oil and Natural Gas.*

Activity III-10

Objective:

Students will trace the route of energy from the coal mine to the electric light.

What to do?

Have students complete and discuss the items following on *How Coal is Used* and *Some Facts About Coal.*

OIL AND NATURAL GAS

Oil is now the nation's major energy source. But neither domestic supplies nor imports from the rest of the world will be able to satisfy indefinitely our seemingly insatiable demand for this fuel. If it could be assumed that world demand for oil would grow at an annual rate of only 3 per cent, the world's presently estimated recoverable oil resources would be exhaused by 2020. It seems clear that within about four generations, the bulk of the world's supply of oil will have been substantially consumed. The oil that remains will have become too expensive to use as an energy source, and will have to be reserved for petrochemical and other uses in which its maximum value can be realized.

Oil and natural gas deposits usually occur together. They are believed to come from animal remains–mainly marine animals–as they accumulated over a period of some 50 million years, a shorter time frame than for the formation of coal.

As organisms died in ancient seas, the remains settled to the sea bottom and became buried in layers of mud and sand. This organic matter was changed into the carbon and hydrogen compounds that are natural gas and oil, probably by gradual decay, heat, pressure, and perhaps bacterial and radioactive actions. (See Figure 5.)

The first oil well of modern times was completed in 1859, at Titusville, Pennsylvania. The grade of crude oil (oil as it comes from the ground, before it is refined or processed) called Pennsylvania crude is still the finest in the world for making lubricants. Unfortunately, reserves of Pennsylvania crude oil are quite small.

Crude oil is refined into many different products. About 90 per cent is made into various kinds of fuels: gasoline, jet fuel, heavy duty fuel oil for industries, heating oil, and diesel fuel. The rest goes into lubricants and is a vital raw material in hundreds of manufactured products such as dye, medicines, detergents, and artificial fibers (nylon, rayon, dacron).

Oil reserves are unevenly distributed in the world. The Middle Eastern countries such as Saudi Arabia and Kuwait have about 53 per cent of the reserves. African countries (Nigeria, Angola) have about 16 per cent. The U.S.S.R., Romania, and other eastern European countries have about 15 per cent, while the United States, including Alaska, has only about 5 per cent. Smaller amounts are found in other countries.

Figure 6 shows the location of oil and gas fields in the United States.

Geologists use various instruments to discover the right conditions for the existence of oil or natural gas under the ground. A derrick is then erected to hold the drills, pipes, and other equipment. Drilling is done, and if oil is found, the crude oil is transported to be refined. If natural gas is found, it is pumped away in pipelines to be used.

Wells may be drilled on land. They may also be drilled off-shore, with a platform provided to support the equipment.

On-shore oil production rarely creates any significant pollution problems, although accidental pollution sometimes occurs when wells blow out, contaminating the area with crude oil. Also, in on-shore production, nearly three barrels of brine pumped from the ground must be disposed of for every barrel of oil produced.

Off-shore operations present more problems, with the possibility of the direct release of oil fouling beaches and affecting animal life in coastal regions. Fires at oil wells could cause significant air pollution.

Oil spills and discharges from oil tankers which transport the crude oil have caused many environmental problems. Millions of gallons of oil have been released when these tankers have run aground or broken up, and this oil is washed up on shore or sinks to the bottom, destroying fishing grounds and birds.

Oil may also be transported through pipelines. These pipelines must be carefully constructed to minimize environmental damage. For example, in the construction of the Trans-Alaskan pipeline, such diverse considerations as these had to be made: keeping the warm oil from melting the permafrost, not interfering with the ancient migratory patterns of the caribou herds, not disturbing salmon spawning grounds, and allowing for earthquakes and thermal expansion and contraction of the pipe.

When used as the fuel for an electrical generating station, oil produces some air pollution, mainly from the oxides of sulfur and nitrogen. But the pollution problems associated with burning oil are not as serious as with coal. This is a major reason why some utilities turned to the burning of oil instead of coal to meet air quality standards.

The biggest air pollution problem from the use of oil comes when the oil is used in the form of gasoline or diesel oil to power cars, buses, and trucks.

Natural gas supplies are limited, and the growing imbalance between resources and consumption of this valuable fuel is of particular concern. It is hoped that short range supplies can be augmented by imports through Mexican and Canadian pipelines. Natural gas can be liquified and imported on tankers, but these imports are quite expensive.

Natural gas is largely methane, which is composed of one carbon atom and four hydrogen atoms. Natural gas was first used in the United States for lighting in Fredonia, New York in 1821. Early usage tended to be localized because there was no way to transport the gas over long distances. In 1947, a major change in the industry was brought about when natural gas from the southwest reached the east coast through two converted liquid pipelines, and the United States became the leading producer of natural gas in the world. Since that time, the use of natural gas has increased rapidly. It is used as a fuel to produce heat, and has become the primary raw material for chemical fertilizer and many other products. At the well, natural gas is compressed and the heavier gas molecules, primarily propane and butane, are separated out as a liquid. These are then transported in pressurized containers and sold as bottled gas. It can be used in the same way as natural gas and is especially useful in rural areas where there is no gas pipeline.

One reason that natural gas has come into such great demand is that it can be delivered as a clean-burning, sulfur-free fuel.

Estimated reserves of natural gas are found in the following areas: U.S.S.R., 31 per cent; U.S., 16 per cent; Iran, 11 per cent; Algeria, 6 per cent; and the remainder in many other countries.

Environmental impacts of the extraction and use of natural gas are less than those for coal or oil.

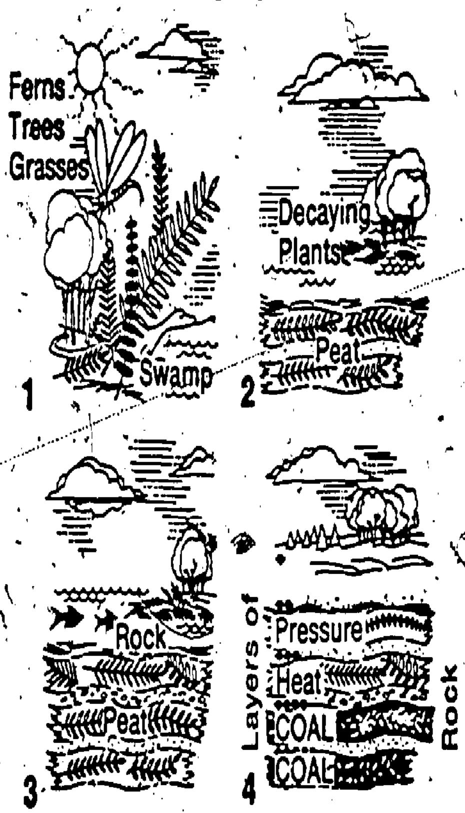
Hydrogen sulfide, a toxic and corrosive substance, must be removed from the gas before it is used.

Pipeline transmission impacts must be considered.

If natural gas is used to generate electricity, disposal of waste heat must be considered.

Fossil Fuels: Coal, Oil, and Natural Gas

HOW COAL WAS FORMED



PLACE THE NUMBER OF EACH PICTURE IN FRONT OF THE DESCRIPTION THAT FITS IT BEST.

_____ When the giant plants died, they formed rotted vegetable matter called *peat*. For thousands of years, plants grew, died, and formed layer upon layer of peat.

_____ When the seas were gone again, heat and pressure from the layers of rock changed the peat into coal.

_____ More than 250 million years ago, forests of gigantic ferns, trees, and grasses covered vast swamp lands and stored up energy from the sun.

_____ Later, when the surface of the earth changed, seas covered the land and deposited layers of shale, limestone and other rock on the peat.

HOW COAL IS MINED

Strip or Surface Mining
Uses huge bulldozers and power shovels to remove coal from a shallow seam near the earth's surface.

Deep or Underground Mining
Tunnel or shaft is built into the earth to the seam of coal sometimes many hundreds of feet below the surface. Workers and equipment remove the coal through the tunnel or shaft.

Read each set of statements below. If there were nothing else to consider, would you think that surface or deep mining (or both) is the best way to obtain coal? Write your choices on the blanks at the left, using S (for surface) or D (for deep).

	SURFACE MINING	DEEP MINING
_____	1. Each miner can produce 30 tons of coal a day.	Each miner can produce 10 tons of coal a day.
_____	2. 90 percent of the coal in a surface mine can be removed.	50-60 percent of the coal in a deep mine can be removed.
_____	3. In 1974, surface-mined coal cost $11.11 a ton.	In 1974, deep-mined coal cost $19.88 a ton.
_____	4. Forest and fields along with their topsoil, are turned over before the coal is removed — at a rate of 1000 acres a week. New laws in every state require land reclamation, but the cost is added to the price of coal.	Much less damage to land and environment.
_____	5. Some coal, very close to the earth's surface, can only be recovered by surface mining.	Some coal, very deeply buried, can only be recovered by deep mining.

It would be easy to decide how to mine coal if there were only one set of facts to consider. As you have seen, however, there are many. What would you say is the main advantage of surface mining?

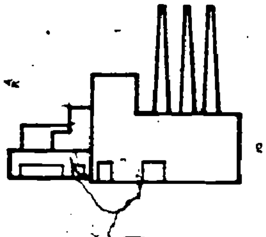
What would you say is the main advantage of deep mining?

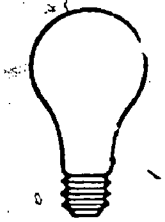
Can you think of a compromise?

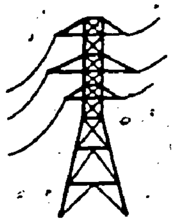
How Coal is Used

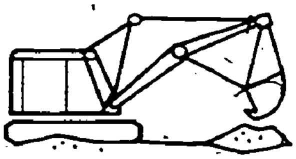
Activity III-10

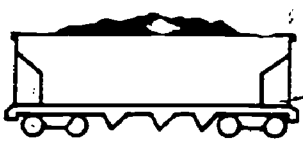
This activity follows coal from the mine to your electric light.











1. Coal is mined either by surface or underground mining. Before it leaves the mine, it is cleaned, crushed, and sorted.

2. About 2/3 of our coal is transported by rail, much of it in special cars. One coal train can carry as much as 15,000 tons per trip.

3. 46 percent of U.S. electrical generators are powered by coal. Power plants burn coal to turn water into steam. The steam turns a turbine, a series of wheels with vanes like a windmill. The turbine rotates coils of wire in a generator through a magnetic field to produce electricity.

4. Electricity is transported on wires at very high voltages. Electricity is usually not shipped more than 600 miles by wire because of expense and loss of energy. Only 26 percent of the original energy remains when the electricity is used.

5. Electricity lights the lamps in your home. How many other uses of electricity in your home can you name? Write them on the back of this paper. Then place a star before those you think you could do without.

Some Facts About Coal

Decide whether each of the following facts is a problem (P) or an opportunity (O). Put a P or an O — or both — in each blank. On the back of this sheet, write down ways some of the problems could be overcome. Compare ideas with your classmates.

_____ 1. 90 percent of U.S. fossil fuel reserves (coal, oil, natural gas) are coal.

_____ 2. Some deep mines are dangerous.

_____ 3. 50 percent of our mineable coal is in the western United States.

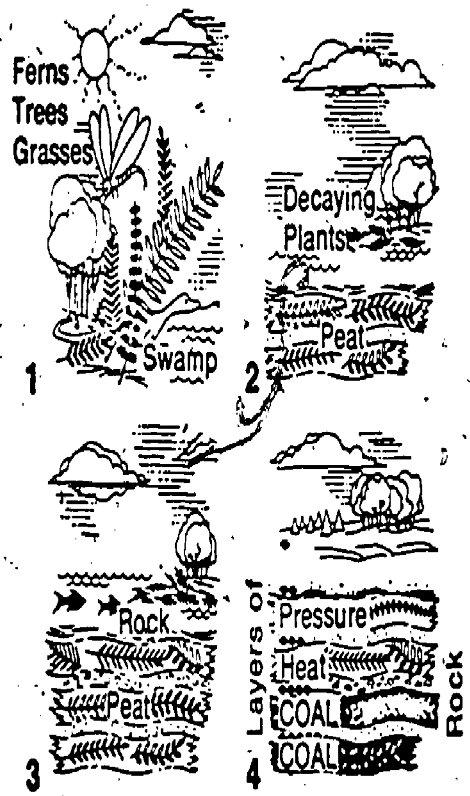
_____ 4. We have enough coal to last for 350 years, at current level of use.

_____ 5. Mining coal can cause damage to the environment.

_____ 6. In the future, we will rely more on coal as a source for synthetic oil and gas.

Fossil Fuels: Coal, Oil, and Natural Gas

HOW COAL WAS FORMED



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__2__ When the giant plants died, they formed rotted vegetable matter called *peat*. For thousands of years, plants grew, died, and formed layer upon layer of peat.

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It would be easy to decide how to mine coal if there were only one set of facts to consider. As you have seen, however, there are many. What would you say is the main advantage of surface mining? *economic*

What would you say is the main advantage of deep mining? *environmental*

Can you think of a compromise?

How Coal is Used

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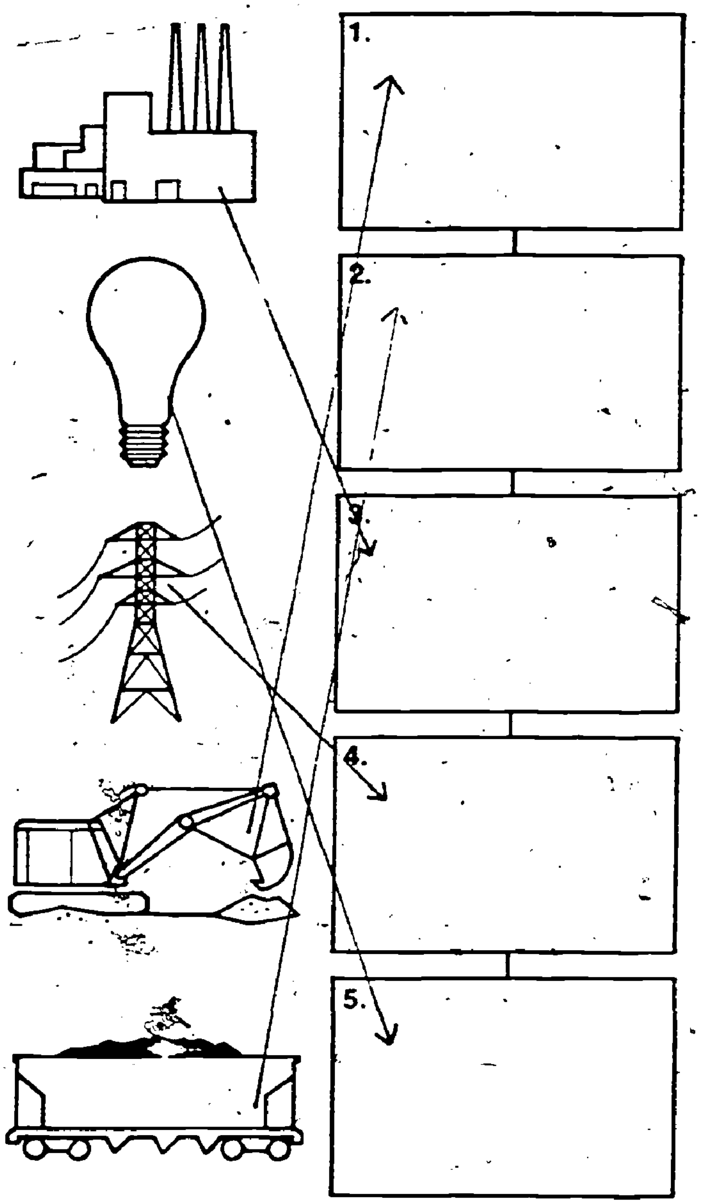

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__O__ 1. 90 percent of U.S. fossil fuel reserves (coal, oil, natural gas) are coal.

__P__ 2. Some deep mines are dangerous.

__O/P__ 3. 50 percent of our mineable coal is in the western United States.

__O__ 4. We have enough coal to last for 350 years, at current level of use.

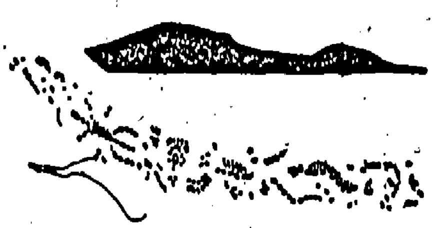
__P__ 5. Mining coal can cause damage to the environment.

__O__ 6. In the future, we will rely more on coal as a source for synthetic oil and gas.

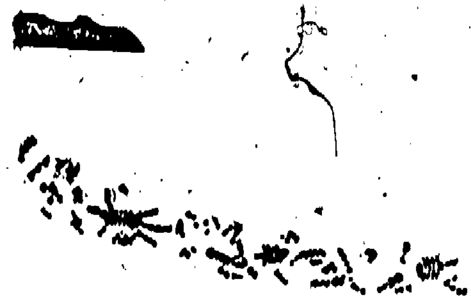
THE GENESIS OF OIL AND GAS

Some Scientists believe patroleum formations began millions of years ago. When tiny marine creatures abounded in and near the seas as they do today.

As marine life died, it settled to the sea bottom and became buried in layers of mud and sand

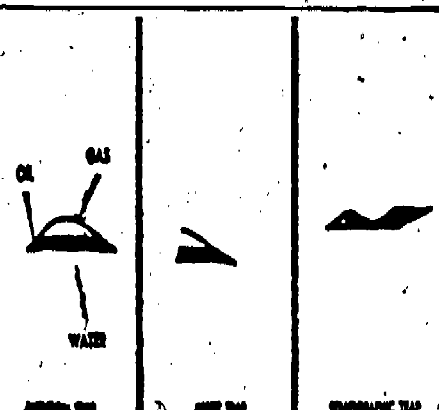


The organic matter held in mud and silt was changed to gas and oil probably by gradual decay, heat, pressure, and possible bacterial and radioactive actions.



As millions of years passed, pressure compressed the deeply buried layers of mud, silt, and sand into layers of rock.

Earthquakes and other earth forces buckled the rock layers.

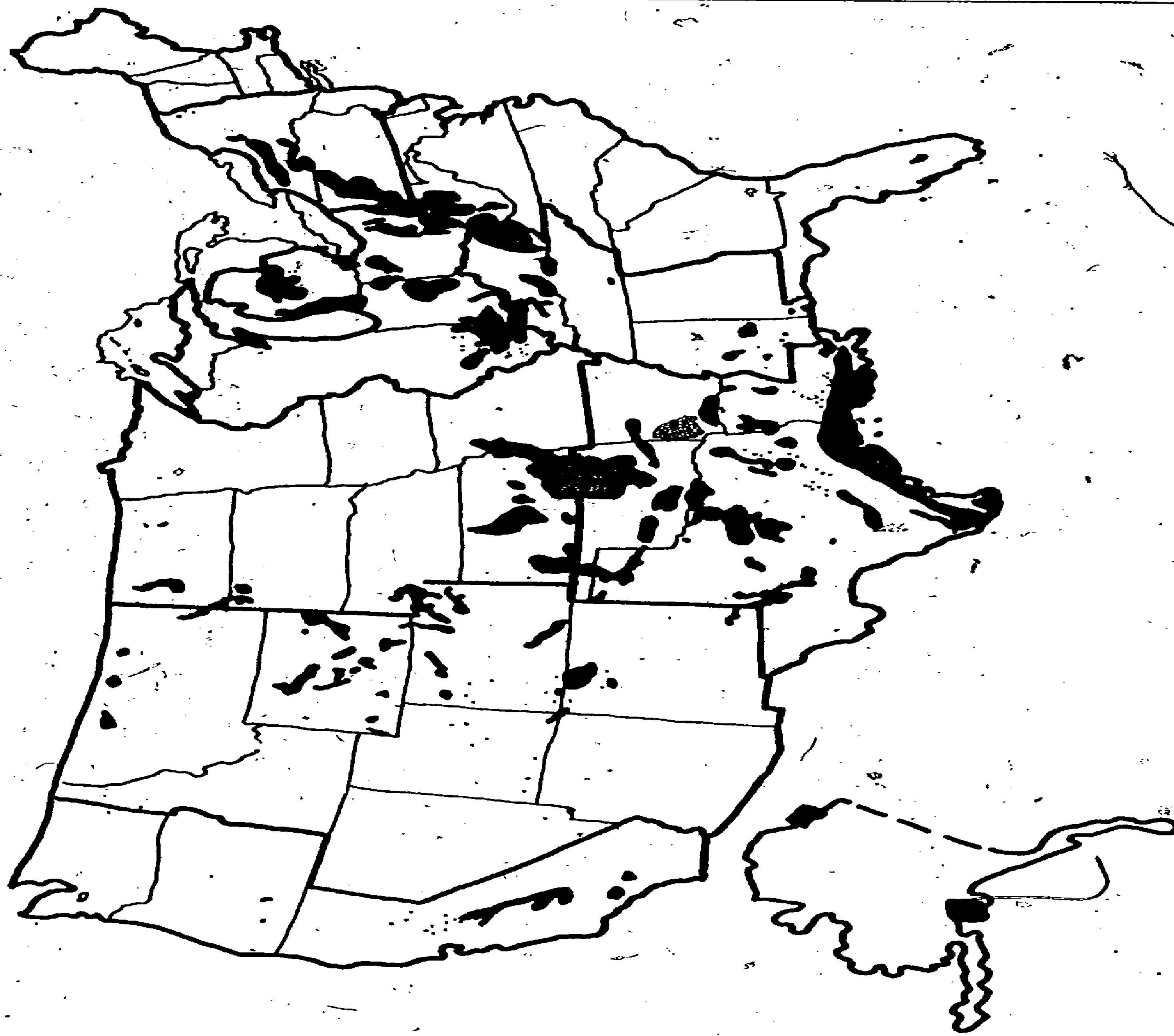


The patroleum migrated upward through porous rock until it became trapped under non-porous rock.

FIGURE 5

FIGURE 5

Oil and Gas Fields in the United States



Source: U.S. Department of the Interior, U.S. Energy Fact Sheets 1971, February, 1973.

FIGURE 6

Activity III-11

Objective: The student will fractionally distill salt water and methanol and recognize the application to petroleum.

What to do?

Materials needed: Ring stand, Bunsen burner, flask, glass tubing, two-hole stopper, one-hole stopper, beaker, salt water, test tube, methanol (duplicating fluid), water, boiling chips, thermometer.

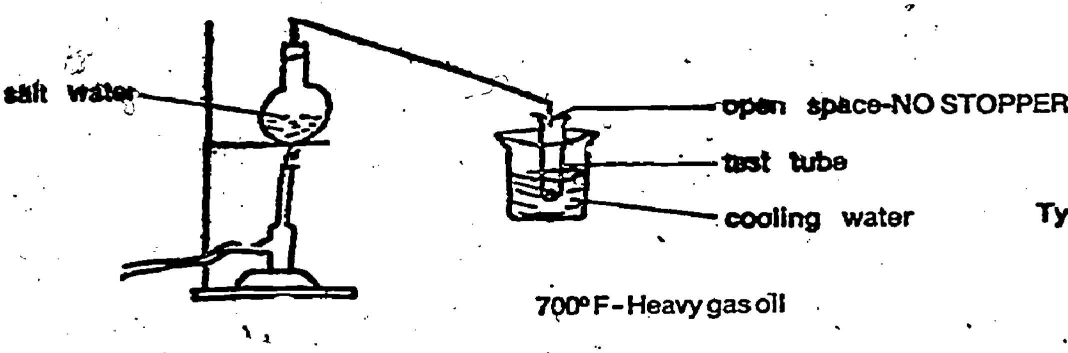
Set up the apparatus as shown in the diagram below. Using boiling chips, boil the salt water. What happens?

Replace the salt water with a solution of methanol and water. Using two-hole stopper, put thermometer into flask in one hole, tubing in another. Heat the flask, recording the temperature every 30 seconds. Which vaporizes first? At what temperature?

Teacher note:

The process of fractional distillation is a method of separating liquids with different boiling points. The mixture is heated gradually until one liquid boils and changes to a gas. The gas is led away and condensed. This process continues until all liquids are separated. In this activity, pure water will be evaporated, leaving salt water, and methanol will vaporize first from the water.

This is the process that allows the separation of crude oil into so many products, as shown below.



Fractional Distillation of Crude Oil

	Typical Products from crude oil
700°F-Heavy gas oil	waxes, asphalts, heavy fuel oils
510°F-gas oil	diesel oil, furnace oil
340°F-light gas oil	light furnace oil, kerosene
235°F-naphtha	gasoline
215°F-gases	liquified petroleum gases

Activity III-12

Objective: The student will research newspapers and magazines to report on tankers which have run aground and the damage that has been done.

What to do?

Have the students research old newspapers and magazines on oil spills which have occurred when tankers have run aground or broken up. Have them report on reasons for the disaster, number of gallons spilled, success or non-success in containing the oil, damages reported as a result of the spill, and possible long-term implications.

Activity III-13

Objective: The student will try to find ways to contain or remove an oil slick.

What to do?

Materials needed: Cooking oil, pan, water, straws, sponge, paper towels, stop watch.

Make a mini-oil slick in a pan of water. Have the students use the materials listed (and any more they may be able to think of) to try to remove the oil from the water. Record the length of time for each method.

Activity III-14

Objective: Students will complete a maze to observe the speed of travel of natural gas in pipelines.

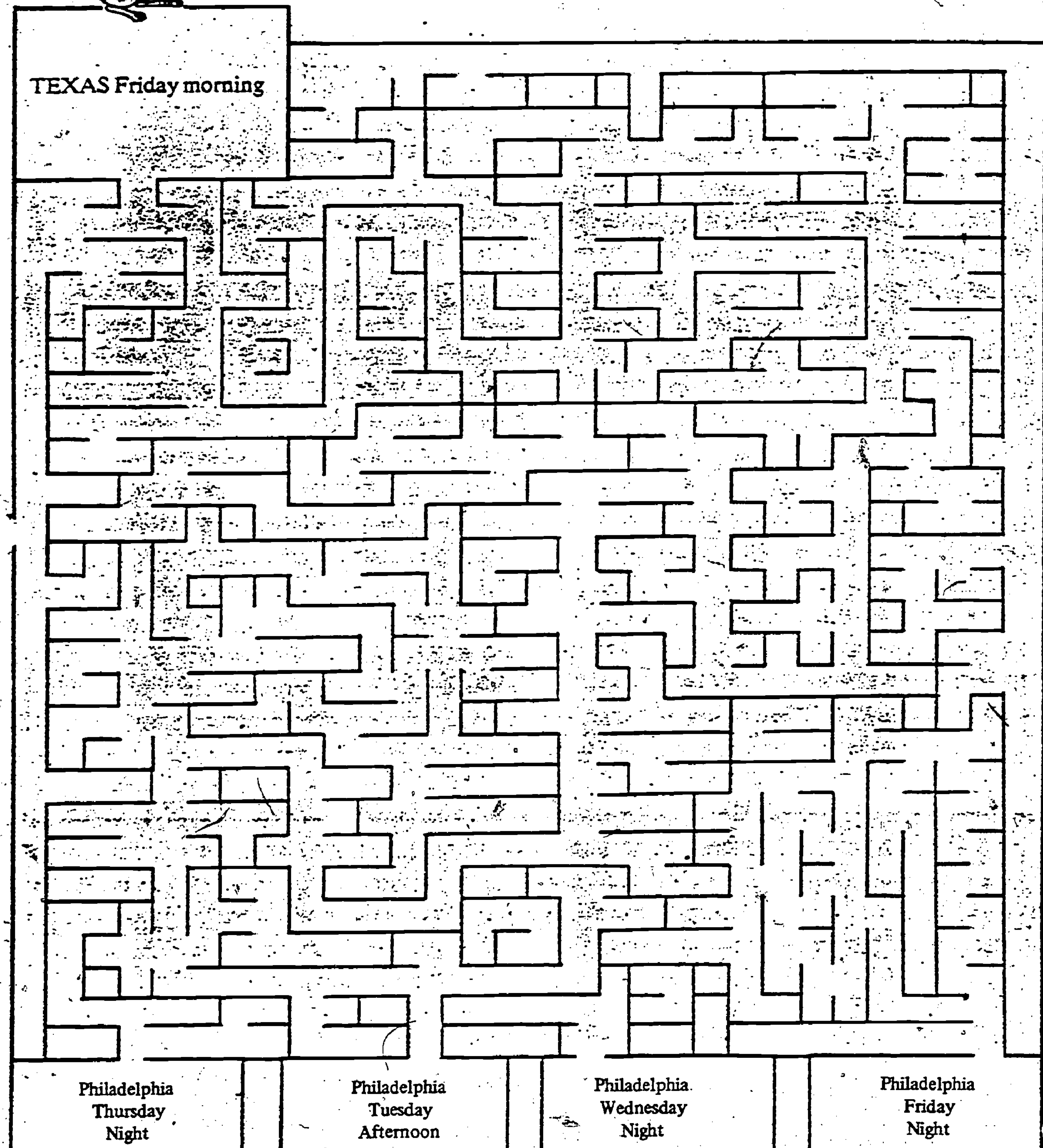
What to do?

Have students complete the maze on the following page.

Teacher note:

From Amarillo, Texas to Philadelphia is approximately 1500 miles. If the gas travels at 15 miles per hour, it would take 100 hours for the trip, or from Friday morning to Tuesday afternoon. This activity could be varied for any city. It is adapted from CONCO Energy Activities.

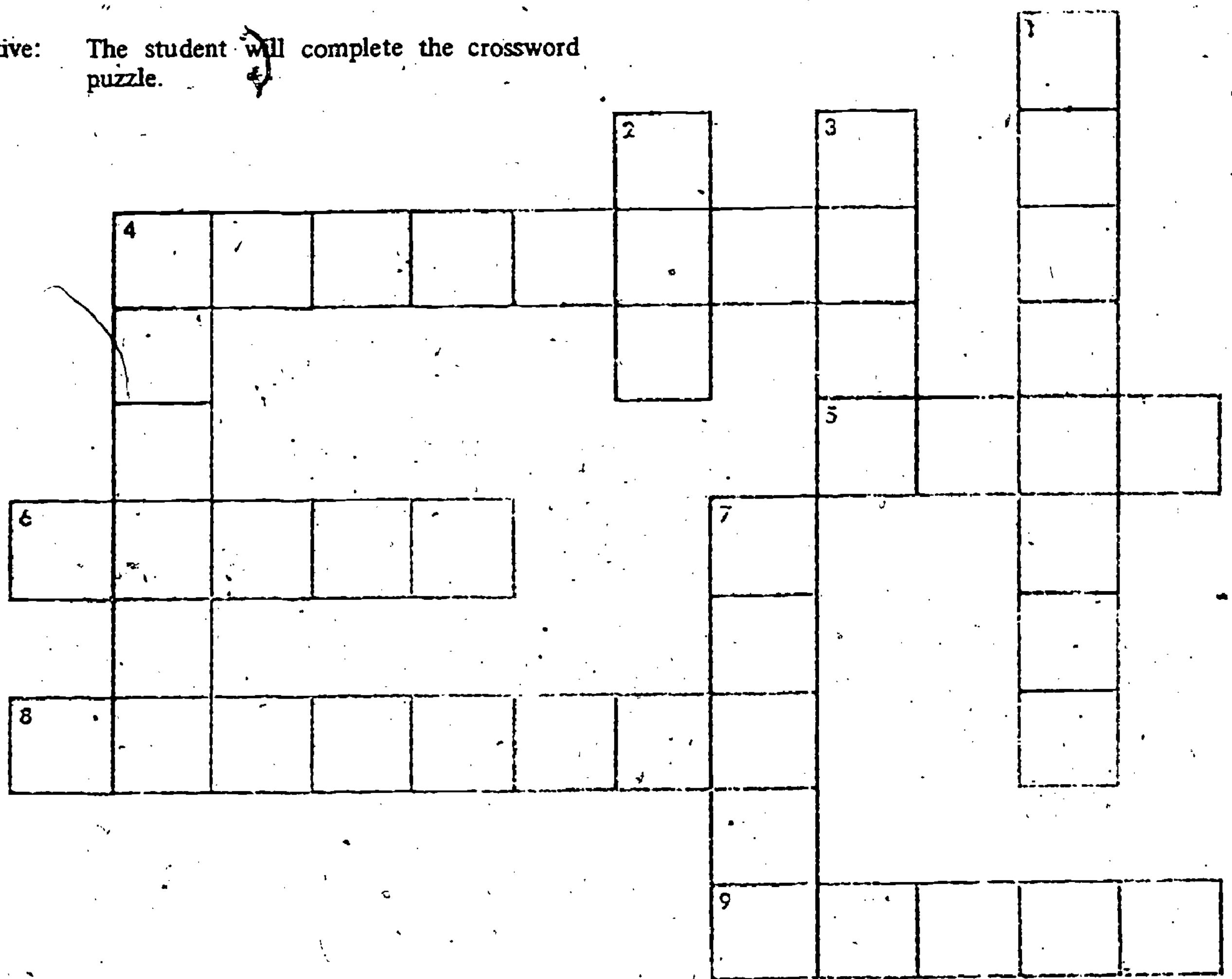
GAS is transported long distances by modern pipe lines. The gas travels at about 15 miles per hour. When would gas that is produced in Amarillo, Texas on Friday morning reach Philadelphia? Complete the maze to find out–



OIL AND GAS

Activity III-15

Objective: The student will complete the crossword puzzle.



ACROSS

4. A fuel made from petroleum (oil) that is used in most automobile motors
5. Usually a large container for oil, gasoline, etc.
6. Oil and gas are found deep in the ________.
8. A thin oil used in lamps and stoves
9. Oil or gas is sometimes found when men ________ a hole deep into the earth.

DOWN

1. A place where crude oil is changed into gasoline and other products
2. A liquid found deep in the earth and is often called petroleum
3. Oil gives off ________ and smoke when it is burned.
4. A very thick form of oil
7. An oil ________ has many oil wells in it.

From Hayes: *Earth Science and Ecology* Crossword puzzle book

Activity III-16

Objective:

The student will be able to illustrate fossil fuel formation.

What to do?

Have the students make charts or models to illustrate the process of fossil fuel formation.

Teacher note:

Although these processes are going on all the time, the time span is so great for completion that we must consider our present supplies as all we will have available.

