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ABSTRACT

The 12 lessons presented in this guide are structured so that they may be integrated into science lessons in 7th-, 8th-, or 9th-grades. Suggestions are made for extension of study. Lessons are approached through classroom role-playing of outer space visitors who seek to understand energy conversion principles used on Earth. Major emphasis is placed on energy flow-through systems. Energy alternatives for the future are also examined. (Author/RE)

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Energy Systems - Present, Future
Extra-Terrestrials
Grades 7,8,9,/ Science

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Introduction

The major emphasis in Energy Systems, Present—Future, is that energy flows through systems. An introduction to energy flow and to flow-charts is presented. This is followed by analysis of common examples of important energy flow systems. The third section is the examination of short term energy options. The last section looks at energy alternatives for future options.

These energy systems are approached through a theme of outer space visitors. The extra-terrestrials, called Solardroids, add a unique perspective to this packet.

Lessons

The twelve lessons are structured so that they may be integrated into science classes in 7th, 8th and/or 9th grades. There is sufficient material and challenge for twelve class periods. Suggestions are made for extension of study over a longer period of time. These lessons have been labeled Optional.

This material has been prepared for teachers of three different grade levels. It is intended to accommodate teachers who use different teaching styles. This joint accommodation can be seen in the implementation of the decision to suggest ways in which some students role-play extra-terrestrials and contribute fun to the class along with an alien perspective to the various topics. Any teachers preferring other teaching methods than the one provided may adapt either particular lessons or all of the lessons, and will find that the materials are organized so this can be done rather easily.

Extra-terrestrials (Solardroids)

Suggested ways extra-terrestrials may be used in the lessons are as report givers, which puts students into a position of talking to each other about energy; role-playing; small group reports; inquirers; leaders; etc. Assigning the extra-terrestrial roles to different students in the various lessons would allow for more student involvement. The suggested extra-terrestrial scripts can be read verbatim, but the students are invited to improve upon them and use their own words.

Metric

In dealing with the many large numbers involved in these lessons, regular use is made of the first six prefixes from the modern metric system known as SI (Le Systeme Internationale d'Unites or the International System of Units).

SI Prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{18}	exa	E	10^{-1}	deci	d
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10^{1}	deka	da	10^{-18}	atto	a

Since the signing into law of the United States Metric Conversion Act (Public Law #94-186) on December 23, 1975, science teachers have an obligation to help their students learn to use the modern metric system. This includes using the recommended base units of measurement which for energy is the joule, symbolized as J. Although the preceding table associates each prefix with a power of ten factor, there is merit in students occasionally seeing the equivalents written out as on the right in the following example:

2×10^{18} J = 2,000,000,000,000,000,000 J

Among the many materials the National Bureau of Standards has for teachers is "Working with the Modernized Metric System," a full scale wall chart, NBS Special Publication 304.

Teacher Materials

The portion of the energy curriculum materials directed to the teacher includes:

An Overview which briefly describes the major thrust of each lesson;

Objectives which state in behavioral terms what performance should be expected of students;

A list of Materials needed to conduct each lesson; and

Background Information for teachers which is found at the beginning of each lesson, on the teachers edition of each flowchart, and in reference material.

Student Materials

It is easy to reproduce the material appropriate for distribution to each individual student on a Xerox, Thermofax machine, or by making a duplicating master. In addition, some of the material may be reproduced as transparencies for use on an overhead projector. Use of the overhead projector makes possible blocking out some of the material on a flowchart with a piece of paper or cardboard so that attention can be focused on a particular portion of the flowchart. After one portion is presented another portion can be revealed and theprocess repeated until all portions have been presented and the entire flowchart can be seen as a whole.

Unit I, Lesson 1: Energy Flow through the U.S. Food Supply System

Overview

This first lesson involves energy inputs, losses, and output in the U.S. food supply system. As energy flows through the system, food is grown, processed, distributed, prepared and eaten. The First Law of Thermodynamics is explained.

Role-playing

The class is introduced to the Solardroids. They will ask questions, and in general introduce a different perspective into the classroom. Solardroids convert energy internally at 100% efficiency. They do not understand step-by-step conversion of energy from one form to another. The Solardroids are amazed at Earthlings' processes of energy conversion. As intelligent beings, the Solardroids are able to translate into English their communication patterns which are not understandable to Earthlings. Through the theme of extraterrestrials landing on Earth, the use of role-playing is carried out in the twelve lessons. These Solardroids should be active learners throughout--asking questions when they don't understand; leading group discussions and experiments; giving presentations of topics "they know about", e.g., fission and fusion. The purpose of the role-playing "game" is to provide the Solardroids with the information they need in order to get back to their own galaxy.

Background Information

Although it is known that sunlight (solar energy) is a major source of food's energy (solar energy is changed into the chemical energy of food through photosynthesis), it is also true that a surprisingly large amount of fossil fuel energy (oil, natural gas and coal) is used in the U.S. to get food to the table. Tracing the energy flow in the food supply system requires keeping track of the energy that goes into each step and also the energy that is wasted either because it is not converted into food energy or because the food itself is thrown away.

Through the Law of Conservation of energy which states that energy is neither created nor destroyed, all energy input must be accounted for at each step.

Energy exists in many different forms: radiation (which includes light), motion (cars, trucks, pipelines, motors, etc.), or as heat energy. It is also available as stored energy (potential energy) in food or the fossil fuels, for instance. Energy is converted for use. Conversions occur at each step in the system. Sunlight is converted to chemical energy by plants; gasoline is converted to heat energy and mechanical energy by tractors. This study of the flow of energy through the food system (and the systems which follow) will identify these various conversions and the efficiency with which they take place.

The energy problems which will come to light in this and the following lessons are not that the world is "running out of energy" or even using it up, but that there is difficulty converting enough of the available energy into the necessary forms. "Energy losses", therefore, refer to energy that is converted or otherwise escapes into a form that is no longer useful.

Objectives: The student should be able to:

1. Explain the phrase "we eat fossil fuels".
2. List the major types of energy inputs, conversions and losses in the food supply system.
3. Give an operational definition of efficiency.
4. Use a flowchart.

Materials:

1. Cracker (or other food)
2. Flowchart Worksheet (Activity 1, Teacher and Student Edition)
3. (Optional) "Toast", film available from Bullfrog Films, Inc., Oley, Pennsylvania 19547; color, 11 minutes.
4. U.S. Food Supply System Energy Flowchart (Figure 1, Teacher and Student Edition)
5. Stopwatch
6. Dictionary
7. (Optional) Calculators (2-10)
8. Covered wire
9. C batteries
10. Flashlight bulbs

Teaching Suggestions

Before beginning this lesson students could complete the Energy Attitude Survey, Figure 14, page 82, Unit III, Lesson 2. This would provide a measure of a potential change in students' attitudes.

1. Begin with the introduction of the Solardroids. A Solardroid introduces the outer space visitors.

Solardroid costumes:
A large star made from aluminum foil to be worn on chest; headgear such as antennae; belts with lights that blink made from wire, C batteries and flashlight bulbs

Commentary

1. Solardroid: Your assignment is to introduce yourself and the other extraterrestrials to the "Earthling" students.

"We...are...from...another...world. Our... starship...became...lost...in...space. We... have...landed...here. Do...you...call... this...place...EARTH?

"Who...are...we? We...are...Solardroids. You...are...Earthlings? Our...planet...uses ...the...direct...conversion...of...starlight ...to...make...the...form...of...energy... we...need."

Earthlings: "STARLIGHT ENERGY? What's that?"

Solardroid: "We...do...not...know. It... has...been...used...so...[illegible]ng...so...many ...countless...years. W[illegible]...don't...study ...Starlight...in...school...any...more."

Optional: Have students make 4 x 8 wall mural of the wrecked space ship.

Earthlings: "How will you get back to your planet? You don't know how your energy source works! What will you do here?"

Solardroid: We...must...learn...about... Earth...energy. To...adjust...to...life... here. Or...to...learn...enough...to...help ...us...get...back...home. Our...first... question...is...how...do...you...get...the ...energy...for...your...bodies?"

Earthlings: (Either describes eating or eats something.)

Solardroid: "Does...that...thing...that... you...put...in...your...mouth...give...you ...energy? What...happens...to...it...inside...your...bodies? Where...did...its... energy...come...from?"

Earthlings: (Explain eating.)

2. The end results of eating food are the production of heat, muscular work, body maintenance, and waste materials. 10% of the food put on tables in the U.S. is not eaten by people. Why?

2. Due to spoilage, surplus, dislike, or feeding to pets.

The short fi[illegible]Toast" could be appropriately show[illegible]t this time.

Introduce students to flowcharts. Use flowchart worksheet.

For students who have not previously worked with flowcharts, provide a step by step explanation.

3. Ask students what kinds of food they eat. Have them name some favorites. Call on Earthling (a student). S/he says that s/he eats fossil fuels. You scowl and ask him/her if s/he knows what fossil fuels are. S/he replies. Give him/her another funny look and ask the class for a show of hands of anyone else who eats natural gas, oil, and coal. (Later the fact that much of the energy in the food we eat comes from fossil fuels will be presented.)

3. Earthling: Your assignment is to have a discussion with your teacher during class. Your teacher will talk with the class about the things they eat and will question you. You should reply, "Mostly what I eat is fossil fuel." The teacher asks you, "What are fossil fuels?" Reply, "Natural gas, oil, and coal are the common fossil fuels." Try to keep a straight face and offer no explanation. (What you are being asked to say is true in terms of the energy invested to produce the food.)

4. Give the students a copy of the U.S. Food Supply System Energy Flowchart, Figure 1.

Explain that MJ, the abbreviation for "megajoule", is a unit of measurement for energy. The joule is the recommended metric unit for energy and the prefix mega means one million. It is helpful in developing an understanding of the size of a joule to tell the class that 200 joules of energy are required each second for a person walking and that 100 joules of energy are required each second for keeping a 100 watt light bulb lit.

The joule is not a big unit of energy. There are 4186 joules in one food calorie (kilogram calorie). Thus, the 200 calories in a candy bar would give you enough energy to walk for 70 minutes.

Have a small group of students time each other walking for 5 seconds. This uses 1000 joules. Have them walk around the room, time the walk, and figure the energy used in joules.

Example: 20 sec walk x 100 joules/sec = 4000 joules

5. Where does food originate? Use this either as a review or as a short introduction to the information.

5. Food originates as green plants, grown mostly on farms, using solar energy in the process of photosynthesis.

carbon dioxide + water + sunlight ⟶ plant material + oxygen

Animals eat plant material ⟶ Animal food products

Ask students what happens to food from the time it leaves the farm until it arrives at a home or restaurant. Where in this flow is energy used?

Teacher edition of Figure 1 shows some of the appropriate responses.

Ask what happens to food at home or in restaurants which requires energy.