Activity III-17

Objective:

The student will investigate how fossil fuels are formed.

What to do?

Materials needed: Ferns, sand, peat, coal, 10 gallon aquarium, slides or charts of geologic time scale.

Have students examine samples of ferns, peat, and coal. Show the students geologic time charts and describe the physical condition of the earth during the coal forming processes. Then simulate these conditions in the aquarium.

Fill the aquarium with tap water. Add enough peat moss to make a one inch layer. Allow one week to elapse. What is the condition of the water? Include such things as PH, odor, turbidity, decomposition of peat, etc. Have any changes occurred in the peat? Suggest reasons for the changes, or explain why changes did not occur.

Sift moderately fine sand over the peat to a depth of one inch. After the sand settles, add an equal depth of peat. Repeat the process for as long as desired, or until several successive layers have formed. Is coal still being formed today naturally?

This activity from Michelle Alexander and John Neth, Groveport-Madison High School, Groveport, Ohio.

Activity III-18

Objective:

The students will research and report on the extraction, transportation, and use of the fossil fuel.

What to do?

Divide the class into three groups. Have each group research one of the fossil fuels--coal, natural gas, or oil. Have them report on the extraction, transportation, use and environmental problems of each. Encourage charts and illustrations.

Activity III-19

Objective:

The student will debate the environmental impacts of the fossil fuels.

What to do?

Debate the question: Which fuel has the greatest environmental impact: coal, natural gas, or oil.

Activity III-20

Objective:

The students will examine the burning qualities of several fuels.

What to do?

Materials needed: Candle, wooden splint, sliver of soft coal, kerosine, alcohol, lamps to burn kerosine and alcohol, natural gas in Bunsen burner.

Burn the various substances in a laboratory. As each is burned, have the students answer the following: Does it burn easily? Does it smoke a lot as it burns? Does it give off odors? Does the flame seem to be very hot?

Activity III-21

Objective:

The student will evaluate the characteristics of a "perfect fuel."

What to do?

Explain to the students that the characteristics of a good energy source are sometimes listed as

1. High energy potential
2. Abundant supply
3. Relatively easy to obtain
4. Relatively easy to convert into useful work
5. Extraction and use should not have undue negative environmental or health effects
6. Equally distributed
7. Few energy losses during transporting and use

Have students rate several fuels with + or - on these characteristics. You might want to include non-fossil fuels as well. The list could include coal, oil, natural gas, wood, peat, dried cow dung, alcohol, wind, water power, solar power, geothermal power, and nuclear power. Pool group judgements to determine areas of agreement or disagreement. Ask: What is the possibility of running out of the "best" fuels? What can be done about it?

Source: Energy Conservation Teaching Resource Units, Junior High and Middle Schools, Ohio Department of Education

Activity III-22

Objective:

Students will recognize the many ways in which petroleum product, or petrochemicals, are an important part of their lives.

What to do?

Have students fill in the blanks of the story on the page entitled "Petroleum and the Way You Live" They may need to look up some of the words at the bottom of the page. Suggest that class members complete the day by listing as many petrochemical products as they can find in their everyday activities.

Petroleum and the Way You Live

Fill in the blanks in the following story from the list of words at the bottom of the page (all products made from petroleum). Each word will be used at least once. How many petroleum or *petrochemical* products can you think of that you used before school this morning?

Sam Super, a seventh grader at O.K. Junior High, hated to get up one dreary, rainy day. Sam flicked on the ________________ lights and washed his hair with ________________ shampoo. To cheer himself up, he put on his brightest plaid ________________ sweater. On the way downstairs, Sam passed his sister's room as she was fixing her new hairdo with her can of ________________ hairspray. Down in the kitchen, Sam's mother had fixed him some eggs in a ________________-coated pan, using her ________________ range. Sam's mother complained that he ate too quickly from the colorful ________________ plate and insisted that, because it was raining, Sam wear his ________________ boots. All that hassle had given him a headache, so he gulped down an ________________, grabbed his peanut butter sandwich wrapped in ________________ and banged the ________________ storm door on the way out. On the way to the corner, Sam slipped in a puddle on the ________________ roadway. Finally, he climbed on the bus, powered by high octane ________________. He sank back onto the ________________ covered seat and unrolled a butterscotch drop from a ________________ wrapper, opened his ________________ notebook, and started his homework from the night before.

plexiglass
teflon
detergent
aerosol-propelled
asphalt
plastic wrap
gasoline
vinyl
acrylic knit
melamine plasticware
synthetic rubber
aspirin
electric
natural gas
synthetic leather
cellophane

Petroleum and the Way You Live

Fill in the blanks in the following story from the list of words at the bottom of the page (all products made from petroleum). Each word will be used at least once. How many petroleum or *petrochemical* products can you think of that you used before school this morning?

Sam Super, a seventh grader at O.K. Junior High, hated to get up one dreary, rainy day. Sam flicked on the *electric* lights and washed his hair with *detergent* shampoo. To cheer himself up, he put on his brightest plaid *acrylic knit* sweater. On the way downstairs, Sam passed his sister's room as she was fixing her new hairdo with her can of *aerosol-propelled* hairspray. Down in the kitchen, Sam's mother had fixed him some eggs in a *teflon*-coated pan, using her *electric or natural gas* range. Sam's mother complained that he ate too quickly from the colorful *melamine plasticware* plate and insisted that, because it was raining, Sam wear his *synthetic rubber or vinyl* boots. All that hassle had given him a headache, so he gulped down an *aspirin*, grabbed his peanut butter sandwich wrapped in *plastic wrap* and banged the *plexiglass* storm door on the way out. On the way to the corner, Sam slipped in a puddle on the *asphalt* roadway. Finally, he climbed on the bus, powered by high octane *gasoline*. He sank back onto the *vinyl*-covered seat and unrolled a butterscotch drop from a *cellophane* wrapper, opened his *synthetic leather* notebook, and started his homework from the night before.

plexiglass	plastic wrap	aspirin
teflon	gasoline	electric
detergent	vinyl	natural gas
aerosol-propelled	acrylic knit	synthetic leather
asphalt	melamine plasticware	cellophane
	synthetic rubber	

A hydroelectirc power plant uses falling water to spin turbines for generating electricity. There are not many more areas in the United States where hydroelectric plants can be built. Remaining potential sites are in remote areas away from the electrical demand. Developing these sites would have potentially adverse effects on increasingly scarce wilderness areas. Hydroelectric plants produce no waste heat, but the effect of high dams on fishery resources can be detrimental.

Objective: The student will demonstrate that falling water can do work.

What to do?

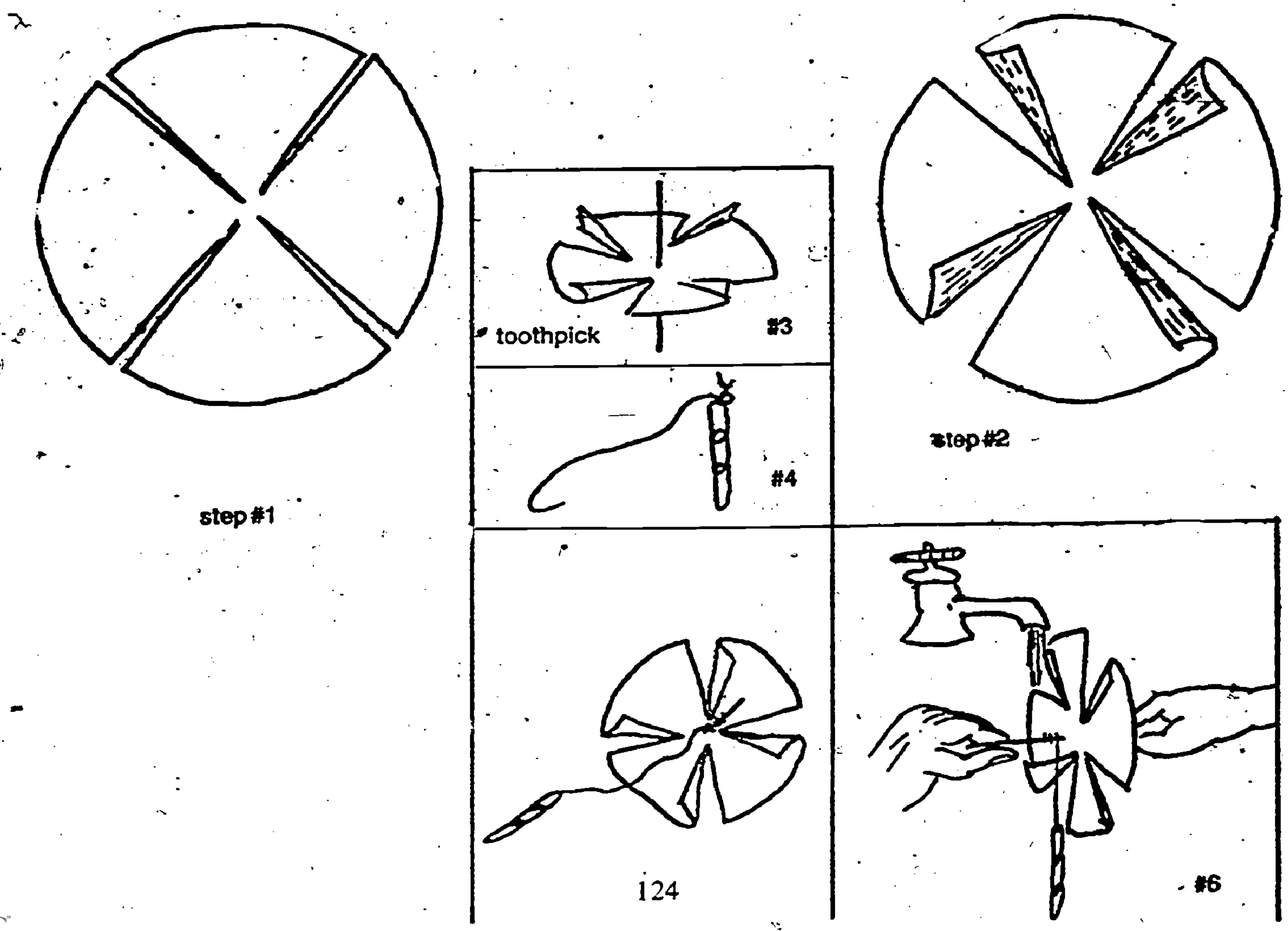
Materials needed: cardboard, toothpick, thread, paper clips, gallon plastic milk container, one-hole stopper, two-inch length of glass tubing, two-foot piece of rubber tubing, medicine dropper.

Cut four slits in a circle of cardboard and fold back the edges, as shown below. Push a toothpick through the center of the circle. Now you have a water wheel. The toothpick is the shaft. The folded parts are the blades.

Fasten one end of a thread about 8" long to a chain of three paper clips. Tie the other end of the thread to the shaft of your water wheel. Be sure it is tied tightly enough to keeping from slipping.

Place the edge of the wheel under a stream of water. Hold the ends of the toothpick lightly between your fingers. The water will turn the wheel. The thread will wind up on the shaft and pull the chain of paper clips along with it. Did the water do any work? What kind of energy did it use?

Cut the bottom out of a gallon plastic milk container. Fit the top of the container with a one-hole rubber stopper. Place a two inch length of glass tubing in the hole. Connect one end of a two foot piece or rubber tubing to the glass tubing and insert the glass part of a medicine dropper into the other end of the rubber tubing. After filling the milk container about 2/3 full of water, hold it upside down. The flow of water can be controlled by pinching the tubing. Direct the stream of water against the pin wheel. The effect of raising and lowering the milk jug on the speed of the pin wheel can also be studied.



NUCLEAR POWER

On December 2, 1942, an event occurred that was to help shape the future. On that date, the first controlled, self-sustaining nuclear chain reaction took place under a stadium at the University of Chicago.

The harnessing of nuclear energy takes place in a nuclear reactor, which is part of a nuclear power plant. In the reactor, fissioning uranium produces heat energy which is used to make steam to generate electricity. The fission process is discussed in Module I. The only real difference between a nuclear power plant and a fossil-fueled power plant is the method of heat production; the end product, electricity, is exactly the same. Nuclear energy, as a primary energy source, has little use other than to generate electricity or steam in large central power plants.

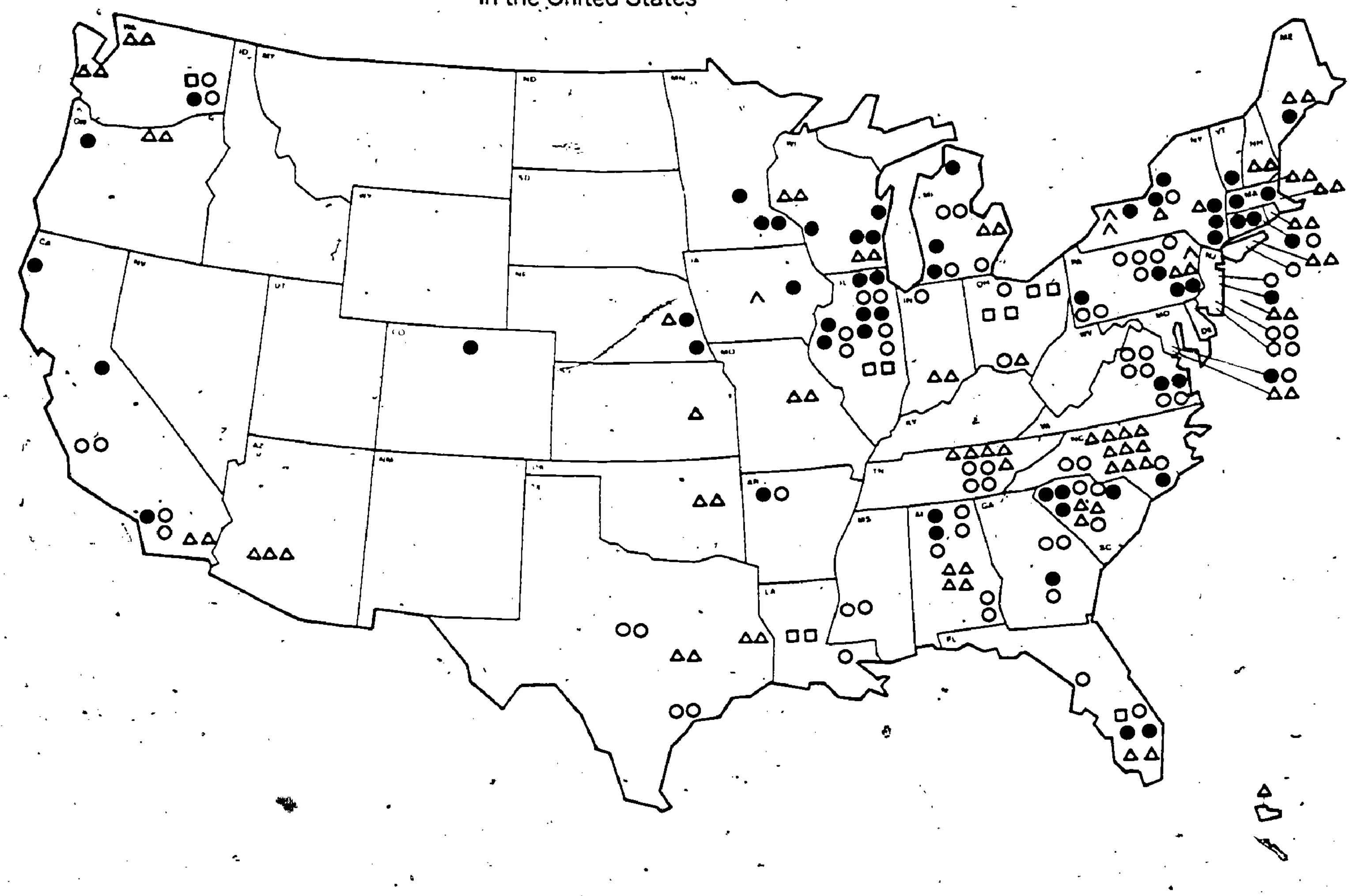
Most U.S. reactors which are now being used to produce electricity are called light water reactors, because water is used to moderate or slow down neutrons to improve the conditions for fission. Other reactors use deuterium (heavy water) as a moderator.

Figure 7 shows the location of operating and planned nuclear power plants as of January, 1976.

Uranium is the basic nuclear fuel because it contains uranium-235, which is the only natural material that readily undergoes fission. Only about seven-tenths of one per cent of naturally-occurring uranium is uranium-235. The balance is uranium-238, which does not readily undergo fission.

The United States has become the leading producer of uranium in the free world. Practically all the deposits of commercial-grade uranium found in the United States to date are in the western part of the country. Some

FIGURE 7 Central station nuclear power plants in the United States



Key
- ● Operable
- ○ Under Construction
- □ Limited Work Authorization
- △ On Order
- ∧ Letters of Intent/Options

58	Reactors operable	39,940 MWe
69	Reactors under construction	72,465 MWe
12	Limited work authorizations	12,149 MWe
80	Reactors on order (including 4 units not sited on map)	91,955 MWe
9	Letters of intent/options (including 4 units not sited on map)	9,680 MWe
228	Total	226,189 MWe

Atomic Industrial Forum, Inc.

January 1, 1976

shallow deposits are mined by open-pit techniques; however, most is taken from underground mines.

The environmental impact of uranium mining is slight, because it takes only a very small amount of uranium to fuel a nuclear power plant.

The environmental impact of the use of nuclear plants to generate electricity is a controversial issue. Environmental issues involved in the normal operation of a nuclear plant include radiation release and waste heat.

With or without nuclear power plants, radiation is around us all the time. Natural radiation is found in soil, in rocks, and in our own bodies. In addition, we are constantly being bombarded with cosmic radiation from outer space. This background or natural radiation seems to do no significant harm to humans. Large doses of radiation can be extremely harmful, however. Many complicated factors determine the effect of a given dose of radiation, but sickness or even death can occur in the person irradiated, and genetic effects can occur in the person's future offspring.

We are exposed to some sources of radiation besides the natural background. Chief among these sources are medical x-rays and radioactive medicines. We also receive some radiation dose from fallout from weapons testing.

If you lived right at the boundary of a modern nuclear plant, the additional radiation exposure you would receive would hardly be measurable compared to the background radiation you are already receiving. In one year, it would be about the same as the additional cosmic radiation you would receive during one transcontinental plane flight.

Nuclear power plants emit significantly less chemical pollution than fossil fuel plants.

We have already said that all electrical generating plants that use steam share the problem of disposal of waste heat. This problem is somewhat greater for nuclear plants than for fossil-fueled plants. One reason is that nuclear power plants discharge almost all their waste heat into the cooling water, while fossil-fueled plants discharge some of their waste heat directly into the air along with the gases released from the plant's stack. Also, nuclear power plants are slightly less efficient than modern fossil-fueled plants, so they have more waste heat to dispose of. Finally, the average nuclear-fueled plant has a larger generating capacity than the average fossil-fueled plant. Thus more heat must be disposed of at one location.

Apart from these two environmental considerations in the day-to-day operations of a nuclear power plant, even more controversy exists over various aspects of safety.

Nuclear power plants undoubtedly have an outstanding safety record. No member of the public has ever been injured or killed by the operation of a commercial nuclear power plant. The basis for nuclear power safety lies in the safeguards built into each plant. After a nuclear plant is designed to operate properly, its designers assume the failure of various safety-related equipment. Then they design auxiliary systems to keep the plant safe despite such failures. Finally, some of these auxiliary systems themselves are assumed to fail, and additional backup systems are provided to still keep the plant safe. The result is layers of safeguards.

The core of a nuclear reactor consists of several hundred fuel bundles. These bundles are made up of hard ceramic-like pellets of uranium oxide. The arrangement and dilution of this fuel is exactly opposite from that needed to produce a nuclear explosion. Therefore a nuclear power plant cannot blow up like a bomb.

The fuel pellets themselves tend to retain most of the radioactive byproducts of the fission process. They thus form the first in a series of barriers to prevent the uncontrolled release of radioactive materials from the plant. The second barrier is the sealed metal tubes which enclose the pellets. The reactor core is in turn inside a 6 to 8 inch thick steel reactor vessel weighing several hundred tons. Surrounding this is a steel shell and concrete containment structure at least three feet thick. This is designed to protect the reactor from outside forces, such as airplane crashes or earthquakes.

The fuel core of a reactor is immersed in water, which is heated by the fission process to form steam to drive the turbine. This water also moderates or slows down neutrons so that fission occurs more readily. If all this water were lost, fission would cease immediately, but the core would still be dangerously hot--perhaps hot enough to melt the core and release radioactive materials to the atmosphere. To prevent this, there are standby systems to reflood the reactor vessel and cool the core.

Nuclear plants cannot be built or operated without a license from the Nuclear Regulatory Commission, the federal agency charged with regulating and licensing nuclear facilities. The Nuclear Regulatory Commission recently sponsored a study which came to the following conclusion: Assuming 100 operating reactors, the chance of a nuclear accident involving 1000 fatalities is about the same as the chance of a meteor striking a U.S. population center, causing the same number of deaths.

Many opponents of nuclear power question the findings of this report, and say that the chances of a serious nuclear accident are much higher. Others say that even through such a serious accident is very improbable, the results would be so highly destructive that the risk is still too great.

The radioactive waste from nuclear power plants is a cause for some concern. Every year or two, a nuclear power plant must be shut down so that some of the depleted fuel bundles in its core can be replaced. This depleted fuel is highly radioactive, and must be maintained in carefully controlled storage.

It is possible for the depleted fuel from reactors to be reprocessed and recycled, although no such reprocessing has been done for some time. It had been envisioned that this reprocessing would be done at special plants. After usable fuel was extracted, the waste remaining would be solidified and sealed in specially designed cannisters, then placed in a carefully monitored federal repository. These wastes would remain radioactive for thousands of years. To simplify the long-term surveillance commitment, several alternatives for permanent, unattended storage were being assessed. The most promising seemed to be burial in deep-lying bedded salt deposits or granite rock. The volume of these solidified high level wastes would be relatively small–a typical nuclear plant would produce about 100 cubic feet annually, about the same volume as two telephone booths.

The future of these reprocessing plants was clouded when on April 7, 1977, President Carter called for a ban on such reprocessing. This will be discussed in Module IV.

With or without reprocessing, the radioactive waste from nuclear power plants will have to be dealt with. Techniques are being developed for processing reactor wastes into vitrified solids. Pilot testing has been delayed by ERDA on the grounds that there will not be sufficient wastes from power plants until 1986 to justify the effort.

Nuclear power opponents point out this lack of present provisions for handling these wastes. Periodic problems with large volumes of radioactive wastes from military sources add fuel to the controversy. Some people question whether we have the right to make a "Faustian bargain" with society—nuclear energy now in exchange for long-term vigilance of future generations.

It should be remembered that nuclear power plants are not the only producers of radioactive waste. In fact, most of the radioactive waste produced through the year 2000 will come from nuclear weapons and nuclear navy use.

One small foot-note to the nuclear power discussion concerns its dependability. In January, 1977, the eastern United States was in the grip of the coldest weather in history. On January 17, ice clogged the Ohio River, preventing delivery of coal and fuel oil to fossil fuel generating plants. Natural gas pipeline supplies were curtailed and rationed. Coal piles were useless because they had frozen solid. However, nuclear power plants were able to operate without interruption, averting massive electrical power failures.

Who can decide these complex issues when even scientists cannot agree? Ultimately the citizens of the country must decide, as they have already been asked to do in several state referenda. And that decision must be made after considering a series of trade-offs. Do the benefits of electricity from nuclear power outweigh the risks involved? What are the alternatives? What risks would we be running if we have inadequate electricity supplies? The answers are not simple.

Activity III-24

Objective:
The student will observe the effects of radiation on photographic film.

What to do?
Materials needed: A radioactive source such as cobalt-60, a key, Polaroid 3000 (speedgraphic) film, drawer.

Tape the radioactive source to the key. Place both on a Polaroid film pack and place in a drawer for a week.

Teacher note:
The radioactivity emitted from the source will put an image of the key on the film.

Activity III-25

Objective:
The student will observe radioactivity in the atmosphere through use of a Geiger counter.

What to do?
Materials needed: Rock and soil samples, Geiger counter (possibly can be obtained from high school science department or civil defense headquarters)

Get a count of the background radiation in the school room. Then hold the Geiger counter over various samples of rock and soil, and other items in the room and around the school. Compare the activity of the Geiger counter when held over the various items. Which seem to be most radioactive?

Activity III-26

Objective: The students will compute their own approximate radiation dosage.

What to do?
Have students complete the activity "Compute Your Own Radiation Dosage" which follows. Have them compare their results with other classmates, and with the U.S. average. If you wanted to reduce your radiation dose, how could you do it?

Objective:
The student will complete the map and locate the nation's resources of fuels.

What to do?
Using the map which follows, have the students locate the nation's fuel resources with an appropriate symbol. You may want to do the same thing with a map of the world. Ask: Which areas have the greatest fuel reserves? What fuels are these?

Activity III-28

Objective:
The student will identify the basic parts of both conventional and nuclear-powered electrical generating plants.

What to do?
The student will fill in the blanks on the activity called "Nuclear Energy" which follows. Ask: What are the similarities and differences between nuclear powered and fossil fuel plants?

Compute Your Own Radiation Dosage

We have seen that radiation is all about us and is part of our natural environment. In this exercise you will get an idea of the amount you are exposed to every year. The unit of radiation used here is the millirem.

	Common Source of Radiation	Your Annual Inventory (mrem/year)
WHERE YOU LIVE	Location: Cosmic radiation at sea level	40
	Add 1 for every 100 feet of elevation where you live	______
	House construction: Wood 35, Concrete 50, Brick 75, Stone 70	______
	Ground (U.S. Average)	56
WHAT YOU EAT DRINK AND BREATHE	Water and food (U.S. Average)	25
	Air (U.S. Average)	5
HOW YOU LIVE	Jet Airplanes: Number of 6000-mile flights x 4	______
	Radium Dial Wrist Watch: Add 2	______
	Television Viewing: Black and white: Number of hours per day x 1	______
	Color: Number of hours per day x 2	______
	X-ray Diagnosis and Treatment Limb x-ray: 420 Chest x-ray: 150 Stomach x-ray: 350 Colon x-ray: 450 Head x-ray: 50 Spinal x-ray: 250 Gastrointestinal tract x-ray: 2000 Dental x-ray: 20	______
HOW CLOSE YOU LIVE TO A NUCLEAR PLANT	At Site Boundary: Number of hours per day x .2	______
	One Mile Away: Number of hours per day x 0.02	______
	Five Miles Away: Number of hours per day x 0.002	______
	TOTAL	______

Compare your dose to the U.S. Average of 200 mrem/year

Courtesy of San Diego Section
American Nuclear Society

THE NATION'S RESOURCES!

- ☐ COAL FIELDS
- ☐ OIL FIELDS
- ☐ GAS FIELDS
- ☐ NUCLEAR FUELS
- ☐ DAMS

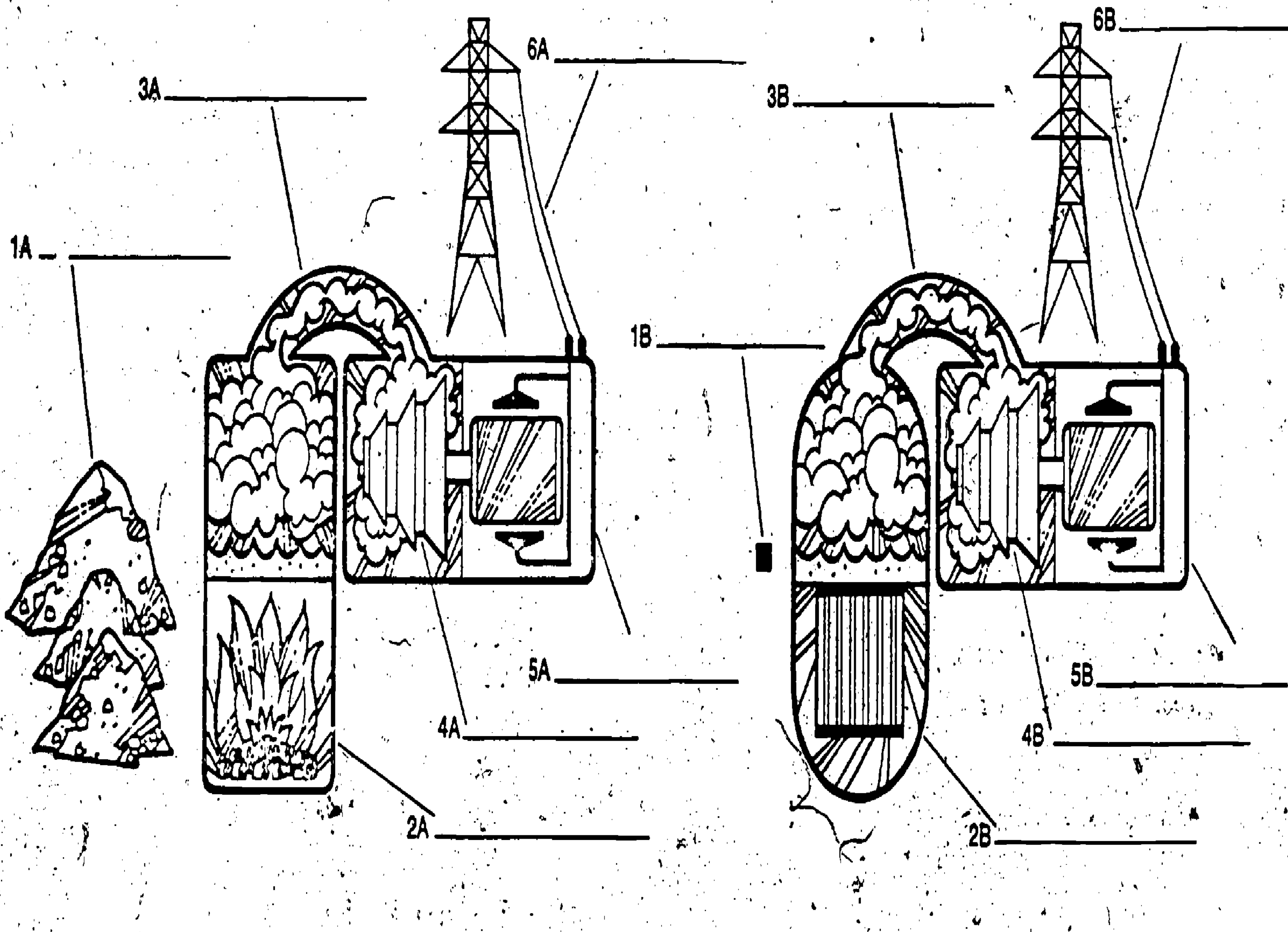
Energy Man's Alternatives, Buffalo Public Schools, Division on Instructional Services, Buffalo, New York

Nuclear Energy (PART 1)

ACTIVITY III-28

One of the energy resources being considered to supplement our limited oil and natural gas supplies is nuclear power, created by the splitting apart of atoms of uranium. This power can be captured and used to create steam which produces electricity much as the power of burning coal is used in an electric generating plant.

The diagrams below show two kinds of electric power plants. They are much alike except that one is powered by nuclear energy produced in a nuclear reactor. Can you label the parts of the two plants. All the words you need appear at the bottom of the page. An encyclopedia or other reference book may help you.



A. ______________________ B. ______________________

FOSSIL FUEL ELECTRIC GENERATING PLANT	GENERATOR	TURBINE	STEAM
NUCLEAR POWERED ELECTRIC GENERATING PLANT	BOILER	TRANSMISSION LINES	REACTOR
	STEAM	FUEL (1 lb.)	GENERATOR
	TRANSMISSION LINES	TURBINE	FUEL (2½ million lbs.)

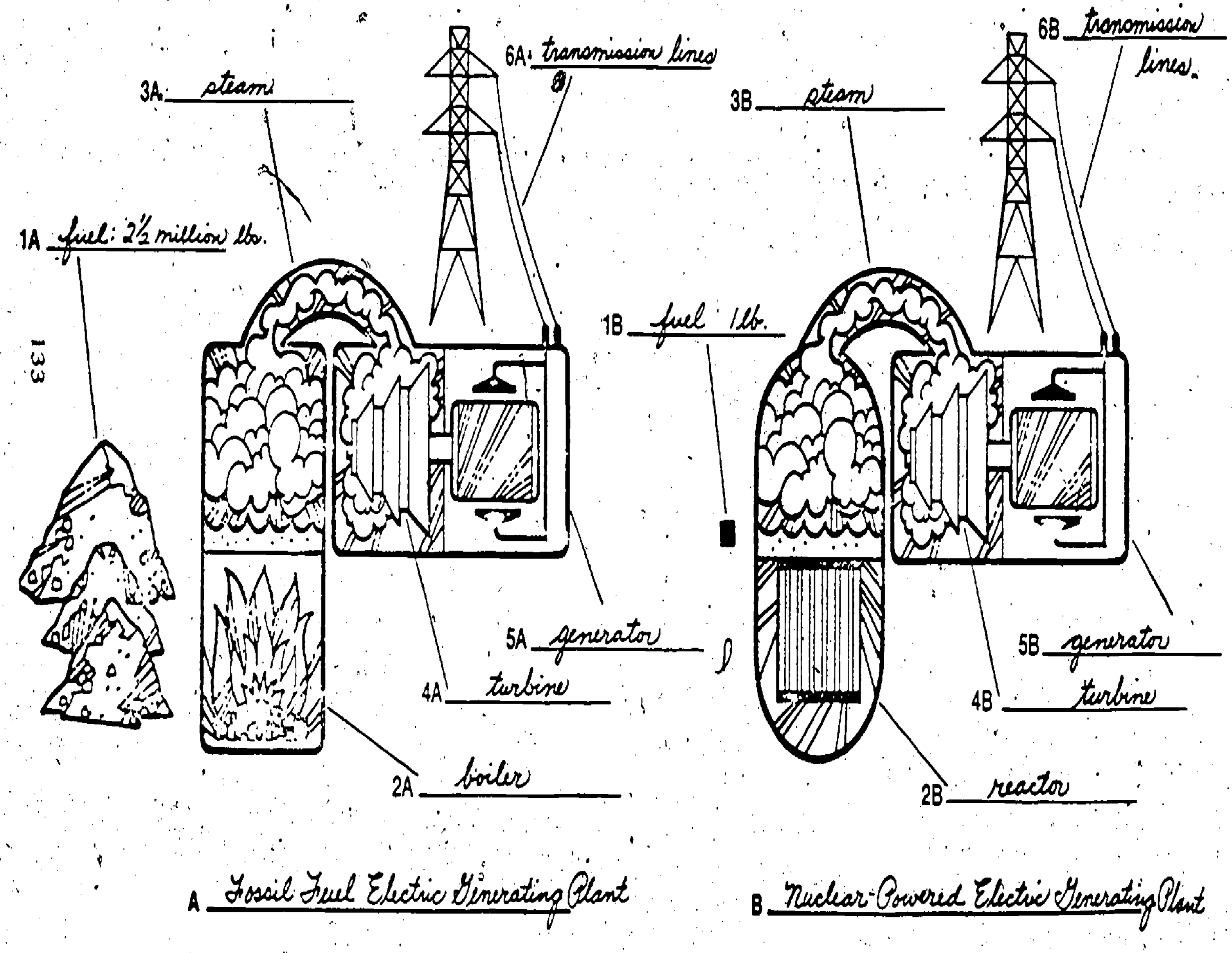
131-132

Nuclear Energy (PART 1)

Activity III-28

One of the energy resources being considered to supplement our limited oil and natural gas supplies is nuclear power, created by the splitting apart of atoms of uranium. This power can be captured and used to create steam which produces electricity much as the power of burning coal is used in an electric generating plant.

The diagrams below show two kinds of electric power plants. They are much alike except that one is powered by nuclear energy produced in a nuclear reactor. Can you label the parts of the two plants. All the words you need appear at the bottom of the page. An encyclopedia or other reference book may help you.



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FOSSIL FUEL ELECTRIC GENERATING PLANT	GENERATOR	TURBINE	STEAM
NUCLEAR POWERED ELECTRIC GENERATING PLANT	BOILER	TRANSMISSION LINES	REACTOR
	STEAM	FUEL (1 lb.)	GENERATOR
	TRANSMISSION LINES	TURBINE	FUEL (2½ million lbs.)

Activity III-29

Objective: The students will recognize the contrasting positions of nuclear advocates and opponents.

What to do?

Have the students study the positions in the following article. Discuss the article in class. Ask: How can you evaluate these positions?

THE GREAT NUCLEAR POWER DEBATE A SUMMARY

(From "Science News," Jan. 17, 1976)

The debate over nuclear energy is heating up again, with opposing positions more solidified than ever. A recent Harris Poll shows 63 percent of Americans favor more nuclear power plants, but another poll shows 40 percent still have no firm opinion. During this year's elections, referenda on allowing construction of more nuclear reactors will appear on ballots of at least two sites, and recent Congressional hearings have highlighted the issues involved. In this first article of a two-part series we present the contrasting, and often irreconcilable, positions of nuclear advocates and opponents. The second article will concentrate on the most controversial aspect of the debate, the breeder reactor.

ECONOMICS

OPPONENT

Utilities are beginning to realize that nuclear power isn't the blessing it was thought to be. Within the last two years they have canceled or delayed orders for the equivalent of 130 large nuclear plants. Construction costs range from 10 to 46 percent higher than conventional plants. Uranium prices have tripled over the last two years. Reactors would never have gotten this far (eight percent of the country's power-generating capacity) without huge Government subsidies; before they can develop further, more huge subsidies will be needed to build new enrichment plants to transform natural uranium into the fuel used by reactors. Once built, the reactors have not performed as reliably as hoped, running at less than two-thirds capacity. The breeder reactor looks even worse: Development costs are projected to be $11 billion, but the actual cost of building a breeder demonstrator project at Clinch River, Tenn., has escalated from $700 million in 1972 to $1.7 billion today.

ADVOCATE

Despite construction cutbacks caused by the recession, nuclear energy is still a bargain, generating electricity at 40 percent less than the cost of fossil-fuel plants, even after considering construction costs. In 1974, nuclear plants saved the country the equivalent of 163 million barrels of oil—some $2 billion worth. The price of uranium is such a small part of the total cost that it could quadruple again and nuclear energy would still be cheaper than conventional power. The initial Government subsidy of nuclear reactors has long since been surpassed by private investment, and the projected economic benefits of the breeder reactor are more than 12 times the cost. Of the cost increases at Clinch River, 60 percent were due to inflation and 20 percent were due to design changes. Nuclear plants are as reliable as conventional ones: From 1964 to 1973, conventional plants operated an average of eight and half months a year; nuclear plants, around nine.

DANGER FROM ACCIDENTS

OPPONENT

The official Government study of reactor safety, the so-called Rasmussen report (SN: 8/31/74, p. 117 and 11/15/75, p. 310) has been severely criticized for underestimating human error (SN: 11/23/74, p. 330) and not adequately considering contamination of land areas by radioactive fallout following a major accident (SN: 5/31/75, p. 286). The study's methodology is questionable, assumptions such as adequate evacuation procedures are unrealistic, and the Environmental Protection Agency says the resulting casualty figures are too low by a factor of 10. Since the report came out, one of the "accidents that couldn't happen" did: A technician at the Browns Ferry, Ala., reactor complex set fire to the electrical control system, while using a candle to check for air leaks. The emergency core cooling system was knocked out, water in the reactor vessel dropped dangerously low, workers argued with firemen for five hours before following their advice on how to extinguish the fire, and no evacuation plans were set in motion.

ADVOCATE

The key finding of the Rasmussen report was that an individual's chances of dying from a nuclear accident are about the same as being hit by a meteorite—one in 5 billion. This methodology is imprecise but is the most sophisticated available, and a factor of 10 one way or the other is practically meaningless. For workers in all aspects of the nuclear business, the most danger arises in uranium mines, not around reactors, and new mining safety regulations are improving those conditions. The Browns Ferry incident demonstrates just how well the nuclear safety systems are designed to compensate for human error. Despite a fire directly under the control room, no evacuation was needed and no damage was sustained by the reactor, core or coolant piping. Despite loss of control over some of the cooling systems, alternative methods were available and successfully employed. There were no injuries and no release of radioactivity. Regulations governing worker conduct are constantly being updated to prevent such accidents.

OPPONENT | **ADVOCATE**

ENVIRONMENTAL EFFECTS

Opponent: In the normal operation of nuclear plants, some radioactive materials will inevitably escape and expose the public. Reactors also give off more waste heat than fossil-fueled plants of the same generating capacity, and this thermal discharge has already adversely affected the ecology of rivers and lakes. The biggest problem, though, is what to do with nuclear wastes. Already 200,000 tons of discarded uranium left over in spent fuel has accumulated in 20,500 steel vessels at Oak Ridge and other sites. Some wastes remain dangerously radioactive for thousands of years—long after steel drums rust away. Not only is there a danger to the public of being exposed to the cancer-causing radioactivity of these wastes, but some of them, including plutonium, are so chemically toxic that accidental ingestion of even very small amounts can cause death. Even if one assumed that secure, long-range storage of these wastes could be found, the cost—including constant guarding for thousands of years—would be very large.

Advocate: The amount of radiation escaping from reactors is minuscule compared with naturally occurring radiation on earth; the average person receives one-ten thousandth as much radiation from the nuclear industry as from natural sources or medical X-rays. Thermal discharge could be used constructively—say, to heat homes, as in some other countries—if the public would accept it. Annual costs of all environmental effects associated with reactors are less than half those associated with coal-fired plants. Nuclear wastes are really not as much of a problem as some have claimed: Long-lived wastes are only half a percent of the total wastes, and these are now molded into insoluble solid masses. By 2010 the total volume of these solid wastes could fit comfortably into a single abandoned salt mine (a very stable geologic formation) at negligible cost. The spent uranium at Oak Ridge is being saved for use in the breeder reactor, where its value could be trillions of dollars. Plutonium is less toxic than many industrial chemicals in common use.

TERRORISM

Opponent: Even if the problems of normal reactor operation, occasional accidents, waste transportation and storage could be overcome, no way has been found to calculate the impact of nuclear terrorism, or to adequately prevent it. A nuclear bomb can be made from only 10 to 20 pounds of plutonium, which is copiously produced in every reactor and shipped elsewhere for fuel reprocessing. On an NET television program, an undergraduate student demonstrated how easy it would be to steal some plutonium and design a bomb—which experts from the Swedish Defense Ministry said would explode. But the aim of the American nuclear industry is not just to build reactors here, where some safeguards do exist, but rather to export its technology, inevitably to countries whose obvious political instability will virtually assure nuclear weapons proliferation. To prevent nuclear theft and terrorism in the United States will require establishment of what some have called a "garrison state;" to prevent it abroad, nothing can be done.

Advocate: Relative to the nuclear power debate, the issues of terrorism and proliferation are simply red herrings—there are much easier ways to go about either. In the first place, the "10 to 20 pounds" of bomb material refers only to the weapons-grade, metallic plutonium-239, which never exists as such anywhere in the whole nuclear fuel cycle. It would take from 200 to 900 pounds of unprocessed nuclear fuel to make a very crude bomb, or 25 to 70 pounds of the reprocessed plutonium oxide—a much more difficult substance to handle than the weapons-grade metal. Designing a bomb may be simple (though none of the Swedish "experts" had actually ever built one), but preparing the materials requires an extensive industry, and assembling the device without cooking oneself is actually quite a trick. Conventional terrorism is a more immediate threat to civil liberties, and the best way to encourage responsibility among developing countries is through creation of a working partnerhip, based on such projects as nuclear power.

ALTERNATIVES

Opponent: Ultimately, the reason nuclear power development should be halted is that so many better alternatives are available, and needed development funds have been usurped by nuclear research. Some 40 percent of the energy consumption in the United States is unneccessary to begin with, according to some estimates. Savings of that amount could easily be obtained in buildings and cars, through careful redesign. The unemployment picture could be brightened if we let people take back some of the jobs machines took from them. For energy increases over the short-term, more coal could be used if the proper environmental protection devices were installed. Geothermal, solar and wind energies are waiting to be tapped in endless supply in various geographical areas and these alternate sources have the added advantage of lending themselves to small, labor-intensive development. Finally, if one insists on nuclear energy, why not wait until the much safer fusion process is perfected, probably in the next century.

Advocate: Ultimately, the reason nuclear power must be developed is that no other viable alternatives are available, despite greatly increased funding. The wasteful elements of society cannot be changed overnight; the best estimate is that conservation can hold down total energy growth to two percent a year—still fast enough to double demand in 35 years. Even modifying 10 percent of the country's homes to solar heat would save at most 1.5 percent of our energy needs, but would cost at least $70 billion. Energy and jobs go together—just restricting oil imports to their 1973 levels would ensure a 10 percent unemployment rate over the next 15 years, if history is any guide. Power-generating plants using solar or wind energy are now extremely expensive, causing the power they would generate over their lifetime to cost two or three times as much as that from nuclear or coal. Opening new coal mines and power plants and installing pollution devices will take years and a huge investment. Fusion is still chancy.

RESOURCES OF PRESENTLY-USED FUELS

As we have seen, our major energy fuels are coal, oil, natural gas, and uranium. Mention has been made of the short supply of some of these fuels. The fact is that no one knows exactly how much of these valuable fuels are left in the ground.

The estimated amounts of various fuels which can be extracted from the ground fall into two general categories: reserves and ultimate resources. Reserves are those supplies which are known to be present (in operating wells, for example, or areas that have been explored.) Ultimate resources are estimates by geologists as to how much fuel might be present in unexplored regions.

Energy reserve estimates are usually made on the basis of the amount of fuel present in a given location which can be extracted using existing technology and then sold at or near the present market value. As mining technology improves and the price of fuel increases, a larger fraction of the resource becomes economically recoverable. For example, only relatively high grade uranium ore is presently economical to extract. There is a lot more low grade uranium ore available. If the price of uranium goes high enough, it will become economical to extract this low grade ore. Or if mining techniques improve, this ore could be economically recovered.

The same situation exists for other fuels. A large percentage of coal is left in mines, either because it is not economically feasible to extract, or because it is left for support structure for the mine.

Oil wells stop producing when only about a third of the oil has been pumped out because the pressure in the ground has been reduced to the point that no more oil flows out of the well. Several methods of enhanced recovery are under study, which may result in the extraction of about another 20 per cent of the oil residual.

To increase natural gas production, ERDA is investigating methods to break up the tight rock formations that hold this premium fuel. The goal in such research is to increase reserves of these fuels–that amount that can be economically extracted and used.

Figure 8 gives one estimate of the amount of ultimately recoverable U.S. energy resources. Above the center line is shown the amount of resource. For example, the estimated recoverable oil in the U.S. is enough to generate 1 x 10^{18} BTU's of energy – that is, a billion billion BTU's or a 1 followed by 18 zeroes. Below the center line is shown the per cent of energy generated by each resource in 1973. The chart is very enlightening in showing how our energy use is out of balance with our energy supplies – 77 per cent of our energy was generated by oil and gas, where the supply is lowest, and only 18

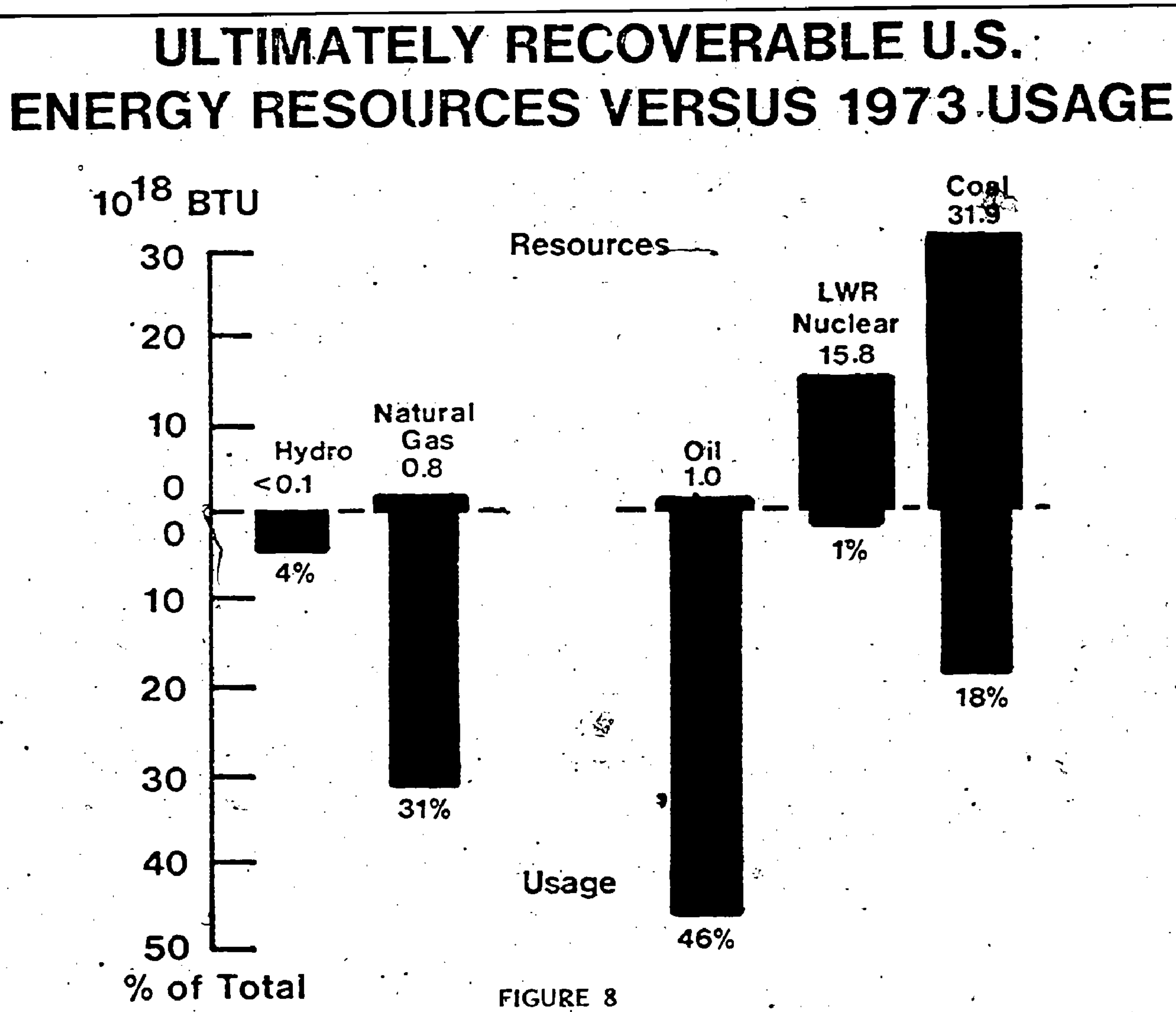


FIGURE 8

per cent by coal, where the supply is large. It also shows our almost total reliance on energy supplies that are for all practical purposes non-renewable. Nature still forms the fossil fuels, but at a formation rate one million times slower than our consumption rate. We consume in a year what nature took a million years to create. The uranium which fuels present-day reactors is also a non-renewable resource. Hydroelectric power, the only renewable source of energy we are now using to any significant degree, cannot be expanded very much.

We have seen that it is difficult to make an estimate of the amount of fuel resources we will have available to us. But it is even more difficult to predict how long these supplies might last. To make such predictions, it is necessary to make some assumptions about the rate at which a particular resource will be used. Some estimates made by ERDA about domestic fuel reserves are as follows: Coal reserves are considered to be 390 billion tons. At the present rate of usage and growth, these reserves would last 500 to 600 years.

The supply situation for natural gas is critical. Natural gas is being used at a faster rate than it is being discovered. U.S. reserves could be exhausted before the end of the century.

Oil reserves are about 35 to 40 billion barrels, with estimates of undiscovered, economical recoverable resources ranging from 60 to 400 billion barrels. With the current rate of usage of more than 14 million barrels each day, these resources could also be exhausted before the end of the century.

There is enough known uranium-235 to last about 40 years at projected usage rates.

Even though these numbers are only estimates of our energy resources, and different numbers are seen in different publications, these estimates should be useful for bringing the energy problem into focus. Most of the projected depletion dates given here are well within the lifetime of many of us today.

Activity III-30

Objective:

Students will discover the limits of the supplies of oil and natural gas.

What to do?

Have students complete the activity "How Long Might Our Oil and Natural Gas Last" which follows.

Activity III-31

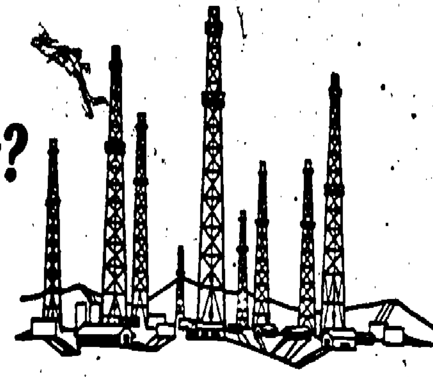
Objective:

Students will learn about the concepts of supply and demand and shortage and surplus and the relationship of these to energy costs.

What to do?

Have students complete the activity "Supply and Demand; Shortage and Surplus" which follows.

How Long Might Our Oil and Natural Gas Last?



Both liquid petroleum, which is more commonly called oil, and natural gas are fossil fuels. Like coal, they were formed by the chemical changes of ancient plants and animals over millions of years and were trapped in rock layers of the earth.

Gasoline that runs our cars, trucks, and planes is made from petroleum. So are paints, insecticides, fertilizers, and many other manufactured products. Natural gas is a clean-burning fuel that heats many of our homes, cooks our food, and serves industry. Together, oil and natural gas supply 76 percent of our total energy needs.

Read the following items; then see if you can determine how long our oil and natural gas resources might last.

Item #1: During 1975, the United States produced from oil wells about **3 billion barrels** of oil (a barrel holds 42 gallons).

Item #2: The Federal Energy Administration estimates that our proved oil reserves in the U.S. (those known to exist and to be recoverable) is **38 billion barrels.**

Item #3: Many geologists figure that it is fairly certain that an additional 27 billion barrels of oil reserves exist.

If this amount of oil still in the ground were all we had, and if we did not increase or decrease our production each year, in about how many years would the U.S. run out of domestically produced oil? (Add #2 and #3, and divide by #1.)

(#2) ________ billion barrels
+(#3) ________ billion barrels
________ billion barrels
÷ (#1) ________ billion barrels
________ number of years

Item #4: The highest estimate is as much as **127 billion barrels** of additional domestic oil still undiscovered.

If item #4 is true, and if we do not increase or decrease our production, how many years might our possible total oil resources last?

(On the back of this sheet, add #2, #3, and #4 and divide by #1. Put the number of years in this space.)

________ number of years

In the same way, determine how long our natural gas resources might last.

Item #5: During 1975, the U.S. produced for use about **20 trillion cubic feet** of natural gas.

Item #6: Our proved reserves at the end of 1974 were **240 trillion cubic feet.**

Item #7: Fairly certain reserves of natural gas are about **202 trillion cubic feet.**

If this amount of domestic natural gas was all the supply we had, it would last about how many years? (Add #6 and #7, and divide by #5. Put the answer in this space.)

________ number of years

Item #8: The highest estimate of undiscovered natural gas resources is **655 trillion cubic feet.**

If this amount is true, about how many years might our supply of natural gas last? (Add #6, #7, and #8, and divide by #5. Put answer in this space.)

________ number of years

BUT . . . the United States is now using **each year** almost double the oil that it produces from its own reserves. Where does this additional oil come from?

What could happen if our usage continues to increase each year?

What if oil and natural gas usage increases in other countries?

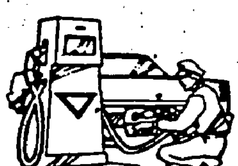
At what time in your life could the U.S. run out of oil and natural gas?

Supply and Demand; Shortage and Surplus

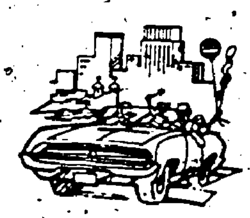
Finish the story by filling in the blanks. Think of the right answer. Then see if it appears in the answers below. Put its number in the blank. Some answers may be used more than once.

POSSIBLE ANSWERS

1. 40	7. shortage
2. lowered	8. raised
3. supply	9. surplus
4. 200 gallons	10. 160 gallons
5. $3.00	11. demand
6. 5 gallons	12. $60.00

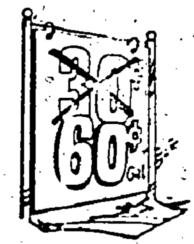


Mr. Smith, a gasoline station owner, received 200 gallons of gasoline regularly each week. His 20 regular Smalltown customers were used to buying all the gas they needed. Although some weeks some people bought more and some bought less, average use was 10 gallons a week. The total demand for gasoline each week, then, was ________ As you have seen, Mr. Smith's supply was ______________. Everybody was pretty happy about the whole thing. The supply was equal to the ______________



Mr. Smith charged 30¢ a gallon for gasoline, a price that was about the same as that charged by the other station in town. Each regular customer spent an average of ______________ each week. Mr. Smith received ______________ for gasoline. When the other station reduced its price per gallon by a penny, four of Mr. Smith's regular customers deserted him and went across the street. He was still getting a delivery of 200 gallons a week, but now the demand was only ______________ He had ______________ gallons left over. This unbought quantity of gasoline is called a ______________ To get rid of the surplus, Mr. Smith ______________ his price. His other regular customers bought up the ______________ and took a few more pleasure trips into the city.

Several weeks later, Mr. Smith and the other station each received only 100 gallons of gasoline. Their suppliers were short of gasoline that week. Their customers' demands were still the same, so the pumps soon became empty. "No More Gas!" the sign in front said. Halfway through the week, Mr. Smith had a ______________ of gasoline. By still charging 30¢ a gallon, he didn't make enough to pay the costs of his station.



The next week he raised the price to 60¢ a gallon. Even at the higher price, most of his customers still had to buy gas to drive to work and do errands, so he sold all 100 gallons. How much money did he receive? ______________ What was the average amount each of the 20 regular customers spent? ______________ What was the average amount of gas each customer used? ______________

Some of Mr. Smith's customers were on a fixed budget and couldn't afford to spend more than $3 a week for gas. Some customers got to the station after the pumps were empty and couldn't get all they needed. Some of the other station's customers came over to Mr. Smith's station. The demand was greater than the ______________ Mr. Smith ______________ his gasoline prices again.

Discuss in your class ways in which the people of Smalltown might solve their gasoline supply problem.

ELECTRICITY

Electricity is a secondary energy source–that is, it is produced through the use of some other energy source. Today, about 27 per cent of the primary energy consumed in the U.S. is used to generate electricity. This percentage is expected to increase because most of the energy sources that are expected to be available to us in the future are best suited for producing electricity. Because of its importance in our day-to-day lives, electricity is included in this section on energy sources.

In 1976, an estimated two trillion kilowatt-hours of electricity were generated, with coal contributing 47 per cent, oil 17 per cent, gas 13 per cent, hydroelectric sites 12 per cent, and nuclear sources 11 per cent.

This electricity was used by the consuming sectors as follows: residential 32 per cent, industrial 41 per cent, commercial 23 per cent, and other 4 per cent.

The National Electric Reliability Council, which encompasses essentially all of the power systems of the United States, helps utility specialists to provide information on the fuel supplies and generating capacities that will be required in the years ahead. Their 1976 report gives projections for 1985. In this report, they conclude that the nation has moved closer to an electrical energy crisis. In their view, a variety of restraints, largely governmental, on power plant locations and emissions, on fuel availability, and on the availability of financing are the major factors adversely affecting electricity supply prospects through 1985. The NERC fuel study estimates that between now and 1985, the demand for electricity will grow more slowly than it has in the past. The proportion of electricity supplied by coal-burning and nuclear plants will rise sharply. On the other hand, the output from gas-burning plants will decline steadily, while the output from oil-fueled plants will rise slowly until about 1982, primarily to make up for the decline by gas, and then will level off.

The report points out that coal must continue to be the prime fuel source for generating electricity. This again brings up the question of air quality standards. Regulations already in effect will seriously restrict the use of high sulfur coal unless acceptable sulfur dioxide removal systems are developed in time. Furthermore, the coal industry itself will have to make huge investments to be able to meet the increased demand for coal.

Nuclear fuel programs also face a wide spectrum of problems, including those people who challenge the safety and other aspects of nuclear power and have caused delays in the national nuclear energy program.

In view of the many problems faced by the utilities, the NERC report concludes that the possibility is emerging that generating capacity shortages will develop in some regions of the country by the late 1970's, and in others by the early part of the 1980's. Many generating plants, both fossil-fueled and nuclear, which would have been built to take up this slack have not been built because of the lack of capital or because of environmental constraints. It takes about five or more years to complete a fossil-fueled generating unit, and at least 10 years for a nuclear plant. So the die is already cast to some extent as far as electrical generating capacity in the early 1980's is concerned.

The impact of a severe electrical shortage would be nothing short of catastrophic. The effects on the health and welfare of the people (particularly in the winter), on jobs, and on the national economy are frightening to contemplate.

The expected increased reliance on electricity will raise many new questions about energy transport and storage. For example, should coal be burned at the mine to produce electricity, which is then transmitted to centers of consumption, or should the coal be shipped to those centers for production of electricity there? Should new generating facilities be large installations located some distance from urban centers, or should they be small plants built close to the areas they serve? What is the possibility of storing electricity which is produced during periods of low demand?

Each of the possible energy options might provide a different set of answers to such questions. Fossil fuel and nuclear power plants are more economically run on a large scale, so such plants have tended to grow larger. Fusion plants that use magnetic containment would probably be even larger. Such large plants would probably be centrally located.

Solar and geothermal plant location will obviously be limited by their very nature–they will have to be where large amounts of sunlight or geothermal resources are located.

Other factors will also determine the location of power plants–for example, the availability of cooling water and the distance that nuclear plants are required to be built from population centers. All factors considered, a growing number of electrical power plants, at least for the near-term future, are likely to be built at large distances from urban centers, necessitating an even greater amount of electrical transmission.

Electrical transmission is unfortunately a very expensive method of energy transmission. Electricity is transported from generating stations to major consumption centers on transmission lines which, in the U.S., are almost exclusively overhead lines. Many more high voltage towers and transmission lines will have to be built to transport our electricity, unless some new transmission methods are found. (Distribution lines carry electricity to individual consumers. They carry much lower voltages so that they involve much simpler technology, and they are already being put underground in many areas.) The proliferation of above-ground transmission towers and lines would certainly be unsightly, and would also be expensive where land area is scarce. Some electricity is lost in transmission lines, adding to the ultimate cost.

There are three main ways to overcome the economic and environmental costs of electrical transmission. One is to increase the efficiency of electrical transmission so that much greater amounts of electricity can be carried by the same number of transmission lines, with less loss of electricity. The second is to develop new methods for generation of electricity, such as laser fusion or fuel cells, so that smaller power plants can be placed near centers of consumption without objections from the residents. The third possibility is to convert the electricity into some other form such as hydrogen, that can be transported more easily and cheaply. The present state of technology puts all these possibilities, especially the third one, years into the future.

Another problem in electrical generation is that there are presently no good, economically feasible ways to store electricity. Batteries are expensive and have limited lifetimes. Pumped hydroelectric storage is being used at some power plants equipped with hydroelectric capability. Electricity generated at off-peak times is used to pump water into a reservoir. Then at peak times, this water can be used to operate hydroelectric generators to produce extra electricity. This storage method has limited application, however, since few suitable sites exist.

This lack of a good method of storing electricity is a significant problem, because demand for electricity varies greatly from day to night and from season to season. Since electricity has to be generated as it is used, the generating capacity must be large enough to accomodate the peak demand, while in off-peak periods only about 50 per cent of the generating capacity might be needed. Since the generating equipment is very expensive, this unused capacity adds greatly to the cost of electricity.

It is possible that "time-of-day metering" will soon appear. Under this system, electricity used at peak demand times will cost more than electricity used at other times. This system would hopefully encourage people to even out the demand for electricity. Habits are hard to change, but if it cost less, people might do things like run dishwashers or wash and dry clothes at night.

Meanwhile, the search for electrical storage methods goes on. One method under study involves the use of excess generating capacity for electrolysis of water, producing hydrogen and oxygen. These gases could be stored, and then recombined in a fuel cell to produce electricity at times of peak demand.

Activity III-32

Objective:

The students will make charts to illustrate production and use of electricity.

What to do?

Using information in this section on production of electricity by various fuels and use of electricity by the various sectors, have students make "pie charts" to illustrate these facts. (Figures 1 and 2 in this module are examples of pie charts.)

Activity III-33

Objective:

The student will determine times of peak load on this electrical power source.

What to do?

1. Through discussion of current life styles, family activity patterns, etc., predict the hours of peak electrical demend. (Note: this will vary with the season.)
2. If possible, on weekends or by special assignment arrangements, have several teams or individuals read home electric meters hourly over a given period of time. Compile results as a class. Compare results with predictions. (Your local electirc utility can give you information on reading the meters.)
3. Explore ideas to spread some of the demands of the peak hours to periods of lighter demands. Concentrate on ideas that students themselves might implement; i.e., deferring television watching to different hours.
4. Report to the class which ideas worked and which seemed impossible.
5. Explore ideas of how entire communities might juggle schedules to even out the electrical demand hours.

Activity III-34

Objective:

The student will do computations related to energy use.

What to do?

The students will do the following computations:

1. The amount of electrcity we use is measured in kilowatt hours (KWH). This means we use a certain number of 1,000-watt units per hour. In 1931, the average home in the United States used 583 KWH per year. By 1970, the average home in the United States used 7,066 KWH per year.
   a. How many more KWH did the average home use by 1970 than in 1931?
   b. Why do you think the amount went up so much?
2. A fluorescent tube turns 1/5 of its electric energy into light for a room. An incandescent bulb (a lamp bulb) turns only 1/20 of its electric energy into light.
   a. Which one wastes more of its electric energy?
   b. If you want to save energy, which should you buy?
3. Industry uses many kilowatts of electricity to make each ton of a product. Some examples are:

steel	750 KWH per ton
aluminum	16,700 KWH per ton
paper	1,050 KWH per ton

   a. Which material uses up the most electricity?
   b. Which uses up the least?

4. Many times electricity can be saved by making new products from old ones. This is called recycling. Some examples are:

	Without recycling	With recycling
steel	750 KWH per ton	585 KWH per ton
aluminum	16,700 KWH per ton	350 KWH per ton
paper	1,050 KWH per ton	780 KWH per ton

   a. How much electricity is saved by recycling steel?
   b. Which is the most important material to recycle, from energy considerations?
   c. Which material uses the most electricity in recycling?
   d. Which uses the least electricity in recycling?

5. In the United States, about 20,540 KWH of energy are used up each year for each person. In Chile, about 2,900 KWH of energy are used up each year for each person. In India, the figure is 260 KWH, and in Thailand, 230 KWH. Compare these countries.
   a. In which country do people use up the most energy?
   b. In which country do people use up the least energy?
   c. Why do you think people in the United States use up so much more energy than people in other countries?