Cooking, refrigeration, keeping food warm, etc.

6. Go over Figure 1. Ask students what the total amount of energy put into the system is, exclusive of the solar energy, and how this compares with the final 14 MJ of energy in food on the table.

6. 34 + 54 + 51 = 139 MJ or about ten times (14 MJ) as much energy comes from fossil fuels according to the numbers on the chart.

Ask students to compare this 139 MJ value with the 33 MJ of energy in plant food "at the farm gate".

This comparison is the basis for asserting that we in the U.S. are eating fossil fuel.

67 - 34 = 33 139 ÷ 33 = 4.2

About 4 times more fossil fuel used to produce farm goods as solar energy input.

7. Ask what is meant when someone or something is described as being efficient. Look up the definition in the dictionary.

Produces with small amount of waste. The general idea is to get more and more output for the same input.

Activity: Divide class into small groups of 5 students; give them 3 minutes to organize themselves into a line in order of their height and then each touch his/her toes ten times. Students must do this one at a time. Discuss efficiency relative to all groups having same input (number of students); how efficient were they in attaining output; did they get finished; how much extra energy was "lost" of expended in trying to get finished; which group was the most efficient in doing the task?

Solardroid: "Won't...you...have...to...charge...up...now...that...you've...spent...that...energy?"

8. Optional: Suggest a general ratio with the output in the numerator, $\frac{\text{output}}{\text{input}}$

When output = input there is 100% efficiency.

Solardroids are 100% energy efficient.

Explain that in any situation where energy is being converted from one form (input energy) to another (output energy), the ratio, $\frac{\text{output energy}}{\text{input energy}}$, is defined as the efficiency of the conversion.

9. From the Food Supply System Energy Flowchart have students take the four values representing the inputs into the system and add them. Similarly add the two losses and the end use value of food on the table. Why are these two sums the same?

9.

INPUTS	WASTE AND OUTPUT
66,880	66,847
34	158
54	14
51	67,019
67,019	

This is an illustration of the Law of Conservation of Energy.

The energy going into this food supply system equals the energy coming out; thus, energy is neither created nor destroyed.

10. Optional: If 66,880 MJ of solar energy falls on a field and 66,211 MJ is not converted into plant material, 669 MJ (i.e., 66,880 MJ - 66,211 MJ) has been converted. This means the efficiency of this energy conversion is, $\frac{\text{output}}{\text{input}}$ =

$$\frac{669\text{ MJ}}{66,880\text{ MJ}} = 0.01 \text{ or } 1\%.$$

Potential Use of Calculators!: If not all students, 2 or 3 could work with one calculator.

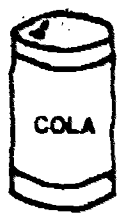
No energy conversion can have an efficiency greater than 100%, because it is impossible to create energy.

11. Optional: Of the 669 MJ of plant material from #10, only 10% or 67 MJ is harvested. This means that 602 MJ (i.e., 669 MJ - 67 MJ) is lost because it is not harvested. An additional 34 MJ of energy is lost as waste heat from the operation of farm machinery. What is the energy loss in Step 1, Figure 1?	A total of 66,847 MJ (i.e., 66,211 MJ + 602 MJ + 34 MJ) are lost in Step 1, Figure 1.
Why are the Solardroids laughing in Figure 1?	Their efficiency is 100% in converting solar (star) energy to needed uses.
Ask students to describe specifically where additional energy is lost as the food goes on to end up on the table ready for eating.	Suggested answers are found in the right-hand column of the Food Supply System Energy Flowchart in the breakdowns of the 54 MJ and 51 MJ inputs.
Have students make suggestions about how not to waste so much energy in this system.	Suggested responses: Uses for plant refuse Cut down on food waste Cut down on food packaging

Activity 1--Teacher Edition
Flowchart Worksheet

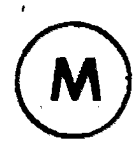
Show the "pathway" of the energy from your food from eating it to the use you make of it. Do this as a flow chart.

Use the following symbols in your Food Flow Chart.

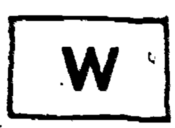


= Food

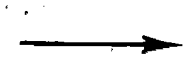
= Heat Energy

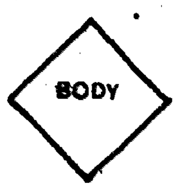


= Muscle (Motion) Energy

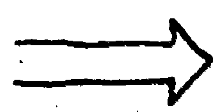


= Waste (e.g., food discarded, solid/liquid body waste)