Activity III-35

Objective:

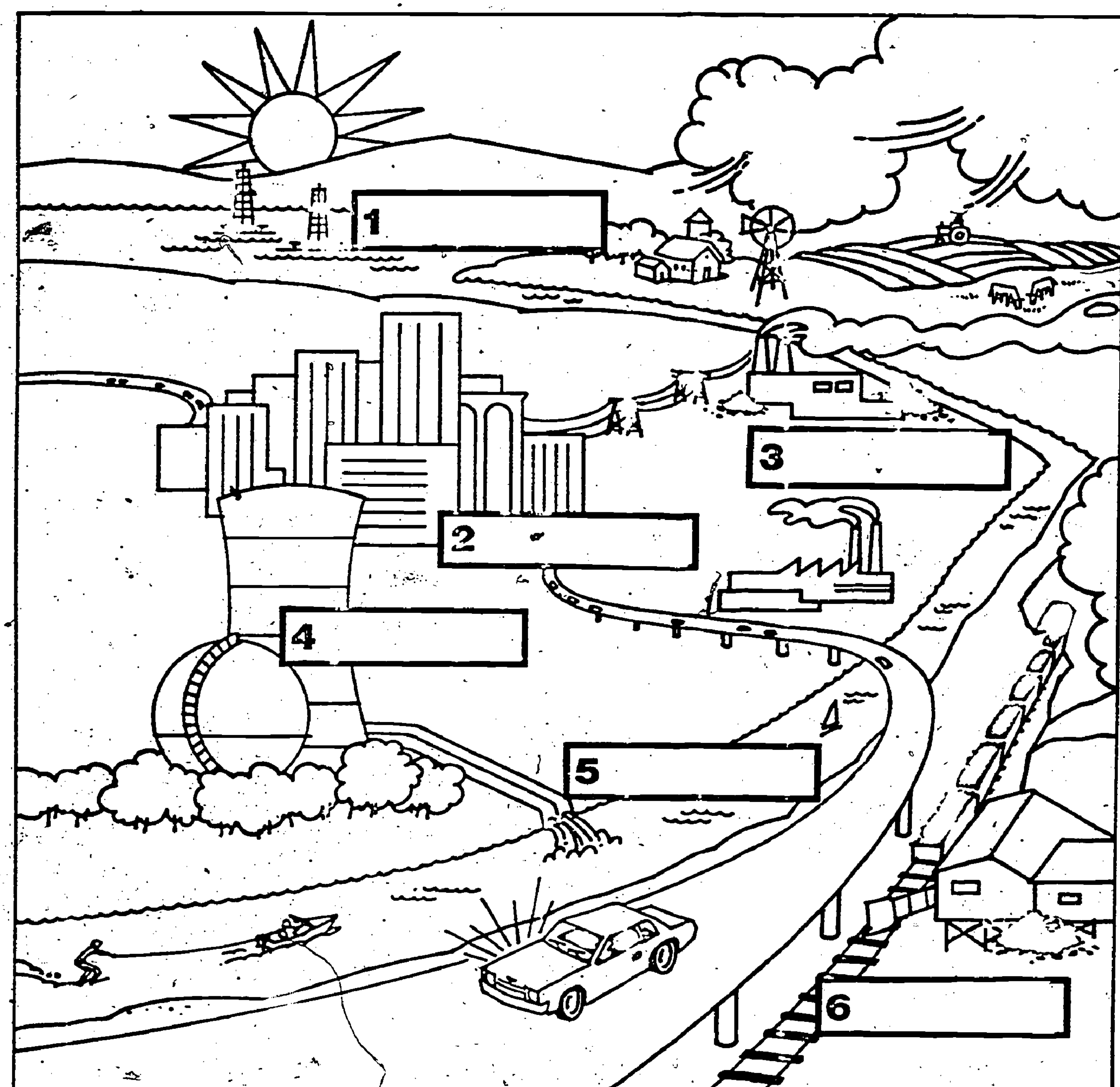
Students will consider the types of pollution possible in energy development and energy use and choose the price they are willing to pay to reduce environmental damage.

What to do?

Ask students to consider their own classroom environment by naming some of the living and non-living aspects of it. List these factors on the board and discuss how they interact with each other. For example, what happens when one student opens the window, makes noise, turns over a chair--how does it affect other students, the teacher, etc. Which activities might be considered disruptive or "polluting"?

After seeing some aspects of environment and its interlocking relationships, students can apply these to the activity on the next two pages. Encourage students to weigh cost "trade-offs" when considering environmental controls.

A Delicate Balance (PART 1)



1. Name the possible sources for energy in the picture. ______________________

____

2. What energy sources shown are used to generate electricity? ______________________

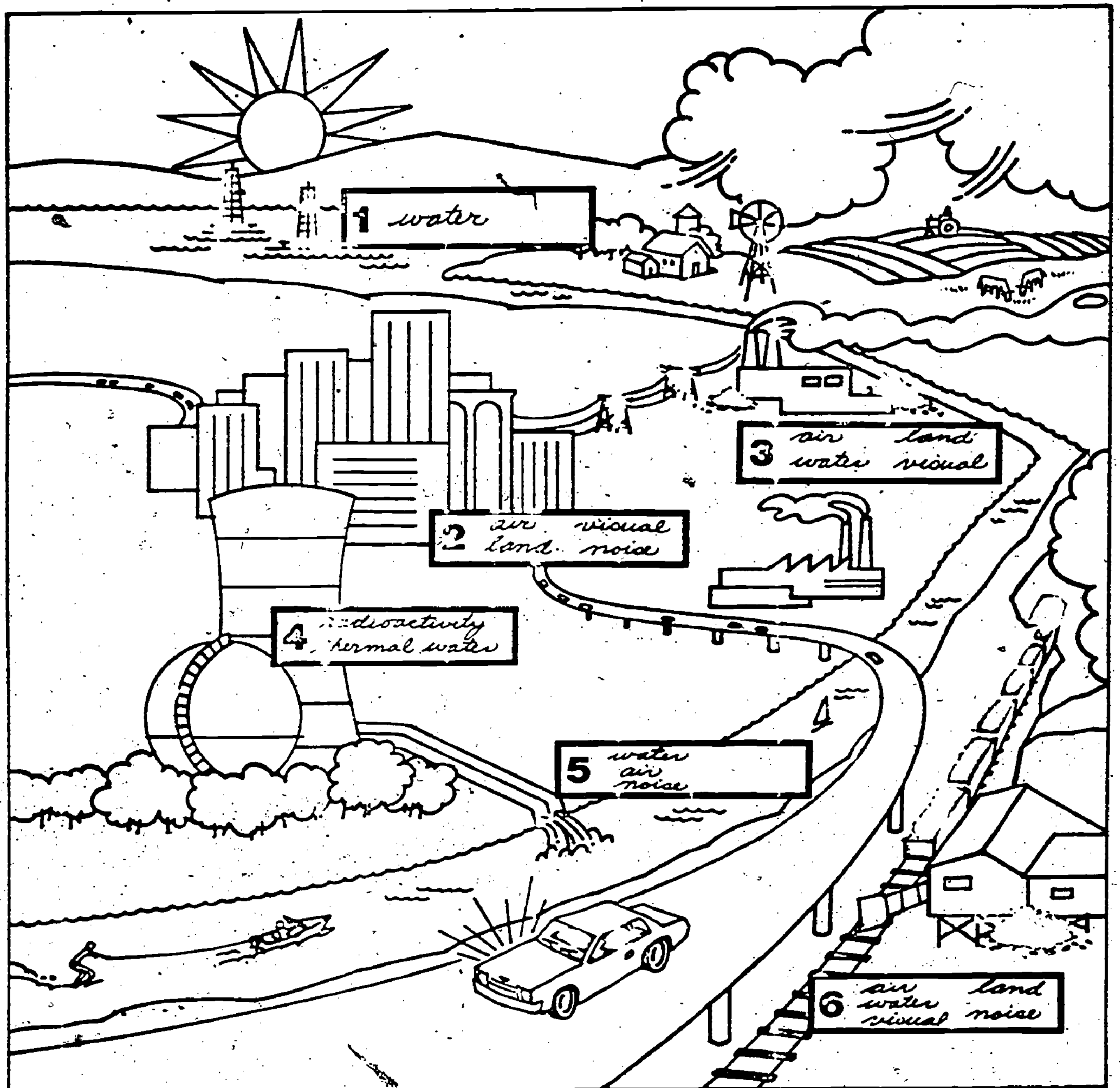
____

3. Seven types of environmental pollution concern us today: air, water, thermal (heat), radioactivity, visual, noise, and land disruption. In the boxes on the picture above, write in the type of possible pollution occurring in that part of the picture.

4. How do different parts of your environment—air, water, land, people, city, country—affect each other?

5. To help keep that delicate balance between meeting our energy needs and maintaining a clean and healthy environment, what in your life would you be willing to change?

A Delicate Balance (PART 1)



1. Name the possible sources for energy in the picture. *sun, wind, coal, oil, nuclear reaction*

2. What energy sources shown are used to generate electricity? *coal, nuclear reaction*

3. Seven types of environmental pollution concern us today: air, water, thermal (heat), radioactivity, visual, noise, and land disruption. In the boxes on the picture above, write in the type of possible pollution occurring in that part of the picture.

4. How do different parts of your environment—air, water, land, people, city, country—affect each other?

5. To help keep that delicate balance between meeting our energy needs and maintaining a clean and healthy environment, what in your life would you be willing to change?

ACTIVITY III-35

A Delicate Balance

(Part 2)

From the clues given on the chart below, identify each type of pollution: water, air, or land disruption. In the last column of the chart, place the number of the choice listed here that you agree with.

1. "I know I will have to spend more dollars to pay for electricity, fuel, gasoline, and other energy-related products so that energy producers can pay for environmental controls."
2. "I will cut back on my own energy use — really practice conservation."
3. "I will support more government regulations."
4. "I can count on business and industry to find the answers."
5. "I'm willing to live with pollution."
6. If you can think of other solutions, write them down.

TYPE OF POLLUTION	WHAT IS IT?	WHAT CAN IT DO?	HOW CAN IT BE IMPROVED?	WHAT WOULD I BE WILLING TO DO?
	It is the adverse effect from burning coal and oil, and from car exhausts. It is high concentrations of carbon monoxide, sulfur dioxide, and unburned ash.	It can increase respiratory illnesses and raise death rates. It can damage crops, plants, and trees.	By installing emission controls on autos and filters or traps on chimneys. By cutting down on the burning of coal and oil. By burning solid wastes in closed incinerators. By capturing and reusing industrial gases for other products.	
	It is the use of millions of acres for mining, development of power plants, refineries, transmission lines, energy-resource storage, and solid waste disposal.	It can disturb wilderness and recreation areas. It can destroy vital plant-animal food chains and can cause erosion and loss of soil nutrients.	By reclaiming mine sites. By landfilling and recycling solid wastes. By replanting vegetation, reforesting, building lakes and recreational parks.	
	It is high amounts of impurities such as disease-causing organic wastes, toxic substances such as acids and pesticides. It can be caused by oil spillage, offshore construction, industrial waste, and municipal sewage.	It can disturb or destroy fish breeding and feeding grounds, can cause taste and odor problems, clog streams, destroy recreation areas and sometimes cause disease in humans. Mines can contaminate ground water.	By installing filters, aeration and settling devices. By breaking down impurities with chemicals. By cleaning up rivers and shorelines. By transforming acid wastes to useful by-products.	

THINK ABOUT IT: Make a list of things you can do today to help stop pollution.
Start with these: Don't litter. Recycle. Use public transportation. Don't burn rubbish or leaves. Can you add to the list?

149 - 150

A Delicate Balance

ACTIVITY III-35

(Part 2)

From the clues given on the chart below, identify each type of pollution: water, air, or land disruption. In the last column of the chart, place the number of the choice listed here that you agree with.

1. "I know I will have to spend more dollars to pay for electricity, fuel, gasoline, and other energy-related products so that energy producers can pay for environmental controls."
2. "I will cut back on my own energy use — really practice conservation."
3. "I will support more government regulations."
4. "I can count on business and industry to find the answers."
5. "I'm willing to live with pollution."
6. If you can think of other solutions, write them down.

TYPE OF POLLUTION	WHAT IS IT?	WHAT CAN IT DO?	HOW CAN IT BE IMPROVED?	WHAT WOULD I BE WILLING TO DO?
air	It is the adverse effect from burning coal and oil, and from car exhausts. It is high concentrations of carbon monoxide, sulfur dioxide, and unburned ash.	It can increase respiratory illnesses and raise death rates. It can damage crops, plants, and trees.	By installing emission controls on autos and filters or traps on chimneys. By cutting down on the burning of coal and oil. By burning solid wastes in closed incinerators. By capturing and reusing industrial gases for other products.	
land disruption	It is the use of millions of acres for mining, development of power plants, refineries, transmission lines, energy-resource storage, and solid waste disposal.	It can disturb wilderness and recreation areas. It can destroy vital plant-animal food chains and can cause erosion and loss of soil nutrients.	By reclaiming mine sites. By landfilling and recycling solid wastes. By replanting vegetation, reforesting, building lakes and recreational parks.	
water	It is high amounts of impurities such as disease-causing organic wastes, toxic substances such as acids and pesticides. It can be caused by oil spillage, offshore construction, industrial waste, and municipal sewage.	It can disturb or destroy fish breeding and feeding grounds, can cause taste and odor problems, clog streams, destroy recreation areas and sometimes cause disease in humans. Mines can contaminate ground water.	By installing filters, aeration and settling devices. By breaking down impurities with chemicals. By cleaning up rivers and shorelines. By transforming acid wastes to useful by-products.	

THINK ABOUT IT: Make a list of things you can do today to help stop pollution.
Start with these: Don't litter. Recycle. Use public transportation. Don't burn rubbish or leaves. Can you add to the list?

ENERGY

POLICY AND PROSPECTS

AN ENERGY CURRICULUM
MODULE #4

Governor's Energy Council

MODULE 4

Pennsylvania Department of Education 1977

THE ENERGY DEFICIT

"The diagnosis of the U.S. energy crisis is quite simple: demand for energy is increasing, while supplies of oil and natural gas are diminishing. Unless the U.S. makes a timely adjustment before oil becomes very scarce and very expensive in the 1980's, the nation's economic security and the American way of life will be gravely endangered. The steps the U.S. must take now are small compared to the drastic measures that will be needed if the U.S. does nothing until it is too late." These are the opening words from "The National Energy Plan" from the Executive Office of the President, Energy Policy and Planning.

From 1950 to 1973, U.S. energy consumption increased at an average rate of 3.5 per cent each year, while domestic energy production increased at an average rate just under 3 per cent. Thus in recent years, imported fuel, primarily oil, has had to make up the gap between production and consumption. Figure 1 illustrates this growth in energy demand.

Energy use has been growing in all the four consuming sectors (residential, commercial, transportation, and industrial).

Population growth has been one contributor to residential energy growth. There is also a tendency toward smaller households, with more elderly people and young adults having their own homes. This increased number of households has led to increased energy use. Another factor in increased residential use has been the tendency for each household to use more energy, as things like air conditioners, color televisions, clothes dryers, dishwashers, etc., are acquired.

Commercial energy use has also been growing rapidly. Office buildings and stores now often have large expanses of glass, allowing undesirable heat loss in the winter and gain in the summer, and causing more use of energy for heating and cooling. There is also more use of devices like computers, electric office machines, and duplicating machines, all of which use energy.

Transportation increases have been caused by increases in vehicle miles and also reduced efficiency. The tendency has been for cars to get heavier, which decreases gas milage. Americans still overwhelmingly prefer automobile travel over more energy-efficient mass transportation. Even in freight transportation, the trend has been toward less efficiency---railroads are losing freight traffic to less energy-efficient trucks and planes.

Industrial energy use, the largest of any of the consuming sectors, has also been growing. This growth has been caused in part by the nation's shift to plastics, aluminum, and other manufactured goods produced with large expenditures of energy.

And even as these increases in energy use were happening, domestic production of energy sources was decreasing.

In the 1950's, Middle Eastern oil costs were so low that Middle East crude oil was cheaper than domestic crude. Oil exploration in the U.S. declined, and major new oil finds were rare. U.S. domestic production has been declining since 1970. New production from Alaska and the outer continental shelf, and improved methods of recovering the oil should help to reverse this decline, but will not be able to satisfy our growing demands. Other major additions to the domestic oil supply are unlikely. As we previously mentioned, the world supply of oil cannot last indefinitely, so even without the economic and political implications of dependence on imported oil, we cannot rely on this source forever.

In the meantime, however, we cannot ignore the implications of our heavy dependence on imported oil. Our reliance on imports rose from 18 per cent in 1960 to about 37 per cent in 1975. More recently, there have been months in which we imported more than 50 per cent of the oil we used. Imports accounted for an average of between 40 and 45 per cent of our petroleum demand in mid-1977, at a cost of $35 billion annually---or an astounding $70 million a day.

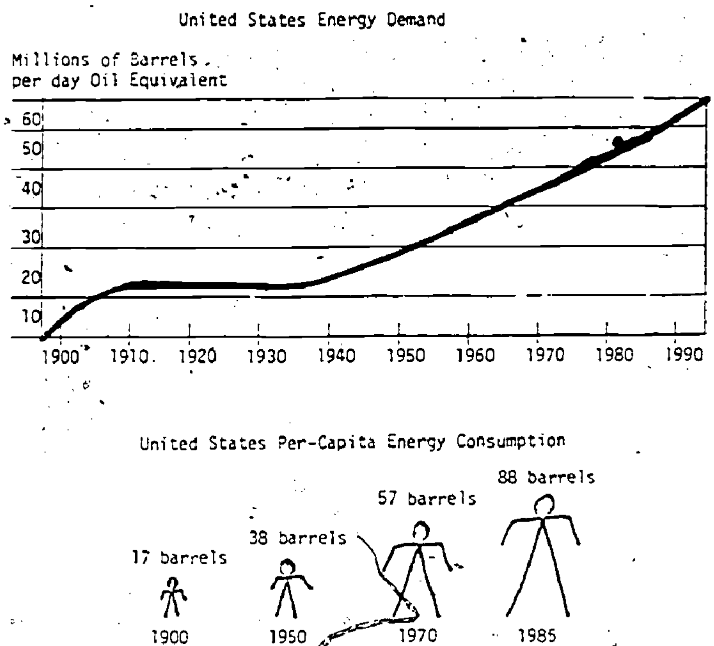


Figure 1

Use of natural gas grew rapidly during the 1950's and 1960's. A growing number of homes and industries turned to natural gas because of its low government-regulated cost, its clean-burning properties, and its convenience. But natural gas supplies and/or pipeline capacity were sometimes too low in the 1970's, and some customers found their natural gas cut off, especially in the northeast in the winter of 1977.

Shortly after World War II, the railroads changed from coal-fired steam locomotives to diesel-powered engines. At about the same time, home owners began replacing coal furnaces with oil, gas, or electric heat. Thus coal output decreased markedly, and is only now beginning to recover.

Labor problems, expensive safety requirements, and pollution control legislation have all hampered the coal industry.

Nuclear power has only recently begun to supply some of our growing energy needs. But public concerns about its safety, and skyrocketing costs of building the plants, have kept it from providing as much energy as original projections showed.

A small portion of our energy continues to be provided by hydroelectric plants. But there are few sites in the country where new dams can be built, so this means of energy production cannot increase significantly.

The availability and price of 73 per cent of the oil we import is controlled by the Organization of Petroleum Exporting Countries (OPEC), whose strength includes the enormous oil reserves (more than 160 billion barrels) located in the Middle East. Most oil is concentrated in large pools in the Middle East, making recovery cheap and easy. And yet OPEC oil now costs more than five times what it did in 1970. Furthermore, on October 17, 1973, most of the oil-producing countries of the Middle East placed an embargo on oil shipments. Although the embargo lasted just five months, the industrialized nations of the world reeled from the economic and social disruption caused by the interruption in the flow of oil. Prices of all commodities rose, and this contributed to worldwide inflation. Unemployment also increased, especially in sectors that used large amounts of energy. We were forced to take a look at our own energy future. Not only does our dependence on foreign oil imports affect costs of energy and goods to the U.S. consumer, but oil has become a major factor in the game of international politics.

The preceding discussion should convince the reader of the gap between energy consumption and domestic production. But why have we allowed this gap to develop? One reason that consumption has grown so rapidly is that until recently, energy was bargain-priced compared to other goods and services. Also we were encouraged to buy many energy-using products to enhance our lifestyles. We were beckoned to drive in our gas-drinking automobiles on miles and miles of new interstate highways. But at the same time, economic considerations, environmental concerns, and government regulations served to slow down domestic production of energy sources and construction of electrical power plants.

Activity IV-1

Objective:

The student will study individual family uses of electricity and/or natural gas.

What to do?

1. Learn how to read electric and gas meters. Actual electric meters are often available, on loan, from the local electric company. Cardboard models of electric and gas meters can be made easily by students who can then practice reading a variety of meter settings as they work in pairs or groups of three.
2. After mastering how to read the meters, ask every student to read the gas and/or electric meters in their homes at an agreed upon time (e.g., 5:00 p.m. on Wednesday). Indicate also that they will be reading the meters exactly one week later to determine how much gas and electricity they used in one week. Record the data for each family on a classroom chart.
3. After securing the base line data for one week, announce an "energy saving week." Urge each student to engage their family in seeing how much they can reduce their gas and/or electricity usage before the next weekly reading will be taken. Record the data for the second week. What family saved the most? The least? What was the average saving? Students from families that saved the most can be asked to explain how they were so successful. Was it hard or easy to save energy?

Teacher Note:

Caution - This should be done, if possible, during a period of relatively stable temperatures such as dead of winter, early fall, or late spring.

Activity IV-2

Objective:

The students will observe energy tranformations in the home.

What to do?

1. Have the students survey their homes with a chart of listed items that transform energy. They will name the energy going into each item and the type of energy used in the end.
2. Which energy transformations and forms are used most frequently by the students and their families?

HOME USE AND ENERGY CHECK LIST

Name of Item Using Energy	Amount of Energy (Wattage) Required	Type of Energy Going into the Item	Type of Energy Being Used in the End	Number of Hours Used per Week	How Does It Help You?
Electric Radio					
Portable Radio					
Electric Can Opener					
Blender					
Range (stove)					
Refrigerator					
Dishwasher					
Mixer					
Hand-operated Can Opener					
Popcorn Popper					
Toaster					
Electric Skillet					
Food Grinder					
Waffle Iron					
Humidifier					
Telephone					
Lamp					
Television					
Toothbrush					
Pencil Sharpener					

HOME USE AND ENERGY CHECK LIST (Continued)

Hair Dryer					
Doorbell					
Vacuum Cleaner					
Furnace					
Water Heater					
Hand Saw					
Saber Saw					
Drill					
Sander					
Grill					
Porch Light					
Clock					
Sewing Machine					
Record Player					
Shoe Polisher					
Movie Camera					
Iron					
Candles					
Broom					
Washer					
Dryer					
Ceiling Light					
Fan					
Deepfreeze					
Mop					

HOME USE AND ENERGY CHECK LIST (Continued)

Vaporizer					
Electric Razor					
Fireplace					
Toys					
Flashlight					
Car					
Grinder					
Bell					
Knife					
Electric Blanket					
Hot Plate					
Garbage Disposal					
Bun Warmer					
Adding Machine					

Activity IV-3

Objective:

The student will be able to calculate the amount of electricity his family uses per day.

What to do?

It took the muscle power of 100,000 slaves and 20 years of work to build a pyramid. It took the energy of 5,000 workers only one year to build a skyscraper with fuel-operated machinery. Use the information below to determine how many people it would take to power one electrical appliance at home.

The kilowatt-hour (KWH) is the unit used to measure this form of energy (or power). Its relationship to the basic unit – horsepower – can be determined.

One horsepower = 746 watts = 3/4 kilowatt (approx.)

One KWH = 2,640,000 ft/lb of work.

An average person can do about 50 ft-lb/sec of work; 18,000 ft-lb/hour; 14,000 ft-lb/day.

An electrical device that produces 14,000 ft-lb of work per day is equivalent to one human worker. *Therefore, since one KWH =2,640,000 ft-lb of work equivalanet, one KWH - 18-1/3 workers per day.*

On the following chart, note the amount of hours per day that your family uses the electrical appliances listed. Compute the number of workers needed to operate each of these electrical appliances for that length of time.

Activity IV-4

Objective:

The student will know how the amount of electricity in the house is measured, and know the differences in energy requirements and operation costs of various household appliances.

What to do?

Define the terms needed to understand the measurement of electricity consumption in the home (watt, kilowatt, kilowatt hour). From an electric company bill determine the average cost of a kilowatt-hour (KWH) for your area. Have students examine the table of "Average Wattage of Electrical Applicances," and then compute what it costs in their own homes to:

1. Leave a 100-watt light bulb burning for 6 hours.
2. Use the vaccum cleaner for 2 hours.
3. Use all burners of the oven and range for 3 hours.
4. Use a dishwasher for 1 hour every day for 30 days.
5. Run an electric clock for 1 year.

A variety of other simple calculations (appropriate for the class) should be devised to illustrate the relative cost of household applicances.

Average Wattage of Electrical Appliances
1000 watts = 1 kilowatt

Appliance	Average Wattage
Bottle Warmer	400
Broiler	1325
Clothes Dryer	4600
Clock	2
Coffeemaker (Automatic)	830
Cooker (Egg)	520
Dehumidifier	230
Dishwasher (With heat unit)	1155
Dishwasher (No heat unit)	290
Disposal (Only)	330
Fan, Attic	370
Fan, Desk	70
Fan, Furnace	225
Fan, Ventilating	85
Floor Polisher	240
Germicidal Lamp	20
Grill	770
Hair Dryer	235
Heat Lamp (Infrare	250
Heater, Radiant	1095
Hot Plate	1140
Mixer, Food	130
Oil Burner	245
Percolator	490
Radio	90
Radio-Phonograph	100
Razor	15
Sewing Machine	75
Stoker	300
Television	220
Toaster	1000
Vacuum Cleaner (Tank type)	375
Vibrator	45
Waffle Iron	855
Washer	280
Water Pump	265

These appliances are usually controlled by thermostats which permit the flow of electricity for intermittent periods only.

Electric Blanket	180
Heating Pad	55
Food Freezer (8 cu. ft.)	125
Iron	1,000
Ironer	1,500
Range	12,000*
Refrigerator	205
Room Cooler (Window type)	400
Roaster	1,300
Water Heater (66 gallons)	3,250

*This includes total wattage of all the burners and oven of the range.

ELECTRICITY WORKS FOR US

Activity IV-3

Electrical Appliance	Kilowatts per Hour	Hours Used per Day	Total Energy Use Per Day in KWH	Workers Needed per Day to operate Electrical Appliance (One KWH=18 1/3 Workers).
Air Conditioner (room)	1.60	5	8.00	146-2/3
Clothes Dryer	4.90			
Coffee Maker	0.89			
Dishwasher	1.20			
Disposal (food)	0.45			
Electric blanket	0.18			
Electric Bulb (40 watt)	0.04			
Electric Bulb (100 watt)	0.10			
Electric Bulb (150 watt)	0.15			
Electric Iron	1.00			
Electric range	12.20			
Electric fan (rollabout)	0.17			
Fan (furnace)	0.29			
Food blender	0.39			
Food mixer	0.13			
Hair dryer	0.38			
Radio	0.05			
Refrigerator	0.60			
Television	0.35			
Washing Machine	0.50			

With the number of workers needed to operate the electrical appliances for your family, how would your family rank in the social ladder during ancient times?

Activity IV-5

Objective:

Students will become familiar with the sources of oil through the world.

What to do?

Have students complete the activity on this page.

The Oil We Import

Because America's demand for oil is greater than its supply, we must buy oil from other countries to help meet the demand. This is called *importing*. During the last five years our imports of oil have doubled, and the cost per barrel has increased more than four times.

1. Find each country shown on the graph on a world map. Then list each country in its proper region below. Beside each country's name write the percentage of oil the U.S. imports from it.

North America

________________ ______

Latin America

________________ ______

________________ ______

The Mideast

________________ ______

________________ ______

________________ ______

Africa

________________ ______

________________ ______

Southeast Asia

________________ ______

2. What do the letters OPEC stand for? (The OPEC nations have formed an association to regulate the price they charge for their crude oil.)

____

3. What percentage of imported U.S. oil comes from OPEC nations?

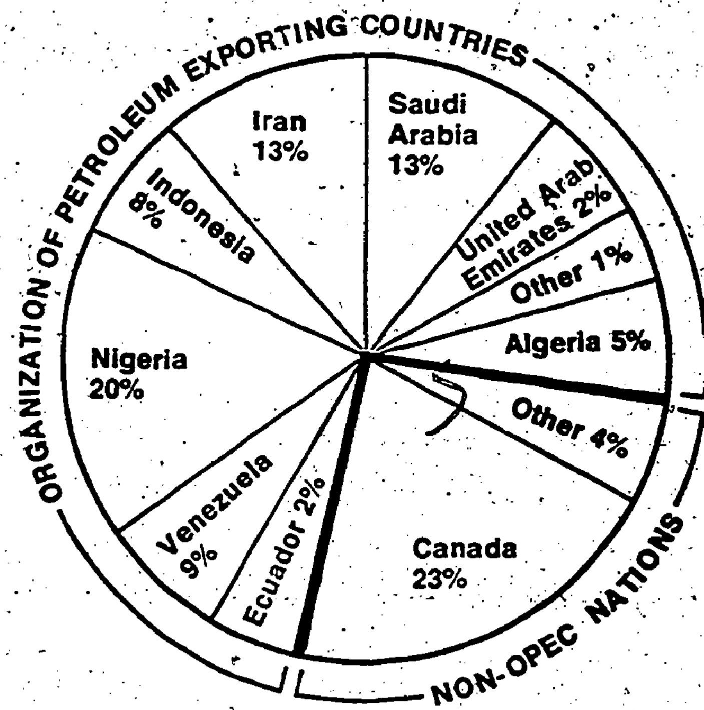
____

4. Which country sells the U.S. the most crude oil? (This country says it will need to end all shipments to the U.S. by 1982.)

____

5. Why does the U.S. need to import oil?

____



PERCENT OF TOTAL U.S. CRUDE IMPORTS IN 1974

Check which of these solutions to our energy consumption problem seems workable to you.

- ☐ Increase domestic production of fossil fuels
- ☐ Decrease our demand for oil
- ☐ Develop new energy alternatives
- ☐ Increase oil imports to fill growing demand
- ☐ Stop importing; become energy independent

Other solutions (Could you name some?)

____

____

____

Activity IV-5

Objective:

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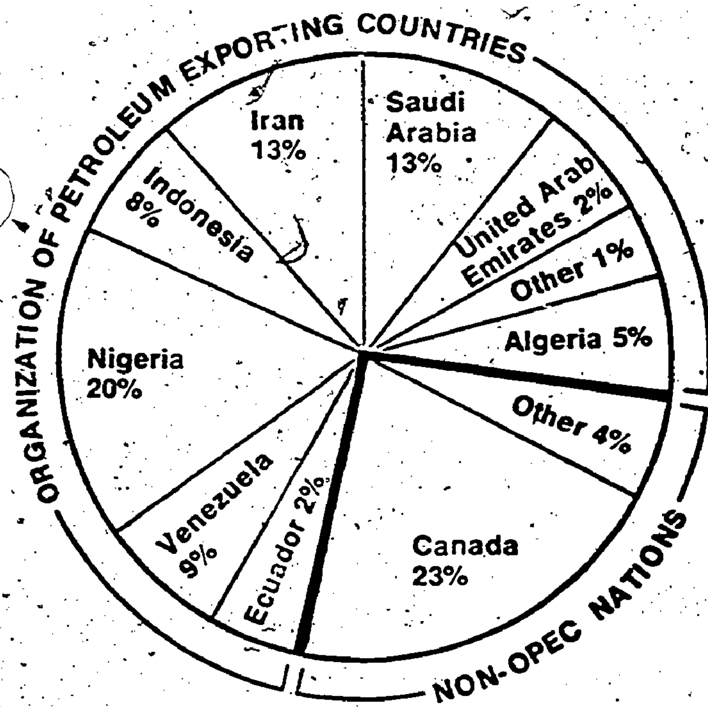
What to do?

Have students complete the activity on this page.

The Oil We Import



PERCENT OF TOTAL U.S. CRUDE IMPORTS IN 1974

Because America's demand for oil is greater than its supply, we must buy oil from other countries to help meet the demand. This is called *importing*. During the last five years our imports of oil have doubled, and the cost per barrel has increased more than four times.

1. Find each country shown on the graph on a world map. Then list each country in its proper region below. Beside each country's name write the percentage of oil the U.S. imports from it.

North America

Canada	23%

Latin America

Venezuela	9%
Ecuador	2%

The Mideast

Iran	13%
Sau'i Arabia	13%
Unite'd Arab Emirates	2%

Africa

Nigeria	20%
Algeria	5%

Southeast Asia

Indonesia	8%

2. What do the letters OPEC stand for? (The OPEC nations have formed an association to regulate the price they charge for their crude oil.)

   Organization of Petroleum Exporting Countries

3. What percentage of imported U.S. oil comes from OPEC nations?

   73%

4. Which country sells the U.S. the most crude oil? (This country says it will need to end all shipments to the U.S. by 1982.)

   Canada

5. Why does the U.S. need to import oil?

   Because its demand is greater than its domestic supply

Check which of these solutions to our energy consumption problem seems workable to you.

- ☐ Increase domestic production of fossil fuels
- ☐ Decrease our demand for oil
- ☐ Develop new energy alternatives
- ☐ Increase oil imports to fill growing demand
- ☐ Stop importing; become energy independent

Other solutions (Could you name some?)

PRESIDENT CARTER'S ENERGY PLAN

In an effort to deal with the problems outlined in the previous section, President Carter has proposed a comprehensive energy plan for the United States. The various portions of his overall plan will undoubtedly undergo some modification as they are considered and accepted or rejected by Congress. The main points of this energy plan are discussed here, followed by some reactions to it.

The plan lists three overriding energy objectives for the U.S. As an immediate objective, which will become even more important in the future, the U.S. must reduce its dependence on foreign oil to limit its vulnerability to supply interruptions. In the medium term the U.S. must keep imports sufficiently low to weather the period when world oil production approaches its capacity limitation. In the long term, the U.S. must have renewable and essentially inexhaustible sources of energy for sustained economic growth.

There are 10 principles set forth in the plan.

The first principle is that the energy problem can be effectively approached only by a government that accepts responsibility for dealing with it comprehensively, and by a public that understands its seriousness and is ready to make necessary sacrifices. The federal government can and must lead, but each of us needs to voluntarily work toward a commonly-accepted goal.

The second principle is that healthy economic growth must continue. Full employment must be promoted, and funds should be returned to the economy that are collected to carry out the energy policy.

The third principle is that national policies for the protection of the environment must be maintained. Virtually every available source of energy has its environmental drawbacks. In energy planning, it is necessary to recognize hazards and risks and to reduce them to relatively low levels.

The fourth principle is that the U.S. must reduce its vulnerability to potentially devastating supply interruptions. National security considerations, as well as the ever-increasing balance of payments deficits, run counter to unrestrained growth of oil imports. The goal here is relative invulnerability. Through effective conservation and increased use of more abundant domestic resources, oil imports can be reduced significantly. A large strategic petroleum reserve, diversification of foreign sources of oil, and contingency plans should help to deter interruptions of foreign oil supply and help protect the economy should such an interruption occur.

The fifth principle is that the United States must solve its energy problems in a manner that is equitable to all regions, sectors, and income groups. In particular, the elderly, the poor, and those on fixed incomes should be protected from disproportionately adverse effects on their income.