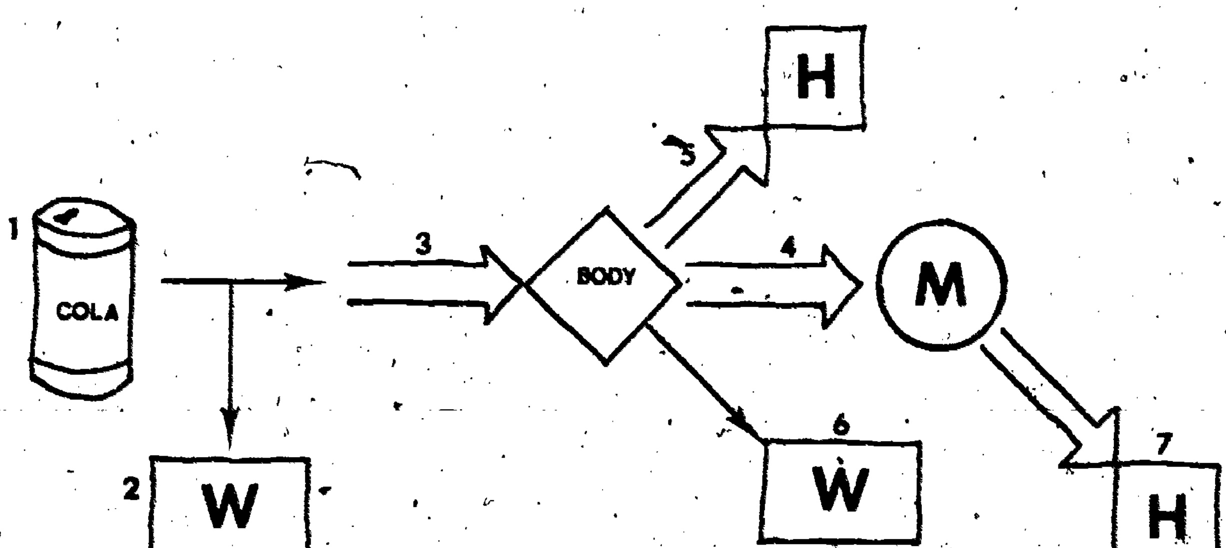

= Path



= Chemical Energy (houses energy conversion)


= Energy from Conversion [e.g., chemical (food) energy into energy of motion (walking)]

Draw your flow chart here. Use symbols as many times as necessary. (A flowchart is a form of mapping. It maps an event. In this case, energy flowing through the human body is the event being mapped.)

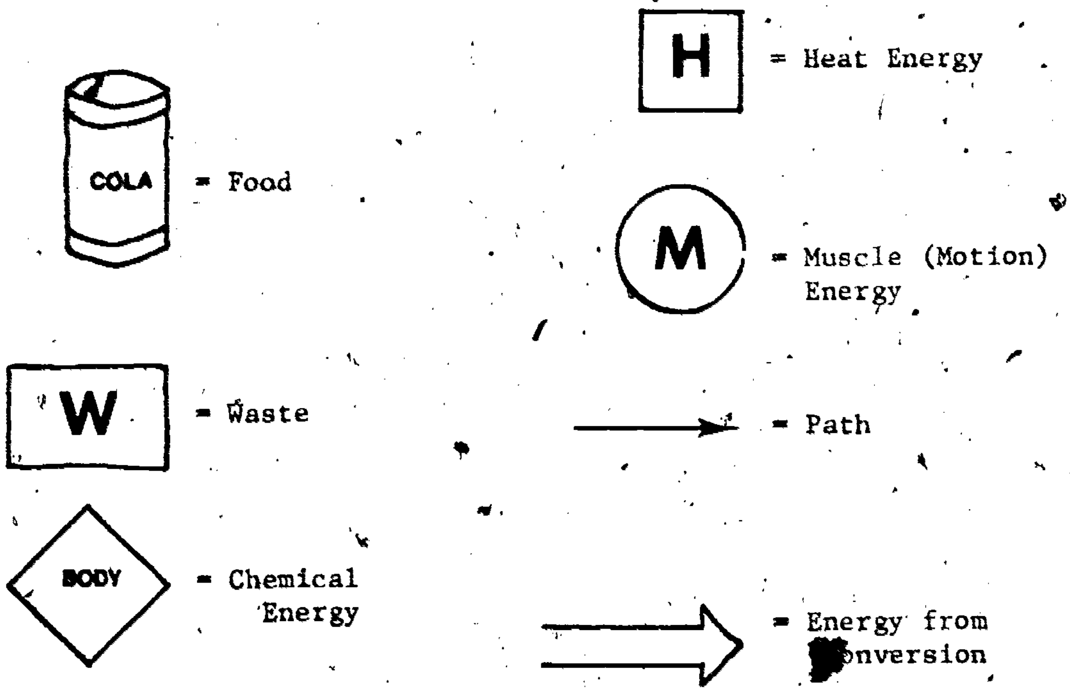


Teacher Note:
1. Food input
2. Food not eaten = waste
3. Conversion of food energy for body use
4. Conversion of energy to energy of motion
5. Conversion of energy to heat energy
6. Energy not used by body = waste
7. Conversion of energy of motion into heat energy

Activity 1--Student Edition
Flowchart Worksheet

Show the "pathway" of the energy from your food from eating it to the use you make of it. Do this as a flow chart.

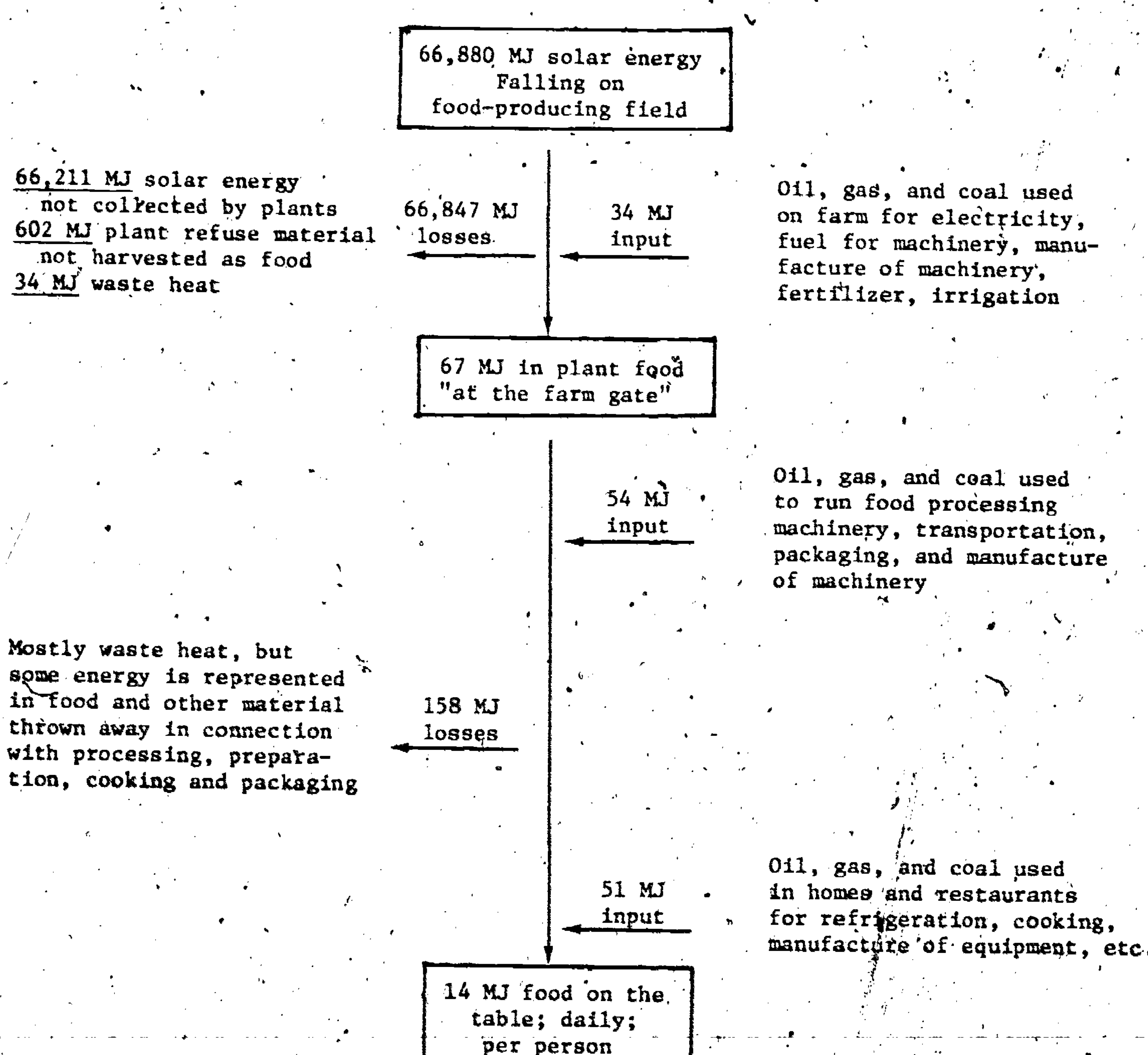
Use the following symbols in your Food Flow Chart.



Draw your flow chart here. Use symbols as many times as necessary.