The sixth principle, and the cornerstone of the National Energy Policy, is that the growth in energy demand must be restrained through conservation and improved energy efficiency. Conservation is cheaper than production of new energy supplies, and affords more environmental protection. Furthermore, conservation and improved efficiency can lead to quick results.

The seventh principle is that energy prices should generally reflect the energy's true replacement cost. If prices are artificially held down by government pricing policies, energy will be overused. Prices need to be high enough to encourage conservation and production, but pricing policies should not cause windfall profits for the producers.

The eighth principle is that both energy producers and consumers are entitled to reasonable certainty about government energy policy. The government should provide business and the public with a clear and consistent statement of its policies, rules, and intentions. Toward that end, the various federal energy agencies are being organized into a Department of Energy.

The ninth principle is that more plentiful resources must be used more widely in place of those in short supply. Although coal comprises 90 per cent of domestic fossil fuel reserves, the U.S. meets only 18 per cent of its energy needs from coal. Oil and natural gas account for less than 8 per cent of domestic fossil fuel reserves, but meet 76 per cent of our energy needs. This imbalance between reserves and consumption should be corrected by shifting from oil and gas to coal and nuclear power.

The tenth principle is that the use of nonconventional sources of energy must be vigorously expanded. Relatively clean and inexhaustible sources of energy are a hopeful prospect, as supplements to conventional energy resources in this century, and as major sources of energy in the next century. Other technologies that increase efficiency of energy use, such as cogeneration of electricity and steam for industrial processes, should also be encouraged.

The plan sets forth 7 specific goals for 1985. These goals are to

- reduce the annual growth of total energy demand to below 2 per cent;
- reduce gasoline consumption 10 per cent below its current level;
- reduce oil imports from a potential level of 16 million barrels per day to 6 million, roughly one-eighth of total energy consumption;
- establish a strategic petroleum reserve of 1 billion barrels;
- increase coal production by two-thirds to more than 1 billion tons per year;
- bring 90 per cent of existing American homes and all buildings up to minimum energy efficiency standards;
- use solar energy in more than 2 1/2 million homes.

The President made many specific proposals concerning ways to achieve these goals and overall objectives. Most of his proposals required legislative action, while some could be carried out by various agencies without new legislation. On August 5, 1977, the U.S. House of Representatives passed energy legislation which left President Carter's energy program largely intact. The Senate had not yet acted on the bill as of this writing.

The many provisions of the House bill would generate billions of dollars in new taxes in an effort to save the equivalent of almost three million barrels of oil per day. The bill would also require a massive shift by industries and utilities away from the burning of natural gas and oil to use of the more abundant coal.

The House bill closely resembles the President's program. The principal deviation was the House defeat of the President's proposed 50 cent standby gasoline tax. Several other portions of the President's plan were weakened.

Following are some of the major provisions of the House bill.

-Tax on "Gas-Guzzlers"

Taxes would be added to the purchase price of cars whose fuel efficiency falls short of a minimum standard, which was set at 15 mpg for 1979 models and gradually rises to 23.5 mpg in 1985.

Under the President's plan, the money collected would have been paid out as rebates to buyers of fuel-efficient cars. Under the House version, the funds would go toward retirement of the national debt.

-Gasoline Tax

The President had sought a 5-cent per gallon tax on gasoline beginning in 1979, if gasoline consumption exceeded Federal targets. This tax would have increased by 5 cents per gallon every year in which the targets were exceeded, up to a maximum of 50 cents. This tax was defeated.

Some gasoline tax provisions were included in the House bill. The deduction for state and local gasoline taxes now allowed on Federal income tax would be repealed. The present 4 cent per gallon Federal gasoline tax, which had been scheduled for reduction, would be retained.

-Conservation Provisions

Homeowners could receive an income tax credit of 20 per cent of the first $2,000 that they spend to install insulation and other energy-conserving devices in their principal residence. Some financing assistance would be provided for those with low incomes. Utilities would be required to help homeowners who are unfamiliar with such weatherization.

A Federal grant program would be established to help schools and hospitals achieve conservation.

The Department of Energy would be required to prescribe minimum standards of energy efficiency for the 13 most energy-consuming appliances.

-Oil Prices

The energy bill would impose a tax on domestic crude oil, gradually bringing the refiners' cost up to the world price level. The price of domestic crude oil now averages $8.65 per barrel, against $14.25 for imported oil.

The tax could cause prices of petroleum products to rise by 7 cents a gallon within 3 years. At least in the first year, these tax revenues would be returned to the public as income tax credits.

An exemption from this tax is included for users of home heating oil and for educational, religious, and other nonprofit institutions.

-Natural Gas Prices

Price regulation would be continued for all natural gas sold across state lines. For the first time, intrastate prices would also be controlled.

Present price ceilings, adjusted for inflation, would remain on all natural gas now being produced. The ceiling price for newly produced gas would be tied to the price of domestic crude oil.

-Utilities

The Federal government would supervise an overhaul of electric rates to eliminate those not conducive to energy conservation, such as discounts to volume users. In general, rates would be required to reflect the cost of service, and might include programs such as time-of-day pricing.

Utilities would be required to buy electricity generated by industry from waste heat, and to transport power not belonging to them across their systems.

-Conversion from Oil and Gas by Industry and Utilities

In an effort to encourage less use of oil and natural gas, stiff user taxes would be applied to utilities and to the country's 1400 largest industrial concerns, beginning in 1979.

The heaviest tax would be applied to industries that use oil and gas to fire boilers. Other industrial users would be less heavily taxed, while use for electrical generation would fall in the middle range of taxes.

Most of the revenues raised by these taxes would be returned to businesses as tax credits to encourage conversion to coal and conservation expenditures.

Small industrial users would be exempt from this tax, as well as users such as fertilizer manufacturers, who must have the fuels for their processes or for feedstock.

Utilities and large industrial users who are unable to convert to coal for environmental or other reasons would not be exempt from the tax.

Authority would be given to the Department of Energy to require power plants and major industrial users to convert from gas or oil to coal.

Facilities not under construction before April 20, 1977, would be prohibited from using oil or gas as their primary fuel, although some exemptions would be allowed. Existing power plants would not be allowed to burn natural gas after Jan. 1, 1990.

-Solar Energy

A tax credit of up to $2,150 of the first $10,000 spent would be available for homeowners who install solar or wind energy equipment.

-Nuclear Proposals

The House bill did not deal with President Carter's proposals concerning nuclear power. Most of these can be implemented without new legislations, although decisions on funding or not funding certain projects, such as the LMFBR, must be made by Congress.

Under the President's energy plan, the country will use more light-water reactors (the type being used now) to help meet energy needs. The government will give increased attention to safety at such power plants, particularly in the areas of plant security, reporting of minor mishaps and component failures, and criteria for plant siting.

The President has directed that a study be made of the entire nuclear licensing process. He has proposed that reasonable and objective critieria be established for licensing and that plants which are based on a standard design not require extensive individual licensing. This is an effort to cut down on the time it takes to get a nuclear power plant built and operating.

The United States, as well as several other countries, has been developing a breeder reactor that uses plutonium, a by-product of uranium in nuclear reactors. The U.S. has also been developing reprocessing technology to recover the uranium and plutonium in the spent fuel from light water reactors. The recovered uranium could be recycled back into light water reactors, or stored for future use in breeder reactors. But plutonium can also be used for nuclear explosives, and the President believes that the risk of nuclear proliferation from these two technologies is too great to warrant their continuance. Thus, under the President's policy, the United States will defer indefinitely the commercial reprocessing and recyclying of plutonium, as well as the commercial introduction of the plutonium-fueled breeder. He is proposing to cancel construction of the Clinch River Breeder Reactor Demonstration Project, concentrating instead on evaluation and development of breeder and other advanced power reactor concepts which do not involve the production of weapons-grade plutonium. The President hopes that these actions will encourage other nations to reject plutonium-based technology. As an inducement for them to do so, he is proposing that the U.S. help to assure supplies of the slightly enriched uranium required for light water reactors. Toward this end, he is proposing that the U.S. expand its uranium enrichment capacity by adding more enrichment plants. These plants are to be of a new type called gaseous centrifuge plants, as opposed to the three gaseous diffusion plants currently in operation in the U.S. These centrifuge plants have the potential for producing enriched uranium at a lower cost and at a drastic savings in electrical power requirements.

The expanded number of light water reactors will require adequate supplies of natural uranium for fuel. Current estimates of U.S. uranium resources vary widely. The President believes that there is enough uranium to continue expansion of light water reactors, without imminent reliance on the breeder. ERDA has been directed to carefully assess uranium reserves to resolve the uncertainties.

With a decision to stop spent fuel reprocessing, and an expansion in the use of light water reactors, there will be an increasing need for facilities to store the spent fuel elements. To insure that adequate waste storage facilities are available by 1985, ERDA's waste management program has been expanded to include the development of techniques for long-term storage of spent fuel.

The fate of a reprocessing plant under construction in Barneswell, S.C., the Clinch River project, and the proposed enrichment plants depends on how much money is voted by Congress to fund them. The funding proposal has been sent by President Carter for all three projects. He is asking for money to terminate the first two projects, and to expand enrichment capabilities. At this writing, these proposals have not yet been acted upon by the Congress.

The President has projected the future impact of his overall energy plan: He has based his projections on the assumptions that U.S. population will increase from 216 million people today to 235 million in 1985, and that the gross national product will increase by about 46 per cent by 1985.

In terms of fuel use, the expected impact is shown in Table 1. For easy comparison, the numbers shown have all been changed to their equivalent in millions of barrels of oil per day.

Table 1
Fuel Supply and Consumption
(Millions of barrels of oil equivalent per day)

Supplies	1976	1985 Projections Without energy plan	1985 Projections With Plan
Domestic			
Oil	9.7	10.4	10.6
Natural Gas	9.5	8.2	8.8
Coal	7.9	12.2	14.5
Nuclear	1.0	3.7	3.8
Hydro, refinery gains, other	1.9	2.6	2.3
Total domestic supplies	30.0	37.1	40.0
Imports			
Oil	7.3	11.5	7.0
Natural Gas	.5	1.2	.6
Coal (Exports)	-.8	-1.2	-1.2
	7.0	11.5	6.4
Total Demand, Domestic and Imports	37.0	48.5	46.4

The plan is projected to save about 4.5 million barrels of imported oil per day over the amount of oil we would otherwise require by 1985.

Note that the 1985 projected oil imports under the energy plan are 7 million barrels per day. The President believes that voluntary conservation could achieve a further reduction to the goal of below 6 million barrels per day.

Projections quoted in the National Energy Plan suggest that the plan would not adversely affect economic growth. There would be a moderate increase in the rate of inflation, but it is felt that this is outweighed by helping to assure adequate energy supplies at reasonable prices.

The impact of the program could be felt beginning early in 1978, and would reach its maximum force in about 3 years. For consumers, the effects would be felt in the gas-guzzler tax, revised utility rates, tax credits for making homes more energy efficient, and higher prices for all products using oil, including gasoline, plastics, and synthetic fuels.

Many of the proposed measures, notably the conservation program, should help preserve environmental quality. Uncertainty continues over the impacts of the increase in coal utilization. The President will appoint a special committee to study the health effects of increased coal production and use, and the coal research and development program will focus on environmental requirements.

REACTIONS TO THE PROPOSED ENERGY POLICY

Representative Mike McCormack, chairman of the House Science and Technology Committee, predicts that the President's proposals on nuclear policy, although intended to reduce the threat of nuclear weapons proliferation, could well have exactly the opposite effect. He further feels that they would probably deny our country its only chance to produce the energy we will need for economic stability. He believes that the President's proposals are based on several false assumptions.

The first of these assumption is that plutonium recycling and the breeder reactor would somehow uniquely contribute to the potential for nuclear weapons proliferation. But as far as is known, no weapon has ever been made from fuel produced in any commercial nuclear power plant in the world. There are other means of nuclear proliferation that provide much easier ways of making weapons. For example, India's nuclear explosive was made from a research reactor sold to India by Canada.

The next assumption is that other nations will follow our lead in abandoning breeder development and nuclear reprocessing programs. Japan and most Western European nations do not have our supply of fossil fuels and feel that it is absolutely vital to their survival to proceed promptly with their breeder programs. Thus our foreign nuclear customers will seek other supplier nations, or develop their own programs.

Rep. McCormack states that the next assumption is that there is some *safe* breeder technologies which can replace the *unsafe* liquid metal fast breeder program. But he further states that any nuclear material which will produce energy in a power plant can be extracted from the fuel and used in a weapon. In short, there is no magic or simple proliferation-proof technology to which we can switch.

According to Rep. McCormack, the most dangerous unverified assumption is that far more recoverable uranium will be found in this country than intense exploration has indicated will be available. No one knows for certain how much uranium will be discovered, but Rep. McCormack and many other experts believe we are taking an unacceptable risk if we proceed under the assumption that we will not need a breeder technology until the next century because fuel will be found as we need it. If the fuel is not found, we would almost certainly suffer a serious energy shortage without the technology to do anything about it.

Rep. McCormack proposes the establishment of regional nuclear reprocessing centers, closely supervised by the International Atomic Energy Agency, with the involvement of all the participating nations. Only blended uranium and plutonium would be produced, which would work for fuel elements, but not for weapons without complicated and expensive separation.

Rep. McCormack has made some projections based on President Carter's energy plan and its effects on energy supplies after the year 2000. If the plan is successful in that the energy growth rate has been lowered to 2 per cent by 1985 and 1 per cent by the year 2000, our nation will by then be consuming energy equivalent to about 55 million barrels of oil per day. Of this, 13 million barrels per day will still be direct oil and gas consumption, including about 4 million barrels per day from oil imports. Rep. McCormack assumed that coal consumption would be 3 times today's levels. He also assumed that hydroelectric power would double and solar power increase ten-fold between 1985 and the year 2000. He further assumed that industrial waste would generate 3 to 4 per cent, and geothermal energy would meet 2 per cent, of our total energy needs by that time. With these optimistic assumptions, these sources would amount to about 36 million barrels of oil equivalent per day, leaving 19 million barrels per day which must be made up by nuclear power or additional oil imports, or else exist as an energy shortage. He assumed that no additional imports will be available by that time, and that an energy shortage of that magnitude is unacceptable. He also assumed that there will be no new energy source which can be developed to the point where it can make up any significant part of this deficit. Under these assumptions, only nuclear power can fill the gap. Nineteen million barrels of oil per day is equivalent to the electrical output of about 600 nuclear power plants. Making the prudent assumption that there is about 1.8 million tons of economically recoverable uranium available for use in reactors, there is adequate fuel to supply only about 270 light water reactors. Thus he concluded that based on the President's energy plan, this nation must soon make a commitment to start building breeder reactors by 1990, or face a severe energy shortage.

Dr. Hans Landsberg, an economist and senior fellow at Resources for the Future, has made an assessment of the energy supply and demand figures of the energy policy, shown in Table 1. Dr. Landsberg believes the 2.5 per cent average annual growth rate in energy use through 1985 is reasonable, so that the demand for the energy equivalent of 46.4 million barrels of oil per day is plausible.

On the supply side, however, Dr. Landsberg sees a great deal of questions. He believes that increasing the use of coal to the extent proposed will be very difficult if not impossible. In the past, utilities and industries have balked at converting to coal, based on environmental, technological, and economic grounds. It remains to be seen whether the conversions will now occur on the scale projected.

In order to produce enough coal, all the facilities associated with coal, most notably transportation and manpower, must also grow. State and federal jurisdictional conflicts must be resolved, land use and restoration practices must be established, and the environmental effects of burning such tremendous amounts of coal must be assessed. Dr. Landsberg believes that in this context it is highly unlikely that the use of coal will come up to the President's projection.

In the projected supply, domestic oil production must rise by 12 per cent and natural gas production must not decline by more than 7.5 per cent. Even considering Alaskan oil, and oil and natural gas from the outer continental shelf, Dr. Landsberg believes these projections to be overly optimistic.

Dr. Landsberg considers the plan's nuclear objective to be completely out of reach because of the long time it takes to get nuclear power plants built and operating. He believes the nuclear projections to be high by 20 to 25 per cent, since the plants which will be producing electricity by 1985 must be under construction now.

Thus Dr. Landsberg considers it virtually impossible to achieve domestic targets so that the demand can be satisfied by oil imports of no more than 7 million barrels of oil per day. He believes that 3.5 to 4 million barrels of imported oil per day above and beyond the target will be needed, a number close to the *no plan* projections of Table 1.

Other reactions to the President's proposal were also fast in coming. By emphasizing conservation of oil more than production, President Carter's program has displeased the oil industry. Oil interests wanted prices to be allowed to rise in a free market, thus providing an incentive for production as well as for conservation.

The coal companies said that environmental controls would make the shift to coal as required by the President's plan impractical. Some conservationists fear that environmental standards will be sacrificed for the use of coal.

Advocates of a free market economy questioned whether the complex system of taxes and rebates would accomplish anything more than the establishment of a new bureaucracy.

THE DEPARTMENT OF ENERGY

Legislation already passed created a Cabinet-level Department of Energy which began operations on October 1, 1977. The Department will have about 20,000 employees and a budget of 10.6 billion dollars. It brings together the functions of the Federal Energy Administration, the Federal Power Commission, and the Energy Research and Development Administration, as well as some 50 bureaus and agencies that have been scattered throughout the Federal government.

The Senate quickly confirmed the President's energy adviser, James Schlesinger, as the country's first Secretary of Energy.

The Department of Energy will administer the national energy plan. It has power to set energy prices, enforce conservation measures, and allocate fuel to various parts of the country. It will have billions of dollars to spend on energy research. A special office will compile information on U.S. energy resources.

The Secretary of Energy does not have complete authority over the pricing of fuels. Instead, a five-member Federal Energy Regulatory Commission will have the final word on fuel prices.

Since this department is so new, a breadkown of its various sections, their duties and their addresses was not available at this writing. Thus reference is made to organizations such as ERDA, recognizing that they are now a part of the Department of Energy.

Activity IV-6

Objective:

The students will describe their concept of life in the year 2000 with emphasis on the use of energy.

What to do?

Have the students write and illustrate short stories or poems describing what they think their life might be like in the year 2000, with emphasis on the use of energy. Have them compute how old they will be then, and what their job and home might be like.

Activity IV-7

Objective:

The student will choose the direction of development of future energy sources.

What to do?

Have the students choose which energy sources they would use to develop as national priority to meet future needs. Have them write a composition using the knowledge they have obtained.

Activity IV-8

Objective:

To examine the importance of energy in changing life styles.

What to do?

As a homework assignment ask each student to interview at least one person who can recall from personal experience what life was like in the U.S.A. forty or more years ago. Ask the older person to identify several of the most significant changes that have occurred regarding the *life style* of the American people.

Develop on the chalkboard a composition listing of all significant changes cited by the persons interviewed. The list will likely include more automobiles, better highways, scheduled airlines, automatic heat, television, supermarkets, frozen foods, longer vacations, fast food operations, and many, many others.

Assign to pairs of students the task of thinking seriously about one of the significant changes and reporting their conclusions to the class. What kind of energy was (is) used to produce the change in life style? Was (Is) that form of energy plentiful in the U.S.A.? Is that energy supply assured for the next forty years? Have the changes in life style been *good*?

Activity IV-9

Objective:

To survey community attitudes regarding energy shortages.

What to do?

Select from the class two or three students who will, with the use of cassette tape recorder, interview people in the community to ascertain their reaction to the energy situation.

Involve the class in developing questions to be used by the students in the interviews and in deciding on the population to be interviewed.

Questions might include the following:

1. In your judgment, is there really an energy problem?
2. If there is a problem, whose fault is it?
3. If there is a problem, what can you do about it?
4. What, if anything, are you doing about it?

The sample of persons to be interviewed should represent a range of ages and occupations such as homemaker, student, store owner, service station operator, trucker, salesman, custodian, and so forth.

Urge the students who are doing the interviews to speak clearly and to urge those being interviewed to do the same since the recording is to be played to the entire class for their study-reaction.

As the recording is played to the class, ask students to determine how perceptions of the energy problem differ. Do these perceptions vary according to income level, age or other criteria? Are there any agreements as to what could/should be done?

The activity might be concluded by asking each student to write a few paragraphs on what he/she has learned about community attitudes toward the energy problem.

Activity IV-10

Objective:

To examine relationships between life styles and energy costs.

What to do?

Review with the class the fact that gasoline sells for $1.00 or more per gallon in many European countries such as Switzerland, Holland, Denmark, France, and Great Britain.

Divide the class into groups of three or four students. Ask each group to think about and develop a list of ways in which *life styles* in those countries with high gasoline costs is likely to be different from the ways people live in the U.S.A., where gasoline is cheaper than in any other highly industrialized country. Encourage the groups to think broadly beyond such obvious things as size of automobiles and number of superhighways. Types of family vacations, suburban sprawl, status of railroad passenger service, extent of air travel, use of recreational vehicles and many other element of our life style can be shown to be related to energy costs.

Ask each group to make value judgments as to whether the life style in high energy cost countries is worse or better than ours. Ask each group to state its conclusion on one or two specific examples and defend its position before the class.

WORLD-WIDE PERSPECTIVE ON THE ENERGY PROBLEM

No country, however large or wealthy, can now view the future of its citizens independent of the rest of the world. National monetary systems are not independent, but are part of an international monetary system. National economies are increasingly dependent on the international flow of resources. One small region, the Middle East, controls the lion's share of the world's known petroleum reserves. North America controls a large share of exportable grain supplies. Interdependence among countries is so great that the size of automobiles and level of thermostats in the United States are influenced by oil production and export decisions in the Middle East. Food supplies in the Soviet Union and Japan are strongly influenced by U.S. agricultural export decisions.

It is therefore important to understand something about the energy situation in the rest of the world, and how world-wide energy consumption is likely to change.

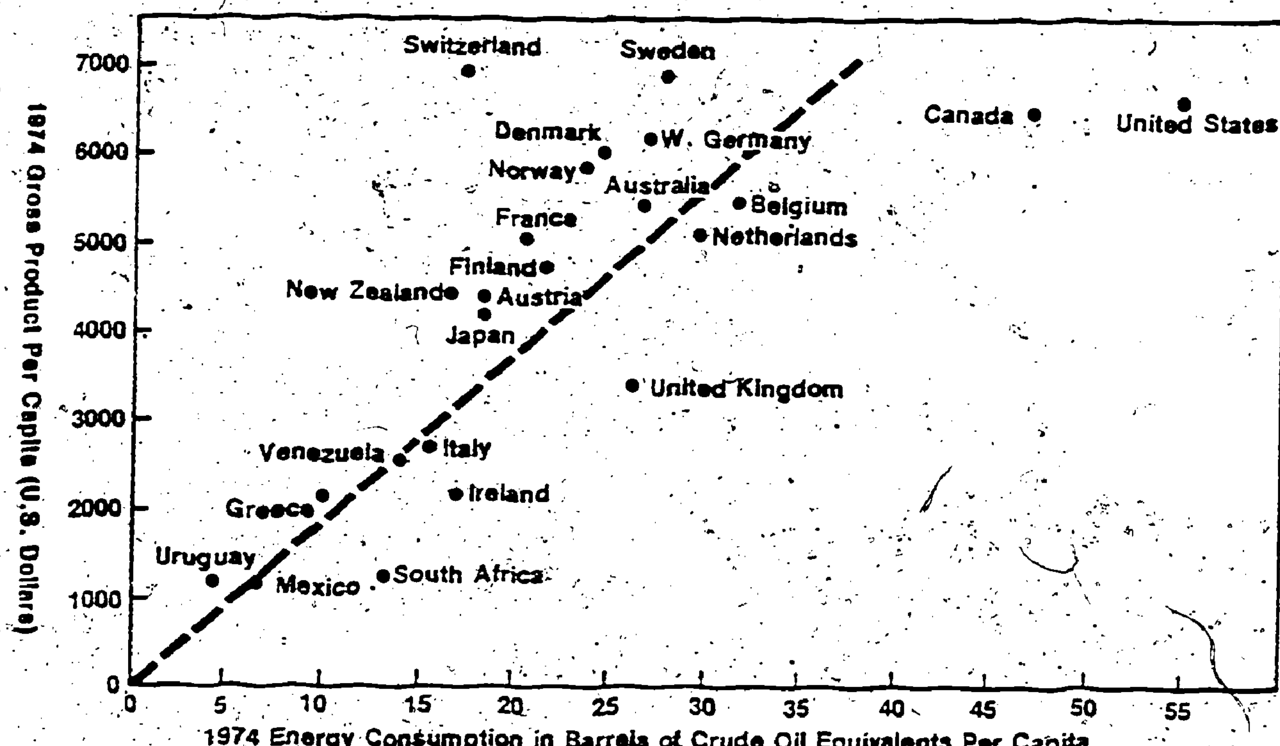
A country's standard of living is closely related to its use of energy. Those countries with a higher per capita (per person) income also had higher per capita energy consumption. As might be expected, the United States leads the world in energy consumption. With only about 6 per cent of the world's population, the United States accounts for more than one third of the world's energy consumption. Furthermore, the United States uses more energy per capita than other countries with similar standards of living. Figure 2 shows the relationship between energy consumption and gross national product (a measure of standard of living). Note that many European countries have per capita gross national products in the same range as that of the U.S., but maintain considerably lower per capita energy consumption.

The less developed countries of the world use very little energy per capita. These countries, where most of the citizens live in poverty, have 50 per cent of the world's population; they consume only 2 per cent of the world's energy. It is estimated that by the year 2000, they will consume no more than 4 per cent, with 55 per cent of the world's population. The developing countries of the world are expected to show the sharpest rise in per capita energy consumption. Smaller rises in per capita energy consumption in the U.S. and other industrialized countries should bring our share of the world's energy consumpiton more into balance.

These figures for per capita consumption are tied in with the world's increasing population, which is expected to reach 4.7 billion people by the late 1980's. Much of this gain will take place in the less developed regions of the world.

It is possible that an unbiased look at the world's energy problems would show OPEC's 1973 action in raising crude oil prices to be a blessing in disguise.

Energy Consumption Per Unit of GNP



Source of Data: U.N. Statistical Yearbook, 1975

Figure 2

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It has forced us to take stock of energy resources before petroleum reserves approached exhaustion and critical shortages resulted. But the price increase alone will not do the job, certainly not in time to avoid much higher prices as reserves of petroleum are depleted. The countries of the world who are high energy consumers need to eliminate waste, improve efficiency, and develop new energy resources. OPEC has helped to provide the economic incentive. It is now up to the world's planners to come up with constructive, practical solutions.

The consequences of inaction appear too great to ignore. For example, world crude oil reserves, which were as much as 50 times as great as annual consumption in 1966, have fallen to about 30 times annual consumption. Thus, in spite of new discoveries, we have been substantially reducing the life expectancy of our petroleum resources. Even the worldwide supplies of this resource are finite. We cannot depend on them to last forever.

The development of new energy sources must play an important role in bringing the energy picture into better balance. Today's petroleum prices give some encouragement to the development of these alternative sources.

Iran, one of the major oil and gas producing countries, has embarked on a construction program designed to support 15 per cent of their total energy demand from nuclear plants by 1993. They are doing this because their electrical consumption has been growing at about 20 per cent per year, and they are advancing programs to conserve their petroleum resources.

Japan, Russia, and most European countries have embarked on an extensive program of nuclear power plant construction. Most of these countries have little or no natural gas or oil, and are thus more dependent on foreign oil than the U.S.

Because of President Carter's nuclear policies, many countries worry that the United States will impose restrictions over the reprocessing of spent fuel of U.S. origin used in their countries' power reactors. Japan, for example, considers fuel reprocessing to be essential. Whether or not such restrictions are imposed, greater control can be expected on nuclear fuel exported from the United States, and even on fuel of non-U.S. origin used in reactors that have been supplied by the United States. Fear of these kinds of restrictions prompted International Atomic Energy Agency director-general Sigvard Eklund to say that, if internationally applied, the U.S. policy would violate the Nonproliferation Treaty, which specified the right of all parties to the treaty to develop research, production, and use of nuclear energy for peaceful purposes without discrimination.

More attention needs to be given to conservation of energy resources and their more economic exploitation on a world-wide scale. One way to do this is through the formulation of national and international programs which provide better matching of energy sources to energy uses. For example, a larger share of the domestic energy requirements of oil-producing countries could be supplied with gas, freeing more oil for export, since oil is better suited for export from the standpoint of both exporter and consumer.

Whether it be development of new or present energy supplies, establishing reasonable energy prices, conserving energy resources, or improving the efficiency of energy systems, the solutions need to be international. Otherwise, independent actions of individual countries or groups of countries may result in competitive programs which, in time, could bring energy and economic crises which none of us want.

Activity IV-11

Objective:

The students will discuss the implications of the high energy use in the U.S. compared to that of the rest of the world.

What to do?

Hold a class discussion on this topic. Bring out the facts about the disproportionate share of energy we use, including the fact that the meat in our diet takes so much energy to produce. Have the students give opinions on whether this is fair. By cutting our own consumption, can we increase supplies for the people who really need it? How is it possible to better the lot of people who live in poverty? Is there anything we can do personally?

Activity IV-12

Objective:

The students will visualize the high energy use in the U.S. compared to that of the rest of the world.

What to do?

The following table shows population and energy use by different categories of nations for the year 1975.

	% world population	% energy use
Less developed countries	50	2
Developing countries	25	13
Industrialized countries	19	40
U.S.A.	6	45

Put slips of paper into a container equal to the number of students in the class. Each slip will be one of four colors representing the four groups above. Have the proportion of the various slips in the container approximately equal to the population figures; for example, one half of the slips should be of the color representing less developed countries, one quarter for developing countries, etc. Have each student pull a slip of paper to determine to which group he/she will belong. Thus the assignments will occur by chance, just as it is only by chance that we live in this country.

Take an unsliced loaf of bread and cut it into four sections equal to the percentage of energy consumption. Give the appropriate section of bread to each group to divide among themselves. For example, the U.S. group will receive almost half the loaf, which represents our current use of the finite limits of energy resources.

Have the class members share their attitudes toward their particular portion and toward the people who had larger or smaller portions.

Activity IV-13

Objective:

The students will recognize the impact of the energy crisis on international relations.

What to do?

A. Have students research areas of the world which have the largest supply of energy resources. Also have the students determine areas of the world which are the greatest users of energy. Graphs and maps would be very appropriate.

B. Have the students draw possible conclusions concerning the effect of the present energy situation on American foreign policy. Discussion should include the Middle East, Latin America, Southeast Asia, the Soviet Union, Red China, and Europe.

C. Have the students consider the energy situation in terms of international trade, including the following:
1. The difference between revenue and protective tariffs.
2. The possible consequences of protective tariffs upon the financial prosperity of the world.
3. An understanding of the European Common Market. Consider the value of such an institution on a world wide basis concerning present day energy, natural resources, and food supplies.

D. Students should consider the possible effects of the present energy situation upon the next half century.
1. How will countries alter their standard of living? (This is especially important to the U.S. and Japan.)
2. Will the countries of the world be drawn closer together or will tensions cause poorer relations?
3. Will the "under developed" nations of the world assume a role of shared leadership?

ENERGY

IS THERE ANOTHER WAY?

AN ENERGY CURRICULUM
MODULE #5

Governor's Energy Council

MODULE 5

Pennsylvania Department of Education 1977

FOSSIL FUELS

Fluidized-bed Combustion of Coal

Coal is by far the nation's most extensive fossil fuel resource, a resource on which we shall surely have to rely heavily. Research is underway on new ways to burn coal cleanly. One of the possibilities is fluidized-bed combustion of coal, in which pulverized coal is burned in the presence of tiny particles of limestone. Sulfur from the coal is captured in the limestone, and the temperatures of combustion are low enough that formation of nitrogen oxides is minimized. The solid residue from such a process, instead of being a disposal problem as in the case of flue gas scrubbers, may have value as an agricultural nutrient. A pilot plant using such a process has begun operation in Riversville, West Virginia.

Magnetohydrodynamics (MHD)

MHD is a method for generating electricity by passing hot combustion gases from burning coal through a magnetic field at high speed. MHD plants would be much more efficient than conventional coal-burning plants, and would also produce significantly less pollution. Many engineering problems remain to be solved, especially in producing the large, powerful magnets required, but this method does show promise.

Coal Gasification and Liquifaction

In order to fill the oil and natural gas gaps of the future satisfactorily, it is possible that coal will need to be converted to liquid and gas fuels. In this way, most existing fuel-burning devices would be able to use the gas or liquid made from coal without major modifications. Also, the processing that the coal would receive would remove most of the pollutants, such as sulfur, oxides of nitrogen, and ash, leaving a clean-burning fuel.

Coal gasification involves subjecting coal to intense heat and capturing the resulting gases. Depending on the process used, the final gas product may have a relatively low-energy content, or may be a "synthetic natural gas" that is very pure and has the same high energy content as natural gas.

The National Pertroleum Council expects some coal gasification plants to be in operation by 1985, but it does not appear possible that there will be enough to fill the projected gap between the demand for natural gas and the domestic availability.

While synthetic natural gas would not present the pollution problems of coal when it is burned, the gasification process presents its own pollution problems. It is, however, easier to remove the pollutants from coal during its gasification than try to remove them from the smoke as the coal is burned.

A major environmental concern with coal gasification is that involved in getting the coal out of the ground. Tremendous amounts of coal would be required--about 605 tons an hour for each plant. Much of the coal would probably be strip mined from large western coal deposits. Without reclamation, which would ultimately add to the cost of the gas produced, large areas of western wilderness lands could be devastated.

Another major problem for coal gasification is water availability. Plants will require a great deal of water, and some of this water will be lost by evaporation. Unfortunately, the western areas where the most promising coal deposits occur have limited water supplies. A recent National Academy of Sciences report concluded that enough water is available for mining and land reclamation at most potential coal mining sites, but not for large-scale conversion to other energy forms at the western locations.

Thermal pollution is also a problem in coal gasification.

Coal could also be liquified and used as a substitute for oil. Techniques to accomplish this are now being studied, but are not as far along as gasification techniques. The environmental considerations for liquified coal are generally the same as for coal gasification, except that water requirements will probably be even greater.

Oil Shale

Oil shale is a finely textured rock that contains a tarlike material called kerogen. When melted, kerogen gives off vapors that can be converted to shale oil. This shale oil can then be refined into oil, gasoline, and other petroleum products. Oil shale deposits are located primarily in Colorado, Utah, and Wyoming. These deposits are estimated to contain the equivalent of several times the recoverable oil in the United States.

There are two general ways of recovering shale oil. The one that has already been demonstrated is above-ground retorting, where the shale is collected and heated, distilling the vapors to produce the shale oil. The other process, which is being studied, is in-situ retorting. This involves breaking up the shale underground by hydraulic pressure or some type of explosion. Then air or gas would be introduced underground to support combustion. Some of the [illegible] would be burned in place to provide the heat to [illegible] of the shale oil so it can be pumped from the [illegible]. This in-situ retorting has many unresolved problems. Control of the explosion and underground fire are among the largest. But it is being studied because above-ground retorting has two tremendous drawbacks. One is the strip mining that an above-ground operation would entail. But an even greater problem is the disposal of wastes. Even high-grade shale is about 87 percent rock or inert material, and these wastes swell up to almost twice the volume of the original shale. Nothing will grow on these wastes without large amounts of fertilizer and watering.

Shale development would require enormous quantities of water in areas where the water is simply not available.

These problems make anything more than token shale oil production unlikely through 1985.

Liquid Metal Fast Breeder Reactor

The future of the liquid metal fast breeder reactor is in considerable doubt because of President Carter's energy proposals. A brief discussion is given here so that the reader may be aware of its advantages and disadvantages.

If the utility industry relies only on light water reactors, the exhaustion of uranium reserves is not too many years in the future. The advanced nuclear reactor which would solve this supply problem is called the breeder reactor. Of many types of breeders proposed, the most promising has been thought to be the liquid metal fast breeder reactor (LMFBR). Such a reactor is significantly different from today's light water reactors. It is cooled with liquid sodium instead of with water. It is called a fast reactor because it does not use a moderator to slow down neutrons. And finally, it actually produces (breeds) additional fuel as it makes heat for electricity.

The breeder reactor would use a mixture of uranium and plutonium for fuel. The plutonium can be fissioned, and in the process, neutrons strike the nuclei of the uranium and produce more fissionable material, including plutonium.

The LMFBR has the potential of being more efficient than light water reactors because of the properties of the sodium coolant. Thus less waste heat would be produced.

Breeder reactors would also reduce the escape of radiation into air and water. The reactor core would essentially be a sealed system, and even the small amounts of radioactive fission products now released by light water reactors would be trapped in the core.

There are problems with breeder reactors, however. Some are due to the nature of the sodium coolant. Sodium is a highly chemically reactive metal that will burn if it is exposed to either water or air. Further, it is a solid at room temperature and requires an elaborate heating system to assure that it will remain liquid throughout the coolant system. Sodium is not transparent, which would complicate refueling and maintenance. The sodium coolant would also become intensely radioactive.

Some people believe that an accidental power surge in an LMFBR could lead to an uncontrolled chain reaction, which could explode the reactor and release dangerous amounts of radiation. Others knowledgeable in this area say such an explosion is strictly impossible.

The major controversy exists over the plutonium produced by the breeder reactor. Plutonium can be fashioned into nuclear weapons, and this is the basis of President Carter's objection to the breeder. Plutonium is also extremely poisonous, and it is a radioactive substance with a very long half life. Thus it must be handled and stored under very carefully controlled conditions and will remain radioactive for thousands of years. It should be noted that plutonium has been transported and stored for years as part of the nation's nuclear weapons program, so the problem is not unique to the breeder reactor. Proponents also contend that light water reactors and breeder reactors can work in complementary fashion by recycling waste plutonium from light water reactors into fuel for breeder reactors. The quantity of available plutonium can then always be adapted to demand so that there would never be a stockpile of plutonium. It has been estimated that the stored uranium-238 left over from producing fuel enriched in uranium-235 for light water reactors and weapons manufacture, if converted to plutonium in a breeder reactor, would make available to us energy equivalent to all our known coal reserves.

Demonstration breeder reactors are operating in the Soviet Union and France and are under construction or planned in West Germany and Japan. The U.S. demonstration plant, the Clinch River Breeder Reactor Project, was planned to be operating by 1983. The future of this plant is now unknown. The U.S. was a pioneer in breeder technology, but we have now fallen far behind other countries. It is probable that by 1985, about 10 breeder plants will be operating in European countries. Germany, Italy, and France are mounting a cooperative effort in the Superphenix project, with a large breeder plant to be completed in 1982.

Fusion

In the process of nuclear fusion, two light nuclei are forced together under extremely high temperatures and pressures to form a heavier nucleus, and a small amount of their mass is converted into a tremendous amount of energy. The fusion reaction for electrical power production will probably use forms of hydrogen called deuterium and tritium to make a single helium nucleus and a neutron.

Scientists have been working for 30 years to control fusion as a power source. The major part of their effort has been spent in trying to create a magnetic "bottle" to hold the thin, hot, ionized gas of hydrogen atoms, called a plasma, needed for fusion. A solid container cannot be used because the slightest contact would destroy the plasma; in addition, no material could remain intact at the temperature needed to achieve fusion. But because the plasma consists of particles with electrical charges, it can be contained within a magnetic field of the proper shape.

No one has yet been able to make such a confinement field that will hold together even for the fraction of a second needed to achieve fusion. In the 1960's, some physicists said that fusion power appeared impossible because of the basic laws of science. But today, it appears that success is possible, although many engineering problems remain to be solved.

The most promising magnetic confinement approach seems to be the tokomak, a doughnut-shaped device originally developed by the Soviets (who have freely shared peaceful fusion information), and later refined by the United States. Other approaches are the theta pinch concept, which uses brief, powerful pulses of energy to squeeze a tube of plasma into the fusion range; and the magnetic mirror concept, which contains the plasma between "walls" of magnetic fields.

A race is now on to see which of these three concepts (each of which has its variations and refinements) will be the most effective—with the possibility that elements of any of the three may be combined in a working fusion power reactor. A progression of experiments in the U. S. and other countries could lead to operation of commercial scale fusion power plants in the 1990's, with fusion making a significant contribution to the overall energy supply in the first decades of the 21st century.

One hope for bettering this timetable is the concept of inertial confinement of plasma. In this process, the powerful, concentrated energy of lasers would be used. Thus this process is often called laser fusion.

These timetables for development of fusion power assume a relative moderate level of government spending. A large increase in spending might speed commercial use of fusion power. But it must be remembered that physicists working on fusion power are roughly in the situation of scientists working on fission in early 1942: they believe that their concept will work, but have not yet proved it by experiment. Considering the engineering problems of building a fusion reactor once the concept is proved, it seems safe to say that fusion power under the best of circumstances will not make an appreciable contribution to the nation's energy supply until the 21st century, unless the most optimistic predictions turn out to be true.

GEOTHERMAL ENERGY

Geothermal energy is the natural heat of the earth. This heat can be tapped by drilling into the earth, and can be turned into usable energy by running turbines to generate electricity.

At present, the only large-scale geothermal power generation complex in the country is the Geysers field in California, whose electrical output is 502 megawatts. The only geothermal facility of comparable size is in Italy, and there are smaller such plants in other parts of Italy and in Japan.

These facilities use a rare natural phenomenon called "dry steam." This is produced when hot water boils in an underground reservoir. Some of the resulting steam condenses on the surrounding rock, and the rest reaches the surface. Dry steam can be used in a turbine without the need for a boiler. There are problems with dry steam–among them the pollution created when minerals such as sulfur are released with the steam. But this form of geothermal energy is the most easily usable, and unfortunately the least available.

"Wet steam" is created when underground water is heated by surrounding rock to the boiling point, but remains liquid because of high underground pressure. This water flows to the surface when wells are drilled in the right places, in a mixture that is 10 to 20 percent steam and the rest hot water. A well-known example is the geysers at Yellowstone National Park. Power production is complicated with wet steam because the steam must first be separated from the hot water before it can be used to run a turbine.

Wet steam now is being used to generate electricity in New Zealand, where the steam is used directly to turn a generator, and in Mexico, where the hot water is used to heat isobutane (a liquid with a lower boiling point than water) which turns the generator. A number of wet steam reservoirs have been identified in the United States, chiefly in the western part of the country. The effort to tap these resources is in its earliest stage.

A third form of geothermal energy is "geopressurized systems," reservoirs of water trapped far underground at high pressures, usually mixed with natural gas. Petroleum exploration has discovered a number of such reservoirs in a belt running 750 miles along the Gulf Coast. There is hope for quick commercial use of these reservoirs, but there is a lack of knowledge about them, especially insofar as how long the high pressures will last. Thus there could be reluctance to invest large amounts of money in the deep drilling needed to reach the geopressurized systems.

The fourth and most common form of geothermal energy is hot, dry, rock, which is found near the surface in large areas of the world, including a substantial portion of the western part of the U. S. The potential energy of the western states' hot rock areas is very large, but use of this energy depends on both an increase in knowledge about this resource and major advances in technology. To tap these resources, it is proposed to drill a hole deep into the rock formations, fracture the rock either by explosives or hydraulically, pump water down and withdraw the heated water through another hole, extracting the heat to generate electricity. The essentials of this technique are commonly used in oil drilling technology, but their application to hot rock systems is still in the experimental stages. Energy production from the normal heat gradient of the earth would require a major advance over the technology needed to tap hot rock resources.

The speed with which geothermal resources are brought into use obviously depends on a number of economic and technical factors. The best estimate is that the nation's geothermal resources will be supplying only a small part of the country's energy needs by the year 2000.

SOLAR ENERGY

Most of the earth's energy comes from the sun. What is needed now is a way of harnessing solar energy other than the method of first allowing solar energy to produce organic material and then having the organic material turn into fossil fuels by geological activity.

The potential of solar energy seems almost unlimited. A solar energy panel of the National Science Foundation and the National Aeronautics and Space Administration estimated that all the electric needs of the U. S. in 1969 could have been met by converting 10 percent of the energy received by just 0.14 percent of the U. S. land area into electricity. But solar energy is a diffuse, low-temperature heat source, and it must be transformed into a more concentrated, hotter form for practical use.

Solar Heating and Cooling

There are a number of buildings in the U. S. using solar energy for heat. ERDA's forecasts are for as many as 2,000 residential units and 400 commercial units using solar heating financed by government research funds by 1980, with additional buildings using solar energy either through private research funds or by purchase of some of the commercial solar energy heating units now on the market.

It is possible for a solar heating unit to serve as a supplement to a conventional heating system, although large areas of the United States have enough sunlight for the solar unit to serve as the main source of heat, with a conventional system as backup. Such a solar unit would have a collector, facing south for maximum solar exposure, with an area of 400 to 600 square feet. The collector, surfaced with glass or plastic, traps energy through the "greenhouse effect"--allowing short wave length solar energy to enter, and retaining longer wave length infrared energy. The trapped energy heats an absorbing surface and is tranferred to a fluid, usually water, to be stored and used to heat the house. While energy can be stored for as long as three days, a conventional heating system is usually required as a supplement, since the least sunshine seems to be in areas needing the most heat.

Solar cooling is a more complex technical problem, since it requires higher temperatures to use solar energy to run heat-actuated air conditioners. But it is regarded as a highly promising area for research and development, since there is a coincidence between the peak times of energy use (mostly for air conditioning) in a given area and the amount of solar energy arriving in that area.

Use of solar energy for heating and cooling depends not so much on technical advances--working solar energy heaters have been used for decades in sunny parts of the world--but on a resolution of the problems involved in introducing an unconventional technology into a market as fragmented as the U.S. housing industry. Studies by NSF show that two-thirds of all buildings are solar candidates--about 40 million buildings by the year 2000. One expert, Charles Alexander of Youngstown State University, estimates that half of the new homes in the U.S. will have solar heating and cooling by 1985. A more conservative estimate, made by a joint NSF-NASA panel, is that 10 percent of new homes will have solar heating by 1985. Since heating and air conditioning of buildings and homes takes a tremendous amount of energy, this promising use of solar energy could take some of the burden off other scarce energy supplies.

Solar Electricity Generation

Solar cells capable of converting 10 percent or more of incident sunlight directly to electricity are now available, but their cost is 100 times the price per kilowatt of conventional generating plants. An important need in making such generating systems practical is the development of a way of storing electricity for use during times when the sun is not shining. A number of systems have been proposed, including the sort of pumped-water facilities already in use with conventional generating sources. Other proposals include giant flywheels, whose effectiveness has not been proved in practice.

The NSF has said that solar cell systems for schools and shopping centers could be in use by the early 1980's. Central generating plants are not expected to be operational before 1990.

A proposal to orbit a giant array of solar cells at an altitude where its orbit would keep it above a fixed spot on earth has been made. The electricity from this array would be beamed back to earth by microwaves. Such a station would be orbited with the use of the space shuttle. It is not expected to become a reality until some time in the 21st century.

The concept of building a solar thermal generating station which would use lenses or reflectors to concentrate the sun's heat for operation of a turbogenerator is also being explored. Such systems have been run experimentally in many areas, but a number of practical engineering questions remain to be answered. It is estimated that such a plant in the southwestern part of the U. S. would require 10 square miles of collectors, covering an area about half the size of the island of Manhattan, to generate 1,000 megawatts. The NSF-NASA panel said that their estimate is that solar thermal plants will represent 10 percent of all new generating capacity after the year 2000 and will provide 5 percent of the nation's capacity by 2020.

Wind Power

Wind power comes under the heading of solar energy, since the winds are sundriven atmospheric systems.

Windmills which were previously used in this country were made obsolete by electrification, but the concept has lived on. Scientists have identified a number of areas in the U. S. where the winds seem suitable for large-scale power production. Although wind power requires large initial capital costs, there are no fuel costs and no pollution. However, objections on esthetic grounds to putting huge windmills on large tracts of unspoiled land may be a problem.

NSF is studying the suitability of wind power at a number of sites. NSF and NASA are cooperating in production of a 100 kilowatt wind turbine with a 125-foot-diameter rotary blade on a 125 foot tower that will be tested at a NASA facility in Sandusky, Ohio. Experience with this unit will determine when and if the next step to larger units will be taken. The problem of energy storage comes up again with wind power, since provision needs to be made for times when the wind is not blowing.

Thermal Gradient

A more speculative proposal would use the difference in the temperature of surface water and deep-sea water to run huge generating stations. In the tropics, solar heat keeps surface water at 80 degrees Fareheit or above, while water at a depth of 2,000 feet is between 35 and 38 degrees. Experimental plants that generated electricity by utilizing this temperature gradient have been operated before, but ceased operation because of damage by waves and currents.

ERDA has commissioned a number of studies on various aspects of solar seapower, but there are no estimates of when such systems might be able to make a meaninful contribution to national energy needs.

Tidal Power

Tidal power is another use of solar energy. A small plant in France has been in operation since 1965, but progress elsewhere has been almost nonexistent. A proposal to build such a plant in Maine has been debated for years, but has not proven to be economically feasible. With a limited number of sites suitable for tidal power generation, and the huge investments necessary to build such facilities, the concept does not seem to be competitive with other energy sources.

Bioconversion

Bioconversion implies converting organic materials to fuels or directly to energy.

A familiar form of bioconversion involves the use of wood as a fuel. In this era of high fuel costs, more and more people are choosing to supplement (or even replace) their home heaters with wood-burning fireplaces and stoves. From an industrial standpoint, however, trees currently have a higher value as a raw material for products than as a fuel. New techniques are making possible the use of more and more of the forest products as a raw material for items such as chipboard and particle board. Thus wastes which would previously have been used as fuel by the forestry industry are now being turned into products. Researchers are continuing to study methods of using wood as a fuel on a wide scale. Methods being studied include direct burning of wood, and using wood as a source of gaseous or liquid fuels or as a raw material for organic chemicals. Proposals exist for "energy plantations" to grow short rotation tree crops or other plants to be used as fuel.

PYROLYSIS OF SOLID WASTE

This process involves burning of solid waste in an oxygen-free atmosphere to produce oil and gaseous products. Such wastes could include manure, garbage, paper, logging residue, some industrial waste, and sewage.

A major difficulty with this method is that the waste material tends to be scattered in small amounts at various sites, and it would be enormously expensive to gather it at a location where it could be burned.

WHERE DO WE GO FROM HERE?

Today's energy sources came into wide use because they were relatively cheap, abundant, and efficient. The attractiveness of any of these alternate energy sources will increase if the sources we are now using continue to become expensive and scarce. It seems that no promising source of energy, however unconventional it may be, should be neglected by a nation and a world that is so dependent on a supply of energy and so unsure of the length of time that supply will last.

Activity V-1

Objective:

The students will demonstrate the most efficient means of trapping solar energy.

What to do?

Materials needed: 6 test tubes with one-hole stoppers to fit, 6 thermometers, sheets of black, blue, red, white, and green colored paper, aluminum foil

Fill each test tube with water, stopper, and insert the thermometer into the hole in the stopper. Behind each test tube, place one of the sheets of colored paper and the aluminum foil. Place the test tubes in direct sunlight.

Record the initial water temperature. After five minutes of sunlight exposure, read the temperature of the water again and record. Repeat this procedure for 30 minutes. What can be said about the color background and temperature change?

Repeat the experiment, this time wrapping each tube completely in the colored paper. Are there any differences observable from the first set of data? Explain any such differences.

Can you see any application of this experiment to the use of solar energy in the home? Explain.

Activity V-2

Objective:

The student will demonstrate how sunlight can produce high temperatures and will build a solar reflector.

What to do?

Materials needed: Magnifying glass, thermometer, flashlight reflector, different kinds of materials (such as wood, paper, cloth), old umbrella, aluminum foil, beaker

1. Using the magnifying glass, direct the sun's rays on different materials and observe what happens. (CAUTION: do not start a fire in the classroom!)
2. Put a thermometer through the hole in a flashlight reflector. Place the bulb of the thermometer so that the sun's rays are focused on it. Observe what happens to the thermometer readings over a period of time. Record your findings on a chart.
3. Line the umbrella with foil (Open the umbrella and line the inside.) Focus the sun's rays with the umbrella on the beaker of water. Using a thermometer in the beaker, record the temperature of the water.

   Ask: How hot does the water get in the beaker? What temperature does the thermometer record in the flashlight reflector? What would happen at night? What about cloudy days? Guide the students into a discussion on the potential use of solar energy to produce steam to run turbines, to heat homes, and to cook food.

From West Virginia Energy Activities

Activity V-3

Objective:

The students will illustrate wind energy and how it is used.

What to do?

Have the students draw as many ways as they can think of for using the energy of the wind. Urge them to be creative and not just stick to conventional things like sailboats and windmills.

Activity V-4

Objective:

The students will make working models of wind-driven vehicles.

What to do?

Materials needed: Tin cans, blocks of wood, sails of cloth or plastic, wheels, miscellaneous hardware.

Divide the class into groups and have them make models of wind-driven vehicles. (Point out that universities are doing similar studies.) Determine which vehicle is the best at the conclusion of the activity and have the students try to figure out why.

From West Virginia Energy Activities

Activity V-5

Objective:

The students will recognize the basic technology of solar collection and of the solar cell and will be able to see the benefits of these energy sources.

What to do?

Have the students complete the items "Energy from the Sun" which follows. Hold a class discussion based on the information in this activity.

Activity V-6

Objective:

Students will discover some of the benefits and problems of eight new energy resources.

What to do?

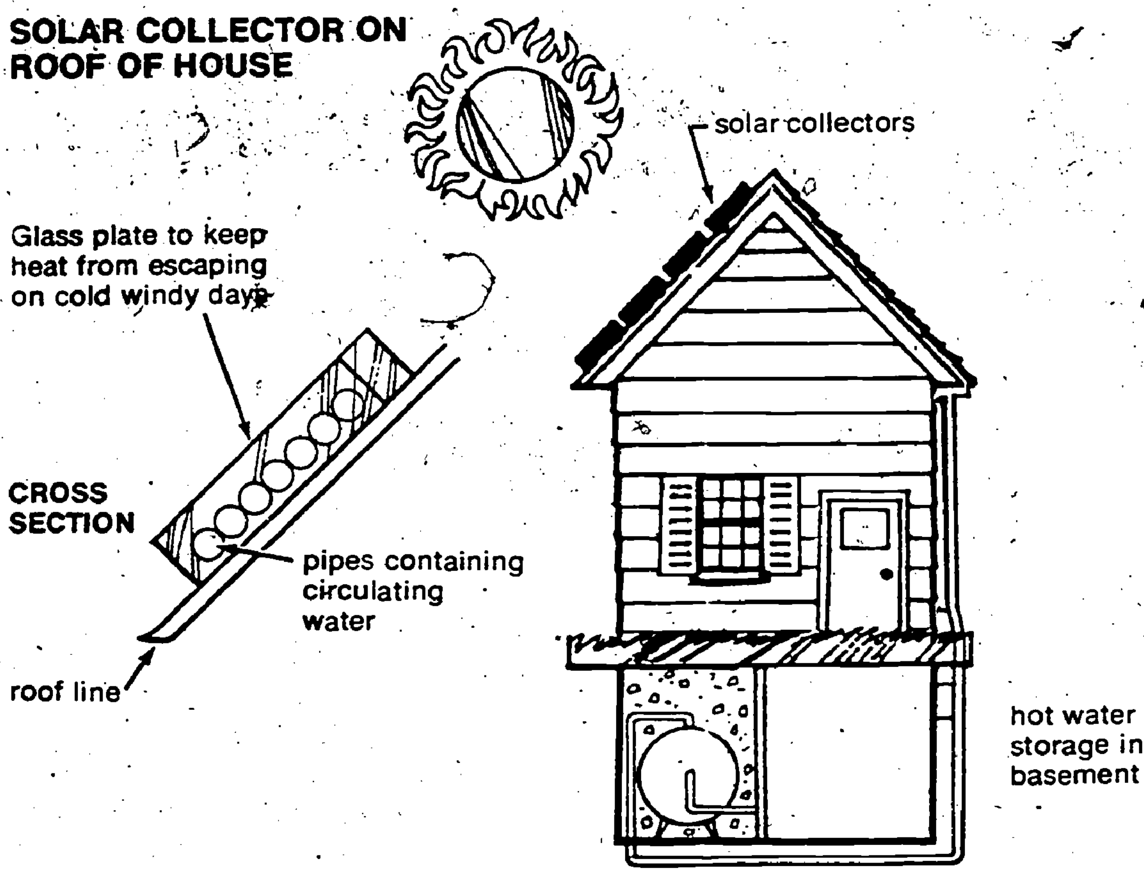
Ask students to read the information in the activity "Problems/Solutions" which offers a quick summary of several new energy sources. To complete the items on the page after next, they will need to refer to this information and to other sources.

After students finish filling in the blanks and after you have discussed their answers, you might want to find the energy sources with the fewest problems and most benefits. But remember that numbers of problems or numbers of benefits are not conclusive. One problem might be so severe that it outweighs all the benefits. Ask students which sources of energy seem more likely to work than others. Which might fill our energy requirements of the future? Point out that our energy needs may be ultimately filled not by a single source, but by a combination of many.

Energy from the Sun (Part 1)

There are several ways to use solar (sun) energy. One way is for each house, apartment or office building to collect enough solar energy to take care of its own heating, air conditioning, and water heating, but not its electric power. Another is to build huge solar farms to collect solar energy, turn it into heat and then to electricity that will be sent to individual dwellings. A one-square mile farm of many of these collectors could supply electricity for about 20,000 houses.

SOLAR COLLECTOR ON ROOF OF HOUSE



1. What parts of the U.S. would be able to use solar heat without a conventional back-up furnace?

2. What side of the roof should the collectors be mounted on?

3. Why is the inside of some types of collectors lined with mirrors?

4. Will the heat from roof collectors be used to generate electicity?

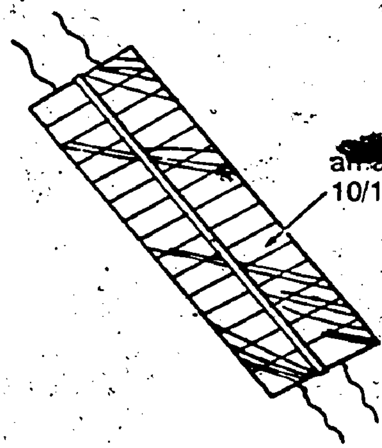
5. Could the heat from solar farm collectors be used to generate electricity?

6. The U.S. Energy Research and Development Administration foresees as much as 25 percent of our energy needs filled by solar technologies by the year 2020. Why will it take so long?

Energy from the Sun (Part 2)

SOLAR CELL

This device converts sunlight directly into electricity, with no moving parts and no pollution.



1. Solar cell systems are now used to power spaceships and ______________________

2. We probably will never run out of silicone as a resource because it is the second most plentiful substance on earth. Do you know its more common name? ______________________

3. If it now costs $20 a watt to generate electricity by means of solar cells, how much would you have to spend on equipment to power just the 100 watt light bulbs in your house? ______________________

4. What do we need to do before we can use solar cells as an energy source? ______________________

5. How can electricity be stored to use later? ______________________

THE ADVANTAGES AND THE DISADVANTAGES OF SOLAR ENERGY

DISADVANTAGES

1. Expensive to install
2. Requires a great deal of space
3. The sun doesn't always shine
4. Would mean modification of housing in many cases
5. New laws would be needed concerning construction that might cast shadows

ADVANTAGES

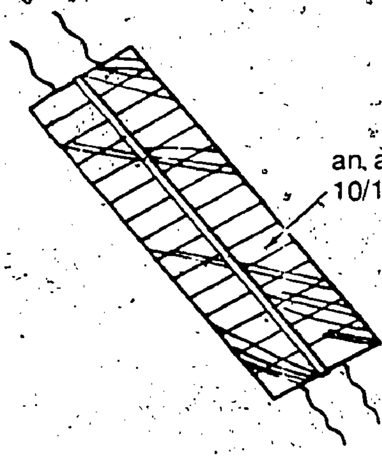
(See if you can supply the advantages. What is good about solar energy in regard to each of the following?)

1. Supply. ______________________
2. Pollution. ______________________
3. Embargoes. ______________________
4. Cost. ______________________

Energy from the Sun (Part 2)

SOLAR CELL

This device converts sunlight directly into electricity, with no moving parts and no pollution.



1. Solar cell systems are now used to power spaceships and *satellites*

2. We probably will never run out of silicone as a resource because it is the second most plentiful substance on earth. Do you know its more common name? *sand*

3. If it now costs $20 a watt to generate electricity by means of solar cells, how much would you have to spend on equipment to power just the 100 watt light bulbs in your house? *# of bulbs × 100 × $20*

4. What do we need to do before we can use solar cells as an energy source? *further develop technology and bring down cost*

5. How can electricity be stored to use later? *in storage batteries*

THE ADVANTAGES AND THE DISADVANTAGES OF SOLAR ENERGY

DISADVANTAGES

1. Expensive to install
2. Requires a great deal of space
3. The sun doesn't always shine
4. Would mean modification of housing in many cases
5. New laws would be needed concerning construction that might cast shadows

ADVANTAGES

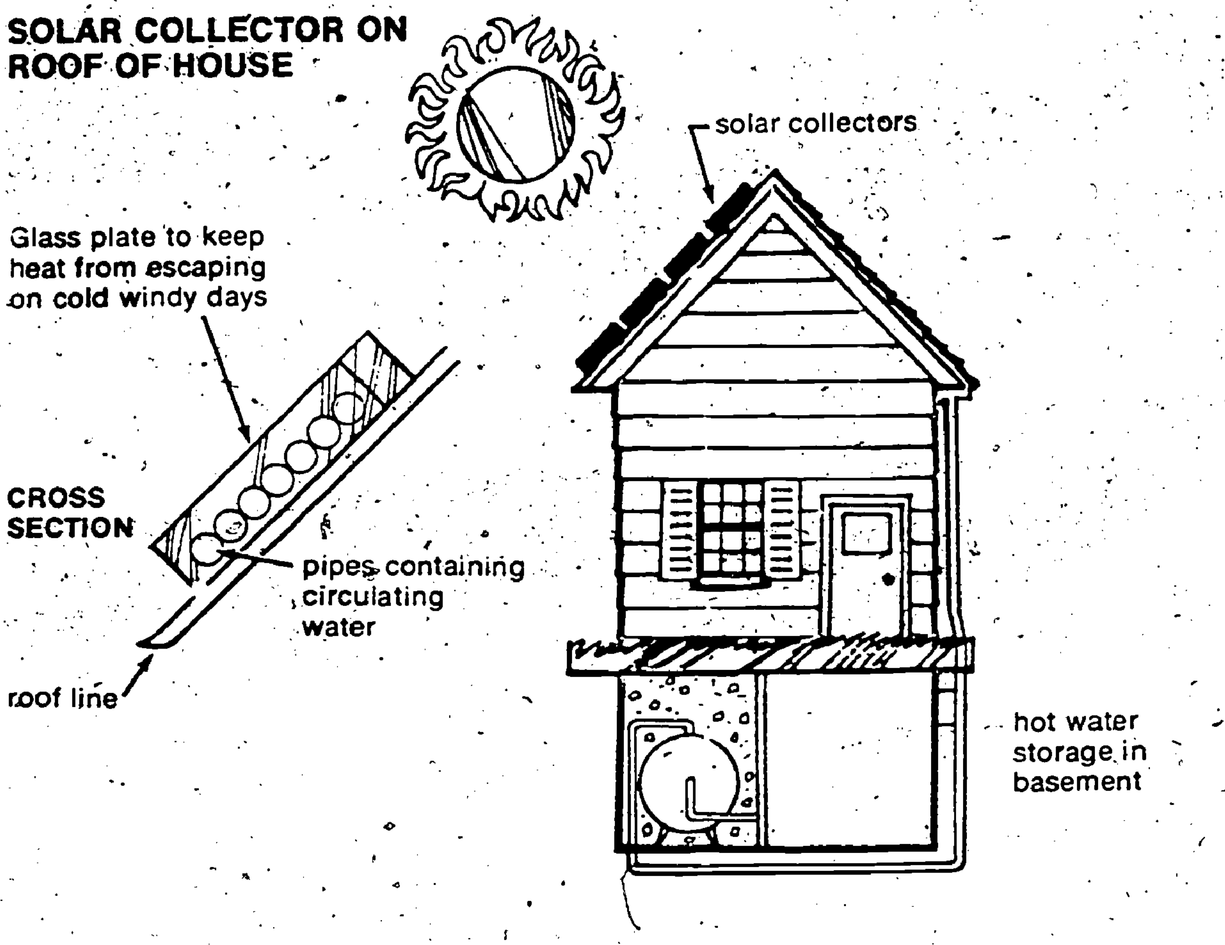
(See if you can supply the advantages. What is good about solar energy in regard to each of the following?)

1. Supply. *The sun's energy is almost inexhaustible*
2. Pollution. *Solar energy is clean; no mining or burning.*
3. Embargoes. *No nation can cut off another nation's supply of sunlight.*
4. Cost. *Installations are inexpensive to maintain.*

Energy from the Sun (Part 1)

There are several ways to use solar (sun) energy. One way is for each house, apartment or office building to collect enough solar energy to take care of its own heating, air conditioning, and water heating, but not its electric power. Another is to build huge solar farms to collect solar energy, turn it into heat and then to electricity that will be sent to individual dwellings. A one-square mile farm of many of these collectors could supply electricity for about 20,000 houses.

SOLAR COLLECTOR ON ROOF OF HOUSE



1. What parts of the U.S. would be able to use solar heat without a conventional back-up furnace?
   the South, Southwest

2. What side of the roof should the collectors be mounted on?
   the south side

3. Why is the inside of some types of collectors lined with mirrors?
   to reflect and concentrate the rays of the sun

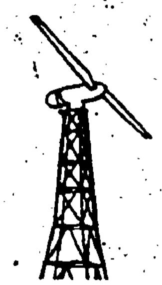
4. Will the heat from roof collectors be used to generate electicity?
   no

5. Could the heat from solar farm collectors be used to generate electricity?
   Yes

6. The U.S. Energy Research and Development Administration foresees as much as 25 percent of our energy needs filled by solar technologies by the year 2020. Why will it take so long?
   technology; cost; setting research priorities

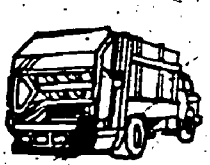
Other New Energy Resources

Besides nuclear and solar energy, there are several other possibilities for the future. Read about some of these new energy sources on this page. Problems and solutions are associated with each of them. On the next page you will decide what some of these problems and solutions are.

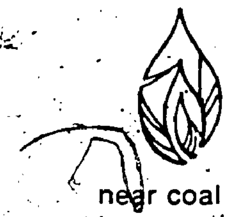


WIND. Wind is actually a form of solar energy since it is caused by variations in the temperature of the air heated by the sun that causes air to move. Sailors used this energy for ages. For many years farms have used windmills to generate electricity. Maybe giant windmills will someday be able to provide electricity for entire towns. The major difficulties are that the wind doesn't blow all the time and that practical storage systems are still being developed.

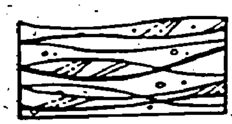
GEOTHERMAL. The earth's center is a molten mass. In some areas this mass is close to the surface. Some evidence of this are volcanos, geysers, and hot springs. This heat can be trapped and used to generate electricity to supply cities without polluting the atmosphere. The problem is that this energy can now be tapped only where it is near the surface. Scientists are searching for other areas where this geothermal energy can be reached, but they don't have all the answers yet.



PYROLYSIS OF SOLID WASTE. It is possible to heat waste in an oxygen-free atmosphere and produce oil and gaseous products. This waste is what we're now having trouble removing from our environment: manure, garbage, paper, logging residue, some industrial waste, sewage, and the like. The difficulty is that this material tends to be scattered in small amounts at various sites. The problem is one of gathering it together at a reasonable cost.



COAL GASIFICATION. By using high temperature and pressure, coal can be converted into a gas very much like natural gas. Building these conversion plants near coal fields can solve the problem of transporting bulky fuel that gives off pollutants when it is burned. When coal gas is burned, it burns as cleanly as natural gas, causing virtually no air pollution. The usual pollution problems occur in the coal mining process, however, as they always have. The conversion process itself, however, uses large amounts of electrical energy.



COAL LIQUEFACTION. Although the technology is not completely developed, coal can be converted to an oil-like liquid. It has the advantage over coal gas of being usable to make all the usual oil products, including a kind of gasoline to run our cars.