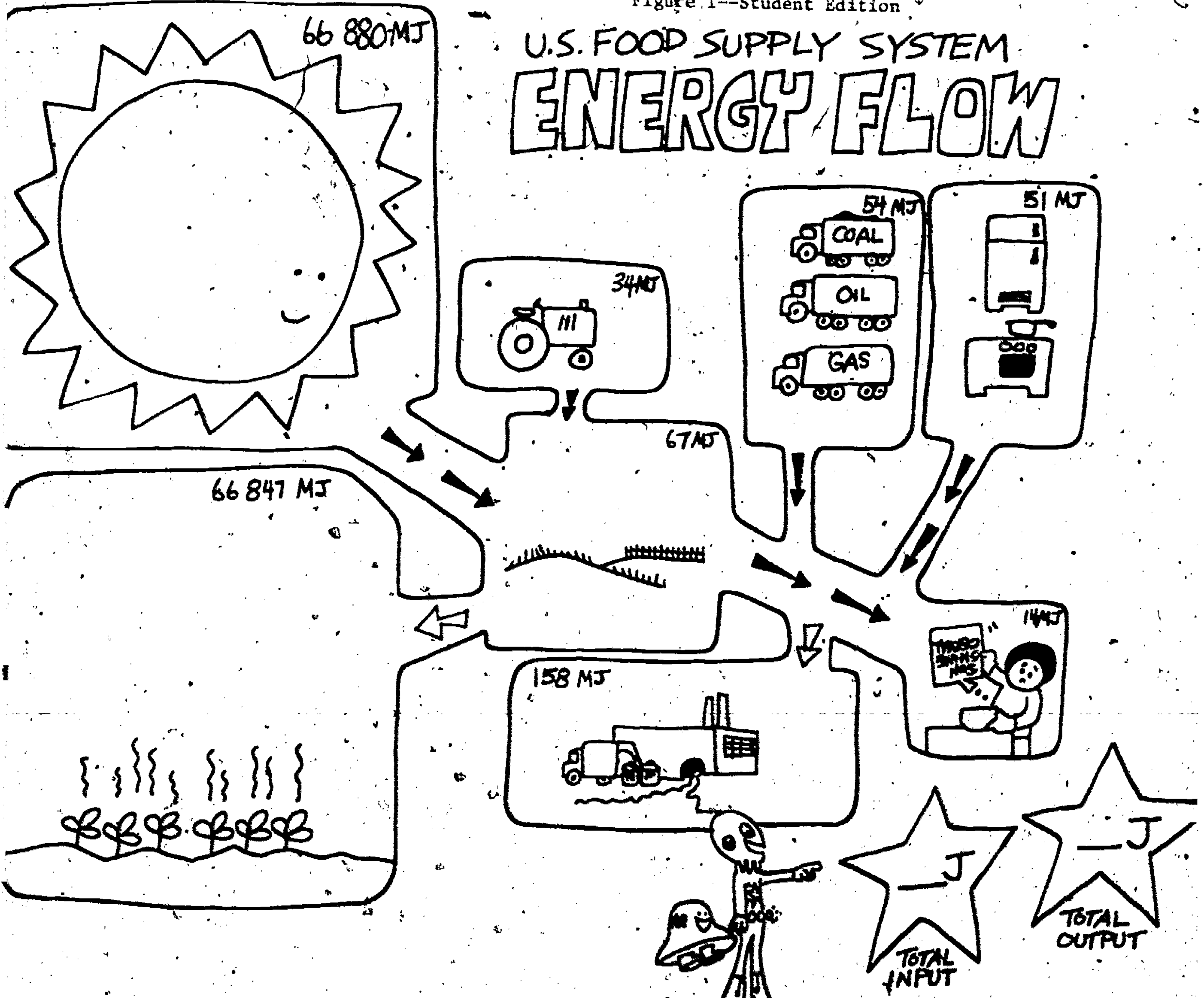
Figure 1--Teacher Edition

U.S. Food Supply System Energy Flow



MJ is the abbreviation for megajoule, a unit of measurement for energy. The joule is the basic recommended metric unit for energy and the prefix mega means one million. Thus, 14 MJ is the same as 14,000,000 joules.

Figure 1--Student Edition



Unit I, Lesson 2: Energy Flow Through the Entire Earth System

Overview

This lesson describes the five pathways taken by the solar energy which strikes the planet earth. The bending of light passing through certain transparent objects is addressed along with reflection and absorption. The energy or heat or evaporation which is associated with the physical change of water from its liquid to gaseous state is given special attention.

Background Information

Visible light is but one kind of radiation that is given off by energetic objects like the sun (and like radio antenna and X-ray machines). It is possible to tell the difference between forms of radiation and distinguish between characteristics like color by the "wavelength" of the radiation. (A wavelength is a measurement for radiation which is similar to the distance between two crests of water waves.)

Incoming solar radiation contains some "ultraviolet" light of short wavelength and some "infrared" radiation of longer wavelength, but most of it is in the visible wavelength range. Visible light ranges in color, as can be seen by separating light into its component wavelengths with a prism, from blue to red. Blue light has the shortest wavelength (and is near the ultraviolet as might be expected), and red light has the longest.

Solar radiation is the most important energy input to this planet. After it strikes the top of the atmosphere, however, it interacts in many different ways with the matter of earth and powers many different processes. As it is "used" in the many ways of earth, its wavelength is shifted from the visible region to infrared and it is radiated away from earth into the deep realm of the universe. These flowpaths are shown in Figure 2.

In this lesson we will examine this flow of solar energy to earth through some of its more important processes. In a more specific way students will also examine the several things which can happen to light when it falls on an object. They discover what it means to say that light is reflected, transmitted and absorbed.

Objectives

Students should be able to:

1. Describe five different pathways followed by the energy in sunlight falling on the planet earth.
2. Distinguish between the reflection, transmission, and absorption of light as it falls on an object.
3. Explain how energy is involved with evaporation.

Materials

1. A glass prism
2. Water or rubbing alcohol
3. Green plant
4. A Difference Between White and Black Objects (Activity 2)
5. 2 boxes
6. White and black paint
7. Thermometer
8. Bending Light and Changing It Into Heat (Activity 3)
9. Magnifying glass
10. Dry paper

11. Direct sunlight (or a 150 watt sunlamp or photoflood lamp)
12. Two Effects from Adding Heat Energy to Water (Activity 4, Teacher and Student Edition).
13. Heat source
14. Container of water
15. Watch
16. Water Evaporation Process (Activity 5, Teacher and Student Edition)
17. Flashlight, globe
18. Solar Energy Flow Through the Planet Earth (Figure 2, Teacher and Student Edition).

Teaching Suggestions	Commentary
1. Show the rainbow of colors resulting from the light passing through a glass prism. This effect is caused by the prism changing the direction of travel of each color of light by a different amount.	1. Solardroid takes a prism and holds it by the window.
2. Figure 2 shows how the several processes are combined in a five pathway energy flow through the entire earth system. Discuss this flowchart, Solar Energy Flow Through the Planet Earth. Use as an overhead transparency and/or individual copies for each student.	
Have students point out on this energy flowchart what each energy pathway represents.	
What happens to sunlight as it reaches the earth?	It hits the earth's atmosphere.
What happens to the light, does all of it come through?	No, some of it is reflected. (Reflection by a transparent medium can be demonstrated with water.)
What happens when it reaches the ground?	It is absorbed.
Accept students' questions about Figure 2. Have them label each pathway.	
3. Demonstrate that light tends to be reflected by objects that are white in color and absorbed by black colored objects. Use role-playing with this demonstration.	Have Solardroid do the demonstration.
In the black/white activity, don't forget to notice that the black material gets hot and that it radiates heat (infrared) away. If a piece of blackened metal is left in the sunlight the students can feel this radiation. The analogy with radiation for the earth is then complete.	

In Figure 2, the top pathway is reflection from the atmosphere of the earth. The second pathway is absorption of sunlight before the energy is returned to space primarily in the form of infrared radiation.