OIL SHALE. Oil shale is a rock containing a material that yields oil when it is crushed and heated. One ton of rock will produce about 25 gallons of oil. Most oil shale deposits are in the West. The rock must be mined, either by deep mining or surface mining. Extracting the oil takes large amounts of water — three barrels to every one barrel of oil processed. One of the big problems is the disposal of the spent rock after the oil is extracted. Vegetation will not grow on the used shale without a moderate amount of rain — scarce in many parts of the West. Without vegetation, some animals may lose their homes and natural food supply. Rain water passing through this rock will possibly pick up pollutants and carry them to larger bodies of water if there is no vegetation. In addition, oil shale processing contributes to air pollution.

Problems/Solutions

In this unit, you have learned about eight new energy resources. The use of any one of these resources may help to supply our energy requirements but may at the same time present us with new problems to consider. In the lefthand column of this page are some of these issues—some are problems, some are solutions. Mark each statement S (for source column on the right to which a statement applies. The first one is done for you.

	IF THIS ENERGY SOURCE IS USED, IT . . .	SOLAR	NUCLEAR	WIND	GEO-THERMAL	COAL GASI-FICATION	COAL LIQUI-FACTION	OIL SHALE	PYROL-YSIS
S	WOULD HELP SOLVE THE PROBLEM OF SOLID WASTE DISPOSAL.	✓		✓	✓	✓	✓		✓
____	COULD POLLUTE WATER.								
____	WOULD CONSERVE THE DWINDLING RESERVES OF FOSSIL FUELS.								
____	COULD DAMAGE WILDLIFE OR THEIR HABITAT.								
____	WOULD BE DIFFICULT TO STORE AND TRANSPORT.								
____	WOULD NOT POLLUTE THE ATMOSPHERE.								
____	WOULD DISRUPT THE NATURAL USE OF LAND SURFACES.								
____	WOULD NOT BE ABLE TO SUPPLY ENERGY ALL THE TIME.								
____	WOULD HAVE TO WAIT UNTIL THE TECHNOLOGY IS DEVELOPED.								
____	WOULD USE LOTS OF WATER TO PROCESS.								
____	WILL DECREASE THE NEED FOR OIL IMPORTS.								
____	WILL MAKE LARGE AMOUNTS OF WASTE MATERIAL.								
____	WILL MAKE USE OF THIS COUNTRY'S MOST ABUNDANT FOSSIL FUEL.								

Problems/Solutions

In this unit, you have learned about eight new energy resources. The use of any one of these resources may help to supply our energy requirements but may at the same time present us with new problems to consider. In the lefthand column of this page are some of these issues—some are problems, some are solutions. Mark each statement S (for source column on the right to which a statement applies. The first one is done for you.

	IF THIS ENERGY SOURCE IS USED, IT . . .	SOLAR	NUCLEAR	WIND	GEO-THERMAL	COAL GASI-FICATION	COAL LIQUI-FACTION	OIL SHALE	PYROLYSIS
S	WOULD HELP SOLVE THE PROBLEM OF SOLID WASTE DISPOSAL.	✓		✓	✓	✓	✓		✓
P	COULD POLLUTE WATER.		✓		✓			✓	
S	WOULD CONSERVE THE DWINDLING RESERVES OF FOSSIL FUELS.	✓	✓	✓	✓				
P	COULD DAMAGE WILDLIFE OR THEIR HABITAT.				✓			✓	
P	WOULD BE DIFFICULT TO STORE AND TRANSPORT.	✓		✓					
S	WOULD NOT POLLUTE THE ATMOSPHERE.	✓		✓					✓
P	WOULD DISRUPT THE NATURAL USE OF LAND SURFACES.		✓		✓	✓	✓	✓	
P	WOULD NOT BE ABLE TO SUPPLY ENERGY ALL THE TIME.	✓		✓					
P	WOULD HAVE TO WAIT UNTIL THE TECHNOLOGY IS DEVELOPED.	✓		✓	✓	✓	✓		
P	WOULD USE LOTS OF WATER TO PROCESS.							✓	
S	WILL DECREASE THE NEED FOR OIL IMPORTS.	✓	✓	✓	✓	✓	✓	✓	✓
P	WILL MAKE LARGE AMOUNTS OF WASTE MATERIAL.							✓	
S	WILL MAKE USE OF THIS COUNTRY'S MOST ABUNDANT FOSSIL FUEL.					✓	✓		

ENERGY

HOW CAN I HELP?

AN ENERGY CURRICULUM
MODULE #6

Governor's Energy Council

Pennsylvania Department of Education 1979

MODULE 6

How can we as individuals conserve energy? It would seem that the best place to start would be those areas where we use the most energy; and for the average person, these areas are automobile travel and home heating and cooling.

AUTOMOBILE TRAVEL

Americans own over 100 million cars, so it should not be surprising to realize that passenger cars consume about 14 per cent of all the energy and about 31 per cent of all the petroleum used in the United States. Much of the gasoline we consume is wasted by poor driving habits, poor car maintenance, and poor planning.

Excessive speed is a fuel waster – gas mileage is about 21 per cent better at the speed limit of 55 mph than it is at 70 mph.

Learn to drive smoothly, anticipating changes and avoiding sudden stops and starts, which waste energy.

Don't warm up the engine more than a minute on cold days – simply drive slowly for the first quarter mile or so. Also, if the car is stopped for more than a minute, turn off the engine. It takes less gas to restart the car than it does to let it idle for more than a minute.

Use air conditioning only when you are really uncomfortable – it decreases fuel economy by about 10 per cent.

Do not carry anything in the trunk except what you really need. The extra weight takes extra gas.

Plan your driving to use less gasoline. Carpool if you can, consolidate many errands into one trip, plan the most efficient route, avoid rush hour traffic when possible, walk when possible!

Keep your car properly tuned, and keep the tires properly inflated and balanced for more efficient fuel use.

Strongly consider fuel economy when buying a new automobile.

HOME HEATING AND COOLING

More than half of the energy we use in our homes goes into heating and cooling. There are several ways to save energy in these areas.

Wise use of the thermostat is one such way. During the winter, a maximum daytime temperature of 65 degrees Fahrenheit has been recommended, with lower nighttime settings. During the summer, use air-conditioning only when absolutely necessary, and set the thermostat no lower than 78 degrees Fahrenheit. If you plan to be away from home for long periods, turn off air conditioners in the summer, and decrease thermostat settings in winter. Make sure your thermostat is properly adjusted and cleaned. Whenever possible, turn off or lower the amount of heated or cooled air going to unused rooms.

Another important way to save energy in home heating and cooling is by using adequate insulation to reduce the leakage of heat into or out of the house. The area of greatest heat loss or gain generally is the roof. Fortunately, this is also usually an easy area in which to install insulation. The effectiveness of insulation is given by its R value, which indicates its resistance to the passage of heat. The higher the R value, the greater this resistance. At least 6 inches of R-30 insulation is recommended for attic floors, while R-13 insulation is recommended for exterior side walls and floors over unheated areas. Adequate insulation will quickly pay for itself and thereafter return a substantial savings in heating and cooling costs.

Other ways to plug energy leaks include weather stripping and caulking around windows and doors and use of storm doors and windows.

In many areas of the country, it is possible for fans to be used in the summer instead of refrigerated air conditioning, at a 90 per cent savings of energy.

High humidity helps our bodies feel warmer. Thus a humidifier may save money in the long run by allowing lower thermostat settings in winter with no decrease in comfort. A pan of water placed near a heating outlet will help to put moisture into the air if no humidifier is available. House plants also give off moisture. It may also be possible to vent your electric clothes dryer inside the house in winter, adding warm moist air. Conversely, the dryer should be vented to the outside in the summer, and moisture-producing activities such as mopping floors should be scheduled for cooler times of the day.

Proper maintenance of heating and cooling equipment means better efficiency and fuel savings. Keep all of the equipment clean and free from dust. Check air filters about once a month, and clean or replace when they are covered with dust or lint. Have your entire heating system cleaned, checked, and adjusted by a professional once a year. If your heating or cooling system includes ductwork, check closely for air leaks and repair them with duct tape. Ductwork that is exposed to outside or attic air should be insulated.

In considering the purchase of an air conditioner, you must consider its cooling capacity, which is the number of BTU's of heat it can remove from the air in one hour. But you should also consider its energy efficiency ratio, which is the number of BTU's of heat that one watt of electricity will remove from the air in one hour. The EER will be a number ranging from about 4 to 12, and will be displayed on the air conditioner. The higher the EER, the more efficient the air conditioner.

Lined or insulated drapes, properly used, can cut heating and cooling loads. On sunny winter days, the drapes on the sunny side of the house should be open to permit warming by the sun. Otherwise, drapes should remain closed in winter to cut down heat loss through the window glass. On summer days, use the drapes to block the sun.

In a weather pattern of cool nights and hot days, open windows at night to cool the house, and close windows and drapes in the morning to retain the cool air. In other words, use natural means of keeping comfortable whenever possible.

OTHER ENERGY SAVING TIPS

Heating water is the second largest single energy consuming task in the home. Set the water heater thermostat as low as possible – about 140 degrees Fahrenheit if you have an automatic dishwasher, lower if you do not.

Think of ways you might be able to use less hot water – showering instead of bathing, stopping dripping faucets, doing laundry in cold water, avoiding letting water run unnecessarily.

If you are purchasing a new water heater, buy only the size you need. A tank that is too large for your needs wastes energy by making unnecessary amounts of hot water. Choose one that is efficient and well-insulated. Try to minimize heat loss in water pipes by locating the water heater nearest the points of maximum hot water use. Use the smallest diameter of hot water pipes, and insulate them.

Refrigerators and freezers are the home's third largest energy users. One important energy conservation tip for these appliances is to open them as infrequently as possible and for as short a time as possible to reduce the loss of cold air. Keep the controls at a setting that maintains a refrigerator temperature of 37 degrees Fahrenheit to 40 degrees Fahrenheit, and a freezer temperature of 0 degrees Fahrenheit. Locate refrigerators and freezers away from sources of heat and direct sunlight, and make sure there is room for air circulation if specified in the operating instructions. Also keep condenser coils and front grills clean. Defrost before frost becomes 1/4 inch thick. Buy a new refrigerator or freezer with an eye toward energy efficiency, and again buy the smallest size that fits your needs.

Save energy when cooking food by matching pan size to burner size, and using covered pans when possible. Never try to use a stove as a source of kitchen heat – it is inefficient and dangerous as well. Use small appliances whenever possible, such as electric fry-pans or toaster ovens. These generally use less energy than the stove itself. A pressure cooker is a great energy saver, as is a microwave oven. Oven cooking is generally more economical than surface cooking. Avoid opening the oven door except when necessary to minimize heat loss.

An automatic dishwasher need not be considered an energy extravagance, since washing and rinsing dishes in hot water by hand three times a day probably takes more energy than doing one load per day in a dishwasher. But do wait until the dishwasher is full to use it. Whenever possible, open the door of the dishwasher when it reaches the drying cycle and let the dishes air dry. This can reduce energy consumption by 1/3 to 1/2.

In the laundry, wash only full loads, but do not overload. Use as little hot water as possible. Do not overdry articles in the dryer – it causes wrinkles as well as wasting electricity. Keep the dryer's lint filter clean. Rediscover the old-fashioned clothes line when its use is practical for you.

Only about 5 per cent of our electric bill goes for lighting, so it does not pay to stumble in the dark or strain our eyes. But of course it does not pay to be wasteful either. It is not true that it is better to leave a light burning than to turn it off and on several times. We do save electricity by turning off lights when we leave a room, even if we are coming right back. It is a good habit to ingrain in our families to turn out the lights when they leave a room. Fluorescent lighting is more economical than more common incandescent bulbs, and should be considered where their use is practical.

Use common sense to conserve energy with other household appliances, and thus save money as well as energy.

One other conservation tip concerns not so much the amount of energy we consume, but the time of day we consume it. We stated in Module III that electricity cannot be stored in any large quantities, but must be generated when needed. There are certain peak periods when a utility may not have enough generating equipment to meet the electrical demand. This is especially true in very hot or very cold periods. When it is convenient for us to do so, we should try to schedule our use of electrical appliances when the demand for power is lower in our area. We should especially avoid excessive use of electricity between 5 and 8 p.m. in the winter and 1 and 6 p.m. in the summer.

What we really must learn to do is to stop and think about our use of energy. We can no longer afford to use it as if it were limitless. If we do use care, we can cut energy use without seriously lowering our standard of living. It is something each of us needs to do in order to make a real impact.

A CONSERVATION ETHIC

"Energy Conservation Creed" (from ERDA's *Energy Conservation in the Home)*

> I pledge that I will learn to participate automatically in all those conservation activities which have no apparent disadvantages to myself and which require minimal energy on my part. I further pledge that although certain conservation activities may have minor personal disadvantages, I will volunteer to participate in them. And in the event that these activities are not sufficient, I will tolerate those activities which may produce serious disruptions in my lifestyle. I pledge all this in the interest of future generations.

American society has in the past emphasized materialism. We have become a *convenience* or *disposable* society. Today's energy situation necessitates the development of a conservation ethic, such as the one given above. This can be done only by awakening in students a moral sense that our greed and waste has been wrong, and by encouraging changes in the buying habits of our young people.

A prime example of our lack of such a conservation ethnic can be seen in our food. The production, processing, transporting, and distribution of food in this country consumes over 8,600 trillion BTU's each year, about 13 per cent of the U.S. energy consumption. Of the total energy consumed in this sector, 24 per cent is used for fossil fuels, electricity and fertilizer to grow the food on the farm; 38 per cent is used in paper packaging, food processing and transportation; and 37 per cent in refrigeration and cooking. Today, ten times as much energy is consumed by food system than is contained in the food produced. In other words, by the time the food reaches your table, 10 calories of energy have been expended for each 1 calorie of food eaten. The energy used to feed beef cattle on feed lots to feed us is an example of this energy intensiveness of our food producing process. Protein in our diets could be obtained by less energy intensive methods.

There is a major waste of energy in food packaging. In the American supermarket, every vegetable is wrapped in plastic and displayed in boxes. Every supermarket plastic bag adds 171 BTUs to the total energy expended to produce the product. Our fast food chains provide meals wrapped and boxed in an extremely wasteful fashion. The most energy intensive food items are foods and drinks in throw-away aluminum cans, plastic bottles, TV dinners, frozen foods, and aerosol cans. EPA estimates that if 90 per cent of the consumers bought returnable beverage containers, for example, the equivalent of 92,000 barrels of oil a day would be saved.

We sorely need to make ourselves and our students aware of these issues, so we can make informed decisions in the marketplace.

Activity VI-1

Objective:

The students will learn how different countries use and conserve energy.

What to do?

Divide the class into four or five groups. Assign each group a country to investigate. The groups will find out how their country uses energy. Conclusions can be reported to the class. Reporting can be done in various ways – bulletin boards, tape recordings for listening centers, drama production, etc. Try to identify unique methods of using or conserving energy. For example, the Netherland uses "Witkars" – cars which run on batteries and do not use gasoline.

Activity VI-2

Objective:

The students will recognize other peolple's points of view concerning the energy shortage.

What to do?

1. Family Roles – The students may divide into groups to roleplay family situations which require reaching decisions based on energy conservation. For example:
   Should the family go on vacation or buy a new car?
   Should the child go to camp or buy a 10-speed bike?
   Should Mr. Jones buy his wife a dishwasher or dryer for her birthday?
   How can the family conserve energy?
   How can the family eliminate unnecessary car trips?
2. Community Roles – Select a community problem or possible problem such as gasoline shortage, a rise in electrical rates, a coal miners or truckers strike, or rationing of heating oil. Problem-solving situations may also be proposed, such as setting up a gas rationing system, eliminating pollution problems, or a wage-price freeze. Select students to play the following roles:
   The owner of a trucking company
   A government official
   A farmer
   A businessman

Activity VI-3

Objective:

Students will become familiar with some possible conservation methods.

What to do?

Have students complete the activities entitled "What Can You Do to Save Energy" and "It's Everyone's Job." They may want to work on the second one in small groups.

What Can YOU Do To Save Energy?

Part 1:

Brenda's mother and Wayne's father each work ten miles away from their homes. In a five-day week, each uses five gallons of gas driving to and from work. Wayne's father drives alone. Brenda's mother is in a car-pool in which she takes four other persons to work. If each of her passengers drove, each would also use five gallons of gas a week. Now that they car-pool, how much gasoline does Brenda's mother help save each week?

____

each year? _______________

How could Wayne's father help save energy? _______________

____

... Bailey's are going away on vacation. They are concerned about burglars and want a light on in their house from 7:30 to 11 o'clock each evening. Can you suggest how they might do this without wasting energy? _______________

____

Selecting the right size electric light bulb can help save energy. On the package is listed the number of watts (the amount of power needed to make the light bulb work), the lumens (the brightness of the bulb), and the number of hours the bulb will last. With this information how could you select the most efficient bulb? _______________

____

____

John and his sister are going to wash clothes. He wants to do his three shirts separately. His sister wants to do them with her five blouses. Which way will conserve energy? _______________

____

Why? _______________

____

Jack has just come in the door after playing in the snow and feels too warm. He wants to turn down the thermostat until he feels comfortable. His mother tells him to leave it where she has set it at 68 degrees. Who is more energy-conscious?

____

Why? _______________

____

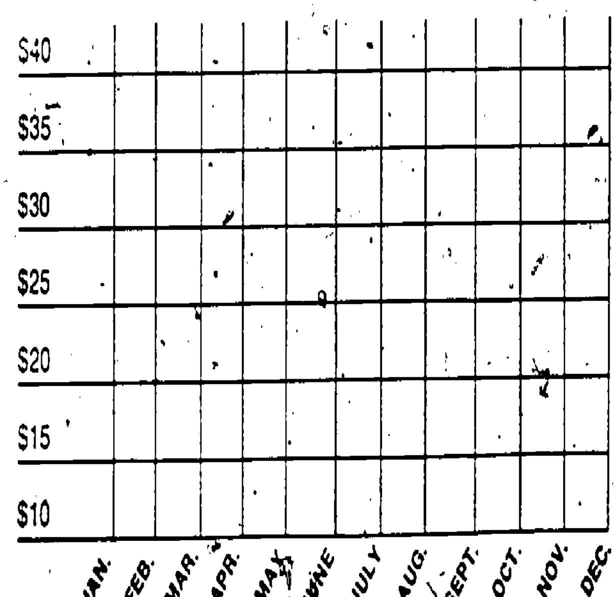
Part 2:

Below are the Hazleton's heating and air conditioning bills for two different years. In 1974, they had no insulation in their home. At the end of the year they had some installed, so the cost of heating and air conditioning in their home went down. In the graph below, place a dot for the cost of each month in 1974. Then draw a line between the dots. Do the same thing for 1975 in red. Compare the Hazletons' savings with insulation.

How much did they save in January? _______________

How much for the entire year? _______________

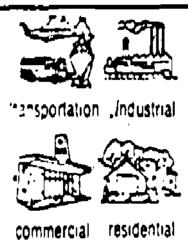
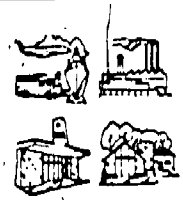
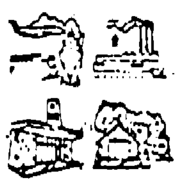
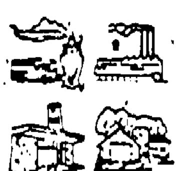
	1974	1975
January	$35	$25
February	$25	$20
March	$20	$20
April	$20	$15
May	$15	$10
June	$25	$15
July	$40	$25
August	$35	$20
September	$20	$15
October	$15	$15
November	$20	$15
December	$25	$20



1. At what time(s) of the year is there the highest utility cost? Why?
2. At what time(s) of the year is there the greatest savings after insulation?

It's Everyone's Job!

Read the idea for conserving energy in the column headed **Conservation Method.** Then answer the questions in the spaces provided.

Conservation Method	What sector of society? (circle one or more)	What energy resources does this save? (write: natural gas, petroleum . . . or coal)	Does it use less energy? (Yes or No)	Does it use energy more efficiently? (Yes or No)	How can we encourage this conservation measure? (brainstorm as many ideas as you can)
Flying passenger airplanes only when they are full					
Shipping freight by train instead of truck					
Replacing incandescent light bulbs with fluorescent lights					
Reducing heating and cooling where space is unoccupied					
Recycling steel, paper, glass, aluminum					
Developing and using mass transit systems					

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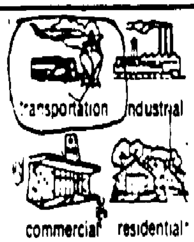
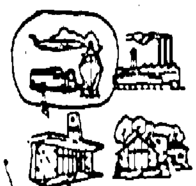
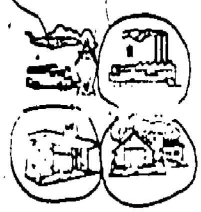
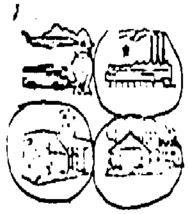
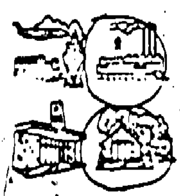
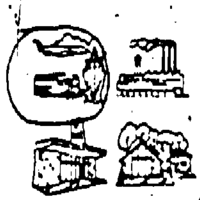
It's Everyone's Job!

Read the idea for conserving energy in the column headed **Conservation Method**. Then answer the questions in the spaces provided.

Conservation Method	**What sector of society? (circle one or more)**	**What energy resources does this save? (write: natural gas, petroleum . . . or coal)**	**Does it use less energy? (Yes or No)**	**Does it use energy more efficiently? (Yes or No)**	**How can we encourage this conservation measure? (brainstorm as many ideas as you can)**
Flying passenger airplanes only when they are full					
Shipping freight by train instead of truck					
Replacing incandescent light bulbs with fluorescent lights					
Reducing heating and cooling where space is unoccupied					
Recycling steel, paper, glass, aluminum					
Developing and using mass transit systems					

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Activity VI-4

Objective:

The students and their parents will prepare a list of ways to save electricity in the home.

What to do?

Have the students discuss ways to save electricity with their parents, and then make a list of specific things that they and their parents develop. Ask them to try to implement the suggestions in their home.

Activity VI-5

Objective:

The students will compare energy use of several home electrical devices.

What to do?

Following is a chart of annual KWH use for each of several home electricity consumers.

	Average KWH
Room air conditioner	935
Washer and dryer	1360
Cooking appliances	1500
Dishwasher	430
Freezer	1500
Lighting	1000
Refrigerator	1400
Color TV	525
B & W TV	360
Water heater	4000
Electric heat	13400
Miscellaneous	1205

Judging from the above figures, in which area are the greatest savings possible? What are ways of saving in these areas? Which areas are the easiest and most convenient to cut back on? Which is most important in energy conservation – turning off lights or turning back the thermostat in a house with electric heat? Turning off the TV or cutting down on the use of hot water? Cooking or heating? Dishwasher or air conditioner? How can you help people to understand which are the top priority areas for conserving energy?

Activity VI-6

Objective:

The students will compute the dollar savings involved in energy conservation.

What to do?

Have students contact your local utility and ask for the cost per KWH in your area. Assume that your home uses the amount of electricity in Activity 5 above, and that the rate per KWH stays the same. Compute the amount of money your family would save if you cut 10 per cent off each of the uses above.

Activity VI-7

Objective:

Students will prepare a poster on electrical energy conservation.

What to do?

Have students prepare posters which will be used to encourage people to turn off lights. Have them write a paragraph about why they think their poster should be awarded first prize in a poster contest. Have the class vote for winners. Display all posters prepared.

Activity VI-8

Objective:

Students will prepare a radio or TV script on electrical energy consumption.

What to do?

Have students create a one-minute radio or TV commercial dealing with some aspect of electrical energy conservation (or any other aspect of conservation you may choose). Have them present their commercials to the class. Ask: How many people does your commercial have to reach to change school or community attitudes? Who does your commercial have to convince?

Activity VI-9

Objective:

Students will relate conservation to their home clothes dryer, refrigerator, and lighting.

What to do?

Give students the instructions that follow. Have them report their findings to the class.

I. Does Your Clothes Dryer Waste Energy?

Put a load of wet clothes in the dryer. After 15 minutes, open the dryer door, wait for the drum to stop turning, and feel the clothes. They will probably still be damp. Close the door and restart the dryer.

Do this again every five minutes until the clothes feel dry to your touch. Look at the timer and see how much longer the dryer was set to run. If your dryer is electric, you can figure that every wasted minute burned up about 4/5 ounce of oil (or one ounce of coal) back at the power company. If your dryer runs on gas, figure that every wasted minute burns about 1/10 cubic feet of gas.

Here are two other energy-saving tips for dryers:

Make sure that the lint filter is cleaned out every time the dryer is used.

Don't dry "half loads" – fill up the machine before using it.

II. Helping Your Refrigerator Work Efficiently

You will need a thermometer for this experiment that will register as low as 30 degrees. Put your thermometer inside the refrigerator, close the door, and wait about 15 minutes for the thermometer to reach the inside temperature. Open the door, and working as quickly as you can, read the inside temperature. It will probably be about 40 degrees Fahrenheit.

Then, unplug the refrigerator's power cord from the wall outlet. Make sure that no one opens the door for exactly 15 minutes. Finally, open the door and take a temperature reading.

Plug the refrigerator back in (its motor will probably come on) and wait another 15 minutes with the thermometer inside. Read the thermometer again, and repeat the experiment – with one difference. Every five minutes, open the door for about 30 seconds. Now when you check the thermometer after 15 minutes, what do you find?

What energy-saving tip can you learn from this experiment? Another energy-saving tip: Vacuum the coils on the back of your refrigerator every three months or so for more efficient use of energy.

III. Checklist for Energy-Efficient Lighting

Walk through your home with pencil and paper and see if your lights stack up! Tell your parents about your findings.

1. Are bulbs and lampshades free of dust and dirt that block light transmission? Dirty bulbs and shades waste the light produced inside the bulbs, and you may turn on two lights when only one is needed.
2. Are lampshades translucent (so light can pass through them) rather than solid? Why produce light and then block it with a solid lampshade?
3. Are ceilings and walls light-colored so they reflect more light?
4. Are "non-critical" lighting levels in your home kept as low as possible? As a rule, one watt of lighting per square foot of floor area is enough for general room and hallway lighting. Use a yardstick or tape measure to make measurements. Of course, some tasks such as reading, sewing, etc. require more light.
5. Does everyone turn off lights when leaving a room? It does not take a lot of energy to start a light bulb, so you are better off turning lights off when they are unnecessary, even if it is for a few seconds.

Activity VI-10

Objective:

The students will solve and evaluate math problems pertaining to the conservation of gasoline.

What to do?

Have the students solve and discuss the implications of the following problems in relation to the conservation of gasoline.

1. Mr. Burns had the tank of his car filled with gasoline and noted that the odometer read 14593. The next time he stopped for gasoline it required 14 gallons to fill the tank and the odometer read 14817. How many miles did the car average per gallon of gasoline? Note: Some time may need to be spent teaching students to compute miles/gallon.
2. If a man travels from New York to Cincinnati, a distance of 660 miles, and his car averages 15 miles per gallon of gasoline, how many gallons are required to make the trip? How many gallons would be required if the car averaged 22 miles per gallon? What would the cost be for each one, if gasoline were 55.9 cents per gallon?
3. How far can a car go on a tankfull of gasoline if it averages 14 miles per gallon? The tank holds 18 gallons. How much farther could it travel if instead it averaged 22 mpg?
4. Correct tire inflation can save the average driver up to 50 gallons a year. If gasoline costs 55.9 cents per gallon, how much money would this save in a year?
5. Regular tune-ups can save the average driver 175 gallons of gasoline a year. How much savings is this with gasoline at 55.9 cents per gallon?
6. Driving at 70 miles an hour can take approximately 25% more gasoline per mile than driving at 50. Assume that, on a 300 mile trip, while traveling at 50 mph, your car has consumed 20 gallons of gasoline. How much more would it consume if you had traveled at 70 mph? How much more would this cost if gasoline were 55.9 cents a gallon?
7. The Government has asked the automobile manufacturers to produce automobiles that will average 20 mpg. The current average miles per gallon is 13.7 mpg. The average car travels about 10,000 miles per year. How many gallons are needed if your car averages 13.7 mpg? How much does each cost if gasoline is 55.9 cents per gallon? How much would you save in a year?

There are about 100 million registered automobiles in the U.S. How many gallons of gasoline would be saved if all automobiles got 20 mpg? (You have already calculated how much would be saved by one automobile above.) How much money would be saved in the U.S. if gasoline were 55.9 cents per gallon?

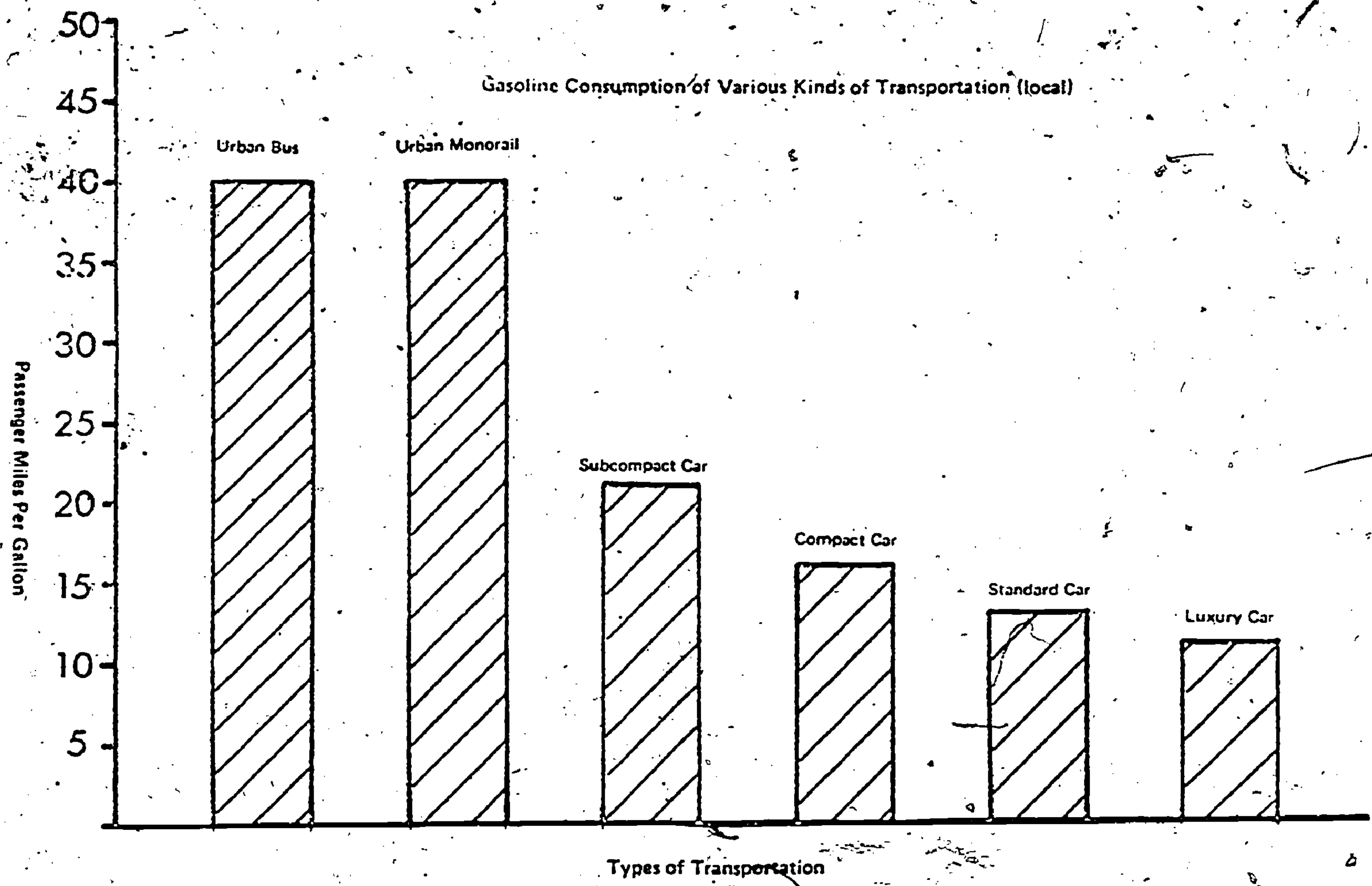
Activity VI-11

Objective:

The student will analyze the gasoline consumption of various kinds of local transportation.

What to do?

Discuss the following bar graph. Why don't more people use the more efficient methods of transportation?



Source: "Energy Efficiencies of the Transport Systems," Richard A. Rice, a paper presented before the Society of Automotive Engineers at the International Automotive Engineering Congress, Detroit, January 1973.

Activity VI-12

Objective:

The student will organize a file of newspaper and magazine articles relating to the oil shortage and then determine the pros and cons of each of the possibilities suggested by the clippings.

What to do?

Instruct a group within the class to begin a file of magazine and newspaper articles related to the oil shortage in the U.S. Special attention should be given to those articles which provide suggestions for increasing the availability of oil. Assign a panel of pupils to weigh the pros and cons of each of the possibilities suggested by the clippings. This panel could hear the arguments of three students selected to play the roles of an oil company executive, a Sierra Club spokesman, and an official of a Federal licensing agency. Then, after the arguments have been heard and the panel has deliberated, conduct a secret ballot among the class to determine the practicality or feasibility of each suggestion. The research activities implicit in this exercise should provide answers to the following questions:

How do we obtain the figures we use concerning the availability of oil?

What do the terms reserves, proven reserves, probable reserves, and future discoveries mean?

How reliable would you judge figures (in billions of barrels) assigned to each of these terms to be?

What would be the environmental impact of exploiting each of the suggested alternative oil sources?

What technological problems would have to be solved before oil from oil shale could be obtained in an economically and environmentally efficient manner?

Why are environmentalists opposed to offshore drilling?

What are the trade-offs that must be considered in the decisions about using these alternative sources of fuel?

What factors might determine whether coal could and should be used, rather than attempting to obtain oil from these alternate sources?

Activity VI-13

Objective:

The students will organize hypothetical car pools for their parents.

What to do?