Do the demonstration described in Activity 2.

"Solardroids...get...too...hot...in...your...sunlight. We...use...weaker...starlight. We...have...looked...at...our...problem. We ...came...up...with...an...answer. Are...we ...right? Earth...people...seem...to...be... cooler...when...wearing...white. Light... tends...to...be...reflected...by...white... objects. It...is...absorbed...by...black... objects."

4. Photosynthesis is the bottom pathway indicated in Figure 2. Have students explain to Solardroids how the last pathway relates to earth's energy flow.

Earthling: "Plants and animals pass on energy as heat associated with their life processes. When they die and decay, additional heat is passed on. In the past some plants and animals became fossilized instead of decaying. When these fossil fuels are burned, the energy stored in them is converted into heat energy.

"What happens to Solardroids when you die?"

Solardroid: "Die? That...is...not...a... happening...on...planet...X. We...have... always... ________." (Allow students to finish this explanation.)

Have students write a Solardroid script which would include this information.

This absorption and reflection applies to colors like red, orange, green and violet. Consider this green plant. It uses sunlight to grow. What color would it appear in green light? (Green is correct.) What color would it appear in red light? (It would appear black.) The green plant will appear black in any color light other than green or white. This happens because a white light like sunshine is made up of all colors of light and when it strikes a plant only the green light is reflected. Green plants absorb and use some other colors like red, orange, and violet light. An object appears black (if you can see it at all) because it absorbs all colors of light and reflects none.

5. A Solardroid has the assignment on the transmission of light through transparent objects. The concentration or focusing of light with a magnifying glass and the concentration of solar energy on one spot emphasizes that solar energy converts to heat energy.

5. Solardroid: "When...light...strikes... an...object...what...can...it...do? (Reflect, absorb, and go through.)

Point to the glass in the window (or if your classroom does not have windows, bring in a piece of clear glass, perhaps a bottle).

To demonstrate the burning or scorching of paper using the magnifying glass, use Activity 3.

6. A large amount of sunlight falls on oceans and lakes. This solar energy causes the water to change from its liquid form into its gas form (water vapor or steam).

Continue with the magnifying glass and cause a small drop of water to boil and disappear. What happened to the water? What common word is used to refer to this change?

It evaporated.

Evaporation.

Represent the process of evaporation on the blackboard in the following way:

liquid + energy = gas

Place some water or alcohol on the skin of several students and allow it to evaporate. Ask students, how does it feel? When does this occur naturally? Explain.

Typical responses: It feels cool. Cooling of one's body when one sweats or perspires. Heat energy flows from the body into the liquid as evaporation occurs.

7. Optional: Activity 4 should be started and the data collection begun. Wait until near the end of the period before discussing the results.

8. Continue discussing with the class water vapor which is produced by evaporation. Have students draw a flowchart of the water evaporation process (see pp. 25-26). The water vapor rises up in the air and eventually condenses, forming clouds and falling back to the surface of the earth as rain or some other form of precipitation. If it falls on ground above sea level some of it will form into streams and rivers. This water has some energy stored in it because of its location or position. How could energy be gotten from position of water? Where does this energy originate?

Students may draw a flowchart or label the Flowchart Worksheet.

Dams are built to use the water to help put its energy to use. In hydroelectric plants the energy is converted into electrical energy. Hydro energy can be seen as coming originally from solar energy.

9. A Solardroid presents the energy of wind. Ocean currents and waves come also originally from solar energy. They are a different cup of tea. They depend on uneven heating, in the fact that the equator is hot and the poles cold. (Shine a flashlight on a globe and show that less energy per unit area will fall on the poles.) What effect will the white snow and ice have? (This discussion relates to the next to the last pathway on Figure 2.)

9. Solardroid: "We...have...nothing...like ...this...form...of...energy. The...sun... heats...the...earth's...atmosphere...unevenly. This...results...in...differences...in...the ...pressure...and...density...of...the... air. It...is...Wind...Energy."

Cools the air at the poles causing air movements.

The wind has been used on earth for such things as propelling sailboats and turning windmills. The same sorts of conversions of solar energy that cause the motions of air known as winds, also cause the motions of water in oceans known as waves and currents.

Have the students brainstorm a list of things that they have done which used wind or water current energy.

Being blown on iceskates; flying kites; windmills; body surfing; etc.

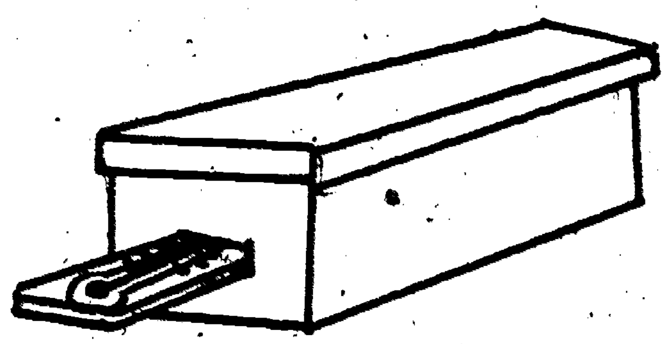
Discuss the results of Activity 4.

10. Summary: Incoming radiation is a) reflected directly; b) absorbed and radiated; c) absorbed by water and causes evaporation; d) absorbed by the earth and causes wind and ocean currents; and e) used in photosynthesis.