Have a group of students devise a questionnaire that each student will complete, giving location of home and parents' work, times of work, etc. Then use the data on the questionnaire to form hypothetical car pools for the students' parents. What problems are encountered in organizing these car pools? Would it be feasible to actually use them?

Activity VI-14

Objective:

The students will read and discuss a spoof.

What to do?

Have the students read the following spoof, and then discuss the questions following it.

"An Arizona newswriter reports that a memo dated A.D. 3100 states that during the 20th century, the earth was inhabited by huge metallic-looking beasts called "autosaurs." These monsters weighed between 1,000 and 4,000 pounds, and could travel at terrific speeds. Although they could be ridden, he relates, they were never completely domesticated by the natives. Apparently thousands of natives lost their lives to them each year.

Around the last few decades of the century, he tells us, the "autosaurs" mysteriously disappeared. Scientists entertain the possibility of their having starved to death because of some inexplicable depletion of their food supply. A picture unearthed near Los Angeles supporting this theory shows great lines of these creatures queued up before a feeding station. One of the natives, in an obvious attempt to forestall extinction, is force feeding the leader by means of a hose injected into its "surprisingly small orifice. This effort was evidently unsuccessful." Our writer continues, "While the extinction of any species is to be mourned, it does not appear that the ecological balance of that period was upset by the autosaurs' disappearance. There is even some proof that it improved."

Questions to discuss:

Why does the name "autosaur" sound scientifically valid?

What characteristics does the writer attribute to the "autosaur" that reveals its identity?

Which of the author's remarkably logical sounding statements indicates that humans are not always the master of their inventions?

Humor can be instructive as well as entertaining. Do you find an underlying truth in this playful piece of prose? What is it?

Do you think the humor is enhanced by the fact that the story sounds possible and believable?

Which of the following conclusions do you think the author intended?

- We should more carefully protect our endangered species.
- Automobiles kill a great many people.
- The gasoline shortage, in the long run, will be beneficial to humans and their environment.

Does there seem to be any advantage in occasionally using a light, humorous touch, such as the author employed here, when you want to make a point? Why?

Activity VI-15

Objective:

The student will compare that heat loss in an insulated container with that in a similar non-insulated container.

What to do?

Materials needed: Two small, identical beakers, two shoe boxes, two thermometers, ceiling or roof insulation, boiling water.

Insulate one of the two boxes as well as possible. Leave the other box uninsulated, and make a few small holes in it. Insert a thermometer in a slit in the top of each cover. Pour the same amount of boiling water into each beaker, place them in the boxes so that the thermometer is in the water, and quickly cover the boxes. On the insulated box, be sure that the lid is sealed onto the box, and that the crack around the thermometer is well sealed. Watch the thermometers and note the changes in the temperature of the water. Ask students to predict what they think will happen, and to explain their predictions. Discuss the results. Use the experiment as a lead-in to discuss insulation in our houses.

Which construction materials provide the best insulation?

What is "thermopane"? How is it used?

Is good insulation important only in the winter when fuel is being used to heat the house? Explain.

What are the advantages of storm windows and doors?

What kinds of materials are used for insulating houses? Prepare a display of some of the more common ones.

How can room decorating (rugs, draperies) help in insulation?

What steps can be taken by the average homeowner to achieve better insulation?

If a well-insulated house saves money in fuel for heating and electricity for air conditioning, why are more new houses not better insulated?

Activity VI-16

Objective:

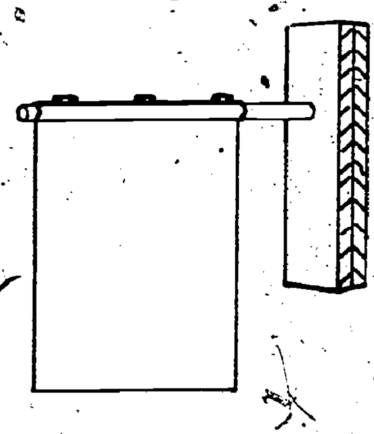
The student will construct a "draftometer" and will use it in various places.

What to do?

Materials needed: Plastic food wrap, a 10 inch length of 1/4 inch diameter wood dowel, one foot of 1 x 2 lumber cut into two 6-inch lengths, thumbtacks, wood glue, drill.

A draftometer is a simple gadget that you can use to locate improperly weatherstripped doors and windows and to pin-point cracks and crevices that need caulking.

Drill a 1/4-inch hole near the top edge of one of the pieces of 1 x 2. This piece is now the support (see sketch). Next, cement the dowel into the hole. The end of the dowel must be flush with the surface of the piece of wood. Then cement the other piece of wood to the support. Now, cut a 5-inch by 10-inch strip of plastic food wrap. Carefully wrap one end of the strip around the end of the dowel until only 4 inches or so of the strip is hanging free. Push 2 or 3 thumbtacks into the dowel to hold the wrap in place. The thin wrap acts like a "sail" – it will respond to the gentlest breeze by bending out of shape. To detect drafts, hold the draftometer near the edges of windows and doors, near passage-holes for pipes and ducts, and close to caulked seams. The piece of wrap should remain motionless. Noticeable movement signals poor weatherstripping and/or caulking.



Activity VI-17

Objective:

The student will investigate the amount of heat generated by light bulbs of different wattage.

What to do?

Hold a laboratory thermometer next to, but not touching, light bulbs of different wattages. What is the thermometer reading for a 40-watt bulb? For higher watt bulbs? How can this heat loss cause further energy waste during the summer? Which gets hotter – incandescent or fluorescent bulbs?

Activity VI-18

Objective:

The student will observe the effects of solar heating on a cardboard house.

What to do?

Materials needed: A cardboard box such as a shoe box, a thermometer, plastic wrap, tape, cloth.

Build a cardboard "house" by taping a piece of plastic wrap across the open top of a cardboard box. Next, punch a small hole in one end of the box and slip the thermometer in place. On a sunny day, place the box on the sunniest window sill with the plastic "front" facing the sun. Record the temperature inside the box. Now put a piece of cloth over the plastic "window" to simulate a window curtain or shade. Record the temperature inside the box. Is it different from the first time? What does this tell you about use of curtains and draperies?

Activity VI-19

Objective:

The students will design and build houses and test them for heat loss or gain.

What to do?

Materials needed: Various building materials, limited only by imagination.

Have the students design and construct different styles of buildings and test them for energy efficiency. The buildings could be built from popsicle sticks, covered with different materials, painted different colors, and showing different architecture, i.e., ranch, two level. The buildings should each have a way of inserting a thermometer to test for heat transfer. What effects do various aspects of the buildings have on their heat loss or gain?

Activity VI-20

Objective:

The student (and parents if possible) will inspect the conservation practices followed in the home.

What to do?

Have students use the checklist which follows as an aid to class discussion and as a guide to making proposals for improving conservation in the home.

A CHECKLIST OF ENERGY CONSERVATION PRACTICES

During the Heating Season

	YES	NO
1. Do you have storm windows and storm doors?	____	____
2. Do you keep outside windows and doors closed?	____	____
3. Do you close the damper on your fireplace when the fireplace is not in use?	____	____
4. Have you caulked all window frames properly?	____	____
5. Do you close off unused rooms and shut off the heat in these rooms?	____	____
6. Do you keep radiators and air ducts clean and free of obstructions to permit the circulation of air?	____	____
7. Have you insulated the hot water pipes or hot air ducts used to heat your home?	____	____
8. Do you set your thermostat at 68° F during the daytime and 60° F at night?	____	____
9. Do you avoid blocking heating vents with draperies or furniture?	____	____
10. Have you installed draperies, shades, or blinds at all windows?	____	____
11. Do you open draperies, shades, or blinds during the daytime to utilize solar heat?	____	____
12. Do you close draperies, shades, or blinds at night to keep the building interior warmer?	____	____
13. Do you have your furnace cleaned and checked yearly to promote efficient use of fuel burned?	____	____
14. Has your thermostat been cleaned and checked prior to the heating season?	____	____
15. Do you shut off all exhaust fans (kitchen and bathroom) when not needed?	____	____
16. Do you have adequate insulation? (R-30 or more in attics, R-19 in exterior walls, and R-19 in floors over unheated areas)	____	____
17. Do you close all exterior doors and storm doors quickly and tightly latch them?	____	____

During the Cooling Season

	YES	NO
1. Have you placed your air conditioners in the shade?	____	____
2. Do you have your air conditioner thermostat set no lower than 80° F?	____	____
3. Have you cleaned the condenser and evaporator surfaces?	____	____
4. Have you cleaned the air conditioner filters at least once every two weeks?	____	____
5. Have you closed the drapes or blinds on the sunny side of the building to keep out the sun's heat?	____	____
6. Have you closed all outside windows and doors?	____	____
7. Do you have the storm windows and doors in place?	____	____
8. Do you have all unnecessary lights turned off?	____	____

	YES	NO
9. Do you have all unused rooms closed off?		
10. Do you run your air conditioners on hot days only?		

Around the Home at any Season

	YES	NO
1. Do you use cold water instead of warm water for warm water instead of hot water whenever possible?		
2. Do you turn off the hot water tank when you go on vacation?		
3. Have you set your hot water tank at 120° F or some other low level that seems reasonable?		
4. Do you have all exposed hot water pipes insulated?		
5. Do you wash only full loads in the dishwasher or washing machine?		
6. Have you checked all water faucets for possible leaks?		
7. Do you turn off the water while you brush your teeth?		
8. Have you started to use less water for your shower or bath?		
9. Have you reduced bulb wattage where possible?		
10. Do you turn off all lights and appliances when not in use?		
11. Do you turn off televisions, radios, phonographs and stereos when no one is listening?		
12. Do you turn on porch lights or outside lights only when you expect visitors?		
13. Do you keep lights off when a room is not being used?		
14. Do you keep a brick in your toilet tank to save water?		
15. Do you keep a jar of cold water in your refrigerator to eliminate the need to have your faucet turned on so long to cool the tap water?		
16. Do you hang your washed clothes outside to dry when possible?		
17. Do you clean lighting fixtures, lamps, reflectors, and shades regularly?		
18. Do you replace broken windows promptly?		
19. Do you keep walls and ceilings clean and repainted when needed?		
20. Do you paint walls and ceilings a light color to brighten the rooms?		
21. Do you defrost all refrigerators and freezers before frost becomes greater than ¼ inch thick?		
22. Have you checked the refrigerator and freezer gaskets to determine if the gaskets should be replaced?		
23. Have you checked the gasket on your oven door?		
24. Do you dry clothes in consecutive loads to take advantage of a warmed-up clothes dryer?		
25. Do you empty the lint filter in your clothes dryer after every load?		
26. Do you use pots and pans which are same size as the burner in use?		
27. Do you plan oven use to bake more than one dish at a time? (little more energy is used to cook two or three things while the oven is heated)		
28. Do you always turn the oven or burner off immediately after use?		
29. Do you always turn off kitchen exhaust fans when you turn off the oven or burners?		

Transportation for you

	YES	NO
1. Do you walk or ride a bike to do short errands around home?		
2. Do you make all trips of ½ mile or less a walking trip?		
3. Do you use public transportation when available instead of your family car for trips over ½ mile?		
4. Do you obey speed limits at all times?		
5. Do you have your family auto tuned up at least twice a year?		
6. Do you have the idle of your family car reduced as much as possible?		
7. Do you maintain a constant speed in traffic?		
8. Do you accelerate and decelerate slowly?		
9. Do you participate in a car pool?		
10. Do you operate a vehicle which gets more than 20 mpg gas milage?		

Activity VI-21

Objective:

The student will determine which takes more water: a shower or a bath.

What to do?

Have students follow these directions:

Fill your bathtub with water (adjusted to the temperature you like best) as usual, but before you step in, use your yardstick to measure the depth of water in the tub. The next time you are going to bathe, close the bathtub drain and take a shower instead of a bath. When you are finished, measure the depth of water that has collected. Compare this reading with the bath water depth. Which takes more water? Why does more water mean more energy?

Activity VI-22

Objective:

The student will determine the amount of energy wasted by a dripping hot water faucet.

What to do?

If there is a leaky faucet available for use in this experiment, us it. Otherwise, adjust a faucet so that it leaks slowly but steadily. Put a measuring cup under the faucet and measure the amount of water collected in 15 minutes. Do some arithmetic to figure out how much water this amounts to in one year. (Figure it out in gallons.)

Now, assume that the drip was all hot water. You can figure out about how much fuel was wasted by using the following calculations:

For an oil fired hot water heater: Divide your answer by 110 – this gives the approximate number of gallons of oil wasted.

For a gas-fired hot water heater: Multiply your number by 0.84. This gives the approximate number of cubic feet of gas wasted.

For an electric hot water heater: Multiply the answer by 0.25. This gives the approximate number of kilowatt-hours of electricity wasted.

Activity VI-23

Objective:

The student will determine in what areas the greatest need for conservation of energy exists, and to see where the priorities lie in energy conservation.

What to do?

Discuss with the students the data on the following page.

The consumed energy in the United States is distributed in this manner:

Industrial	41.2%
Transportation	25.2%
Residential	19.2%
Commercial	14.4%

In which area is the most energy consumed? Why does the burden of conservation seem to fall on the average citizen in the residential area? Could industrial use be cut in half? What effect would this have?

Let us break down these areas to see where the greatest savings may occur.

A Industrial -

Process steam	40.5%
Direct heat	27.7%
Other	31.8%

Would it be easy to cut the industrial energy use? What effects would this have? What inducements could be given to industries who come up with energy saving ideas and methods? Why are industries themselves eager to cut back on their consumption of energy?

B. Transportation -

Urban passenger transportation	34.5%
Intercity passenger transportation	26.1%
Intercity freight transportation	14.5%
Other	24.9%

In which areas do you and your family consume most of your gasoline? In what area should the major emphasis on conservation be placed? What are some ways in which energy could be conserved in each area? Compare the energy consumed by shipping freight by truck, rail and air. What are some other factors involved besides cost in choosing the method for shipping freight?

C. Residential -

Energy consumed nationwide in the home is broken down as follows:

Space Heat	57.3%
Water heating	15.1%
Refrigeration	5.7%
Cooking	5.7%
Air conditioning	3.7%
Other	12.5%

In which areas are the greatest savings possible? What are some ways of saving energy in those areas?

D. Commercial -

Energy is consumed commercially in the following manner:

Space heating	48.0 %
Air conditioning	12.5%
Refrigeration	7.6%
Water heating	7.6%
Other	24.3%

How would you suggest that commercial and business establishments can best conserve energy? Is it reasonable to expect home owners to cut back on their thermostats but not business? How could business be induced to cut back on heating costs? Commercial heating is for you, the consumer. How could you influence businesses to cut back on thermostats and air conditioning? Do you prefer shopping at an air conditioned store in the summer?

Activity VI-24

Objective:

The student will become aware of the reliance of communities upon energy availability.

What to do?

Have the students develop the hypothetical Conservation City, as detailed below.

Conservation City is a new planned community to be located in Pa. Within and surrounding the community are to be located a petroleum refinery; a corporation interested in developing a summer resort area, a canning company, a paper mill, and a clothing factory. The population will be approximately 15,000. You are to develop a model community and decide what resources you will need and what type of transportation system, keeping the following in mind:

a. What type of natural resources are needed for the industries?
b. What type of locations are needed for the industries – include site description, water sources, fuel sources, wind direction, economic impact, environmental impact and human resources.
c. What type of energy will be needed for the industries and homes?
d. What type of transportation is needed for the industries? You will want to consider convenience, cost, pollution, and congestion.
e. What type of public transportation system should be established? Consider cost, convenience, and desirability. You will want no parking problems, traffic jams, or excessive gasoline consumption.
f. You want to hold pollution and environmental impact to a minimum.

Draw a map of your new community indicating plant location, natural resources available, street lay-out, public transportation systems, and residential areas.

Activity VI-25

Objective:

The students will observe the dependence of modern society on energy.

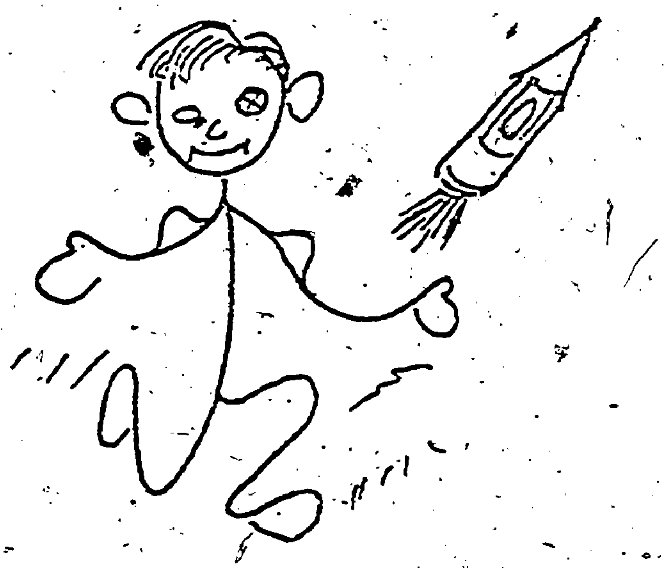
What to do?

Have the students contrast Robinson Crusoe with the Six-Million Dollar Man, as outlined below.

A. Robinson Crusoe, who was shipwrecked on an isolated island, for many years, had to survive under difficult conditions that fortunately provided him with some resources with which to work.

Discuss the supply of natural resources with which Robinson Crusoe had to work. How did he convert them to energy? Discuss the ways he developed to harness energy. Classify the ways he used energy into five categories: mechanical, chemical, radiant, nuclear, or electrical. Compare the methods he used to produce energy and power to those used by modern day society.

B. Have student itemize ways that the Six-Million-Dollar Man utilizes energy in a manner different from our everyday use.



Extend this study by assigning various works of science fiction by Arthur C. Clarke, Isaac Asimo v, H. G. Wells etc, and asking student to list the innovative uses and ways to produce energy used in those books. Classify them into the five types of energy (mechanical, electrical, chemical, radiant and nuclear). Other possible sources of research are the Star Trek, Popeye, and Superman television shows as well as many types of comic books.

Activity VI-26

Objective:

The student will make murals on energy conservations.

What to do?

Have the students as a group come up with a list of 5 ways the school could save energy and 10 ways the community could conserve energy. Have them do a mural to illustrate these ways. Display the mural for the school or community.

Activity VI-27

Objective:

The students will consider conservation in relation to lawn care.

What to do?

Have the students take a neighborhood poll on lawn care. Ask the following questions:

How much fuel does it take to keep your lawn mowed? (How much per month or per mowing season.)

Do you use any other fuel-consuming garden tools, such as clippers, edgers, mulchers? How much fuel do they consume?

What kind of fertilizers and pest killers do you use on your lawn and garden?

What do you think about unmowed lawns? (Lawns that grow naturally without any care).

Discuss the results of the poll. Is the use of powered garden tools justified? Is a lawn necessary? Is the "no mowing" idea unacceptable or acceptable?

Activity VI-28

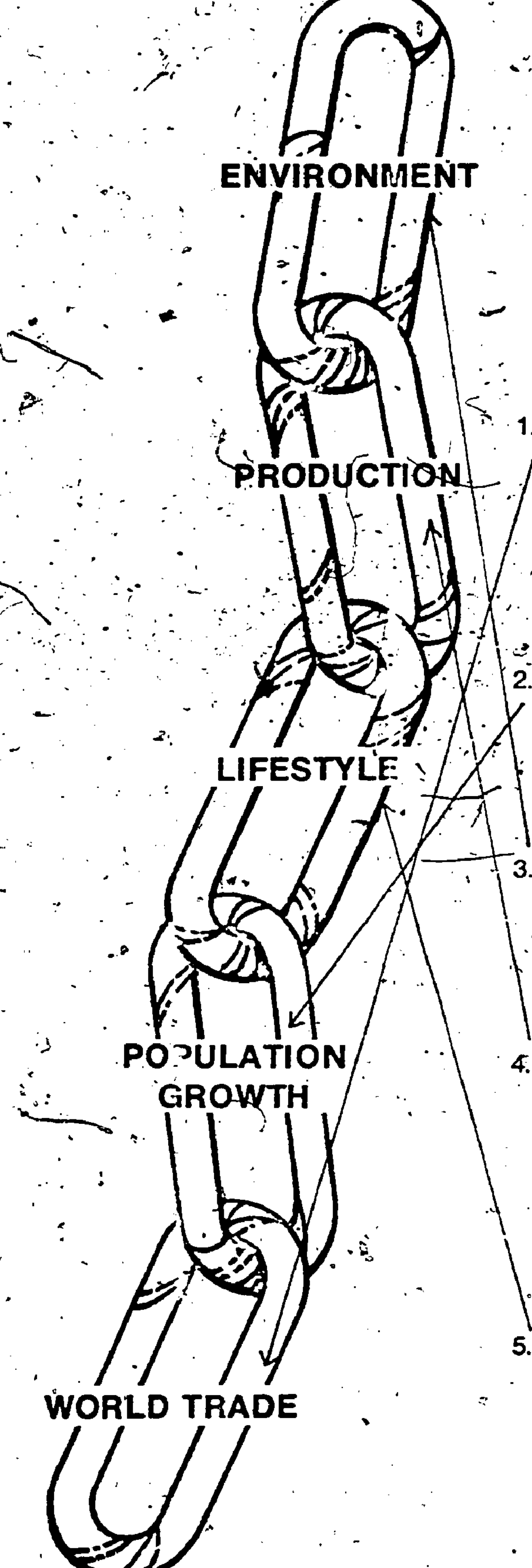
Objective:

The students will relate the information learned to personal experiences.

What to do?

In small groups, have the students brainstorm the conditions of the problems and solutions set forth on the page entitled "The Energy Chain."

The Energy Chain



Population growth, production of goods and services, dependency on foreign oil supplies, environmental health and safety, and the effect of these on our lifestyles — each of these is a link in the chain of energy use. Each is part of the energy challenge.

Draw a line from each short story to the appropriate link. Form small discussion groups. With others in your group, define the problem in the following situations and discuss what your solutions might be.

1. Time: One possible day in the future. Canada has decided to stop exporting oil. Some of the other oil-producing countries decide to band together and withhold oil in order to raise prices. U.S. supplies of oil are suddenly cut in half. There is no milk or bread in your house, no gas in the car, and you live 5 miles from the nearest store. What kinds of problems would you and your community face if there were a serious oil-shortage? How could you solve these problems?

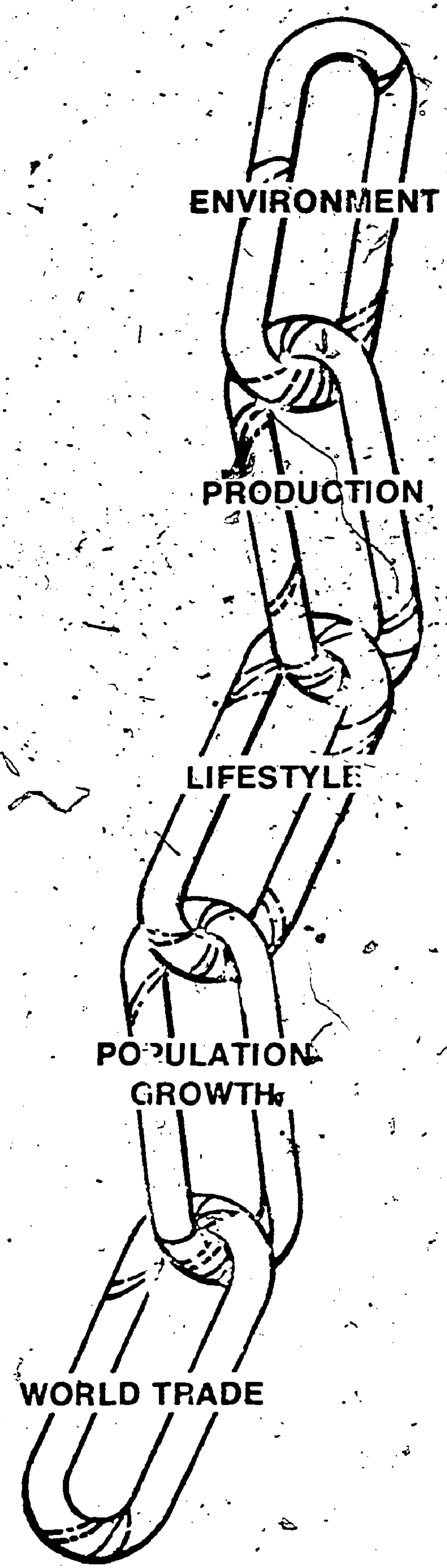
2. Each year the number of students in your classroom increases. This means more seats in less space, more noise, less personal help from your teacher. A new business has opened in your town, employing 300 people. Suddenly, your class size has doubled. How will this affect you and your school?

3. A large utility company is planning to build an electric generating plant right where you and your family camp and fish every summer. The coal resources are nearby (mining hasn't started yet, though) and the city 500 miles away is desperately short of electric power. Should the plant be built? Why or why not?

4. Your uncle manages a large farm that produces many food products. He operates tractors and giant combines; he runs a gasoline-powered irrigation system, cow-milking machines and crop-drying equipment. He uses fertilizers made from petroleum. Because petroleum is scarce, his costs have more than doubled. If he cuts back on his use of petroleum-based products, he would seriously reduce food production per acre. Is there any way he can cut back on his reliance on petroleum? How can consumers help cut energy needs for food production?

5. The annual operating budget of your city (your public tax money) can pay for either completion of the super highway system or enlarging the suburb-to-city mass transportation system, but not both. Most commuters don't like to ride buses, so the buses are usually only half full. The vote is coming up at the council meeting next week. How should the council vote?

The Energy Chain



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T	R	A	I	N	C	E	M	B	A	R	G	O	P	G
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L	U	M	E	I	N	S	T	E	I	N	S	I	I	O
E	C	A	P	D	S	R	O	Y	B	L	O	F	M	T
C	L	U	S	Y	E	P	L	L	U	T	M	E	A	H
T	E	I	U	M	R	M	E	R	A	M	U	S	R	E
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T	O	[illegible]	Y	I	I	E	R	A	S	B	C	E	L	L
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Y	A	T	L	L	N	I	D	E	L	O	S	E	A	M
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S	E	C	O	N	D	A	R	Y	E	N	E	R	G	Y

Hidden Word Review

Hidden in the diagram are energy-related words that you have met throughout *The Energy Challenge* activity program. There are 30 words altogether. Try to find as many as you can and circle them across, down, or diagonally. The letters of each word are always in sequence. You can answer the questions on this page with words from the puzzle.

1. In 1776, James ______ ______ put the steam engine to work and started an energy revolution.

2. Albert ______________ prepared the way for the atomic age in 1905.

3. The three fossil fuels are ______________, ______________, and ______________.

4. About 65 percent of our coal supply is used to generate ______________ ______________.

5. A ______________ of coal is a layer of coal lying beneath the surface of the earth.

6. Electricity is not a primary energy source; it is a ______________ ______________ source.

7. Oil is measured by the ______________, which is the same as 42 gallons.

8. Burning solid wastes at high temperatures without oxygen is called ______________

9. An almost inexhaustible source of energy that does not pollute, is inexpensive to maintain but costly to install is ______________ energy.

10. Sunlight can be captured using a solar ______________ to provide electric power to a building.

11. Being careful about the amount of energy we use, by practicing ______________, we can save valuable energy.

12. If you ______________ your house you can keep the heat in in the winter and out in the summer.

13. Shipping freight by ______________ rather than by truck is much more energy-efficient.

14. Coal ______________ turns coal into a clean, easily transportable fuel that can be used like natural gas.

15. The Organization of Petroleum Exporting Countries is usually abbreviated ______________

16. As a result of the oil ______________ in 1973, there was a shortage of gasoline and fuel oil.

17. One of the worst sources of pollution in the U.S. is ______________ ______________ without emission control devices.

18. Prices very often go up or down because of supply and ______________.

19. More and more people in every country in the world means a ______________ growth that will use more and more energy in the years to come.

20. We will have to reach a delicate balance between ______________ ______________ concerns and our growing need for ______________

Activity VI-30

Objective:

The students will identify energy consuming steps in the food system and select ways to save energy.

What to do?

Have the students look at the steps below in the preparation and eating of a frozen vegetable. Have them propose which steps could be eliminated to save energy.

- eat it
- throw away the package
- thaw and cook it
- take home and put in freezer
- drive to market to buy it
- supermarket keeps it in open freezer
- refrigerated truck takes it to supermarket
- food company freezes it
- food company packages it
- food company slices it by machine
- It is transported to the food processing plant
- A truck farmer grows the vegetable on his farm

Teacher notes:

The answers will vary. Growing vegetables in your own garden and eating that vegetable raw are the two least energy intensive steps. Have the students construct a food pyramid for pop drinks in cans, TV dinners, ice cream, cereal. Find ways of saving energy for each item. (This activity comes from *Energy Conservation in the Home*, curriculum guide for Home Economics Teachers produced by ERDA.)

Activity VI-31

Objective:

The students will calculate the energy consumed for marketing trips and plan ways to save energy on their family trips.

What to do?

Have the students take a survey of the trips family members make to do their marketing in a one week period. Have them record distance and mode of travel. Each student will then make a plan to save energy in their own family shopping patterns.

Date	Stores Visited	distance traveled	vehicle used	mph of vehicle

Teacher Notes:

It would be helpful to ask the following questions:

1. Are the car trips less than 1 mile in distance?
2. How else could you get there?
3. How could you cut down on the number of shopping trips?
4. What ways could you recommend to your family to conserve energy when shopping?

Activity VI-32

Objective:

The students will plan menus which are the least energy consuming.

What to do?

Ask the students to plan menus for a day's meals which use the minimum amount of energy, taking into consideration that energy cost includes fertilizers and insecticides used to grow the food, farm equipment, transportation to market, processing and packaging and preparation.

Teacher Notes:

Bring out that foods without excess packaging and those in returnable containers usually cost less. Follow this activity with a field trip to a supermarket to compare prices of foods in different kinds of containers. Stress that forming food cooperative groups to buy food in bulk or growing food yourself cuts down on energy used as well as being cheaper, and better for you.

Activity VI-33

Objective:

The students will investigate kinds of clothing for fiber content to determine energy wastage in manufacture.

What to do?

Have the students read the labels on the clothing they are wearing to class to determine the fiber content of the clothing. List the kinds of fiber on the board by per cent, if possible. Discuss the advantages and disadvantages of each kind of fiber for energy usage in its production and for maintaining the best body temperature for the individual wearing the article of clothing made of those fibers.

Teacher Notes:

Natural fibers such as cotton and wool are able to hold body heat by trapping air. They are also able to "breathe" and absorb moisture. The living material in a natural fiber garment regulates the climate around the body; if it is cold the material retains heat. Synthetic fibers (rayon, acetate, nylon, acrylics, orlons, polyesters (dacron)) are derived from petroleum and do not "breathe". It might be noted that cotton and wool fibers are more difficult to buy and that cotton without some polyester fiber usually has to be ironed (which uses energy).

Activity VI-34

Objective:

The students will calculate and identify energy savings in recycling and reusing containers.

What to do?

Discuss with the students the concept of the three R ways of conserving energy:

Re-Fuse: Don't buy items in packaging that is not needed.
Don't buy throw away bottles and bi-metal cans.
Don't buy plastic containers or styrofoam.
Don't buy paper products - except when made from recycled paper. Ask to see the label.

Re-Use: Don't throw things out after you use them. Create a new use for them.

Re-Cycle: Collect materials in your home and take them to a recycling center in your community or start one. Cans, glass, paper and aluminum can all be recycled.

Have them complete the following problems:

1. EPA estimates 92,000 barrels of oil per day would be saved if 90 per cent of Americans used returnable containers. The energy used in 1976 was 37 million barrels of oil a day. What per cent is this?

2. How much energy could be saved per day at the maximum by eliminating excess packaging, shopping in bulk through coops and growing our own food, if 4 per cent of the energy usage in the U.S. goes into processing and packaging foods. How much per day? How much per year?

3. With virgin or raw materials 750 KWH (electricity) is used to produce one ton of steel, 16,700 KWH is used to produce one ton of aluminum, and 1,050 KWH is used to produce one ton of paper. Using scrap or recycled material, 585 KWH is used to produce one ton of steel, 780 KWH is used to produce one ton of paper, and 350 KWH is used to produce one ton of aluminum. Figure out how much electricity is saved by recycling one ton of steel? one ton of aluminum? one ton of paper? Which material saves the most electricity? Which is the most important to recycle? Do these same calculations for 10 tons, 50 tons.

Teacher Notes:

Point out that aluminum is a light metal and a lot more volume of material is needed to make a ton. How many average homes could this energy supply?

Activity VI-35

Objective:

The students will decide which activities are energy wasteful and which are energy saving.

What to do?

Divide the class into teams. Put appropriate headings on the chalkboard for saving energy and wasting energy. Give the students turns by teams and put the items mentioned below under the appropriate heading. Allow an opportunity for the other team to challenge each entry. Set up a point system for the score. Include such things as:

backpacking, using recreational vehicles, walking, bicycling, motorcycling, mopeding, hotrodding, driving in a car by self, riding in a bus, riding on a train, riding on a plane, carpooling, buying natural food, buying processed and packaged food, home grown food, coop purchased food, junk foods, quick foods, camping out, staying in youth hostels, staying in hotels, staying in motels, recyclable containers, returnable bottles disposable bottles, aluminum cans, wearing a sweater, turning up the thermostat, and others.

VII. MAJOR OBJECTIVES FOR ENERGY EDUCATION

1. The learner will define energy in the physical sense as the ability to do work.

2. The learner will describe the various forms of kinetic and potential energy.

3. The learner will describe the transformation of energy from one form to another, and describe these transformations as processes in which energy is always last.

4. The learner will describe the historical impact of the availability of energy upon human achievement and life style.

5. The learner will describe the present and projected world demand for energy and its effect upon the United States and the other nations of the world.

6. The learner will describe the social and economic effects of the present finite energy supply.

7. The learner will describe the sources of fuels used to supply energy, their present and projected availability, and the probable consequences of shortages.

8. The learner will differentiate between exhaustable and renewable fuel sources, and will explain our dependancy upon both types.

9. The learner will identify the future options in fuels and will describe the economic, environmental and political consequences of their use.

10. The learner will identify conservation as the optional short-term response to the present fuel crisis. He/she will demonstrate practical ways to conserve energy in the home, school and community.