Activity 2
A Difference Between White and Black Objects

Materials
- 2 boxes
- White and black paint or paper
- Brushes
- Thermometer

1. Paint two identical shoe boxes, one black and the other white.
2. Make a small slit in the end of each box.
3. Place both boxes in the sunlight for about 30 minutes.
4. Without opening the boxes, insert the thermometer and record the temperature in the boxes.
5. Is there any difference in the two temperatures? Explain.



Activity 3
Bending Light and Changing It Into Heat

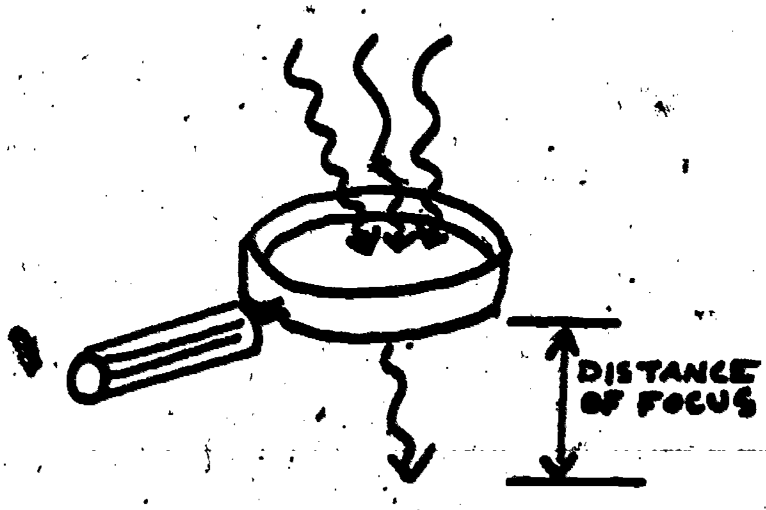
Materials — Magnifying glass, wide diameter
Dry paper
Direct sunlight (or a 150 watt sunlamp or photoflood lamp)

1. Find the distance of focus for the magnifying glass. Do this by pointing the surface of the magnifying glass directly at the sun.

2. Hold the magnifying glass at a particular angle and slowly move it closer to and farther away from a flat piece of paper.

3. Watch for the appearance of a small bright spot on the paper. When this bright spot appears, note the distance that the magnifying glass is from the paper. This is the distance of focus (focal distance) and is how far you should hold the magnifying glass away from the paper you are trying to scorch or burn for the demonstration.

Safety Precaution: Have a bucket of water available.



Activity 4--Teacher Edition
Two Effects from Adding Heat Energy to Water

Materials: Heat source
Container of water
Thermometer
Watch

1. An arrangement for boiling water is needed. Start with no more than 200 ml (about a cup) of water. Heat energy is shown flowing into the water continuously.

2. Take the temperature of the water at one minute intervals. This shows that the water temperature increases to 100°C (212°F) and then stops rising.

3. What happens to the heat energy flowing into the water once it stops increasing the temperature of the water? This heat energy is required to change liquid water at 100°C into gaseous water at 100°C.

4. Note the absence of any temperature change.

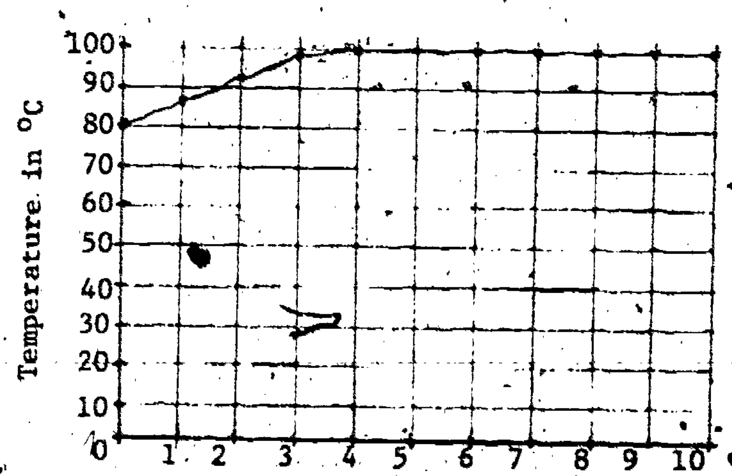
5. Collect the data in tabular form.

6. Make a graph like that to the right below.

Sample Table

Time in Minutes	Temperature in degrees C
0	80
1	87
2	93
3	98
4	100
5	100
6	100
7	100
8	100
9	100
10	100

Sample Graph



Activity 4--Student Edition
Two Effects from Adding Heat Energy to Water

Materials
- Heat source
- Container of water
- Thermometer
- Watch

1. An arrangement for boiling water is needed. Start with no more than 200 ml (about a cup) of water. Heat energy is shown flowing into the water continuously.

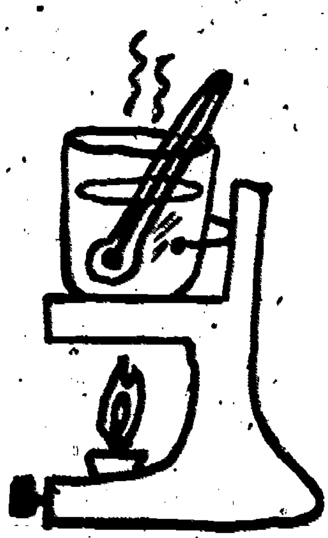
2. Take the temperature of the water at one minute intervals. This shows that the water temperature increases to 100° C (212° F) and then stops rising.

3. What happens to the heat energy flowing into the water once it stops increasing the temperature of the water?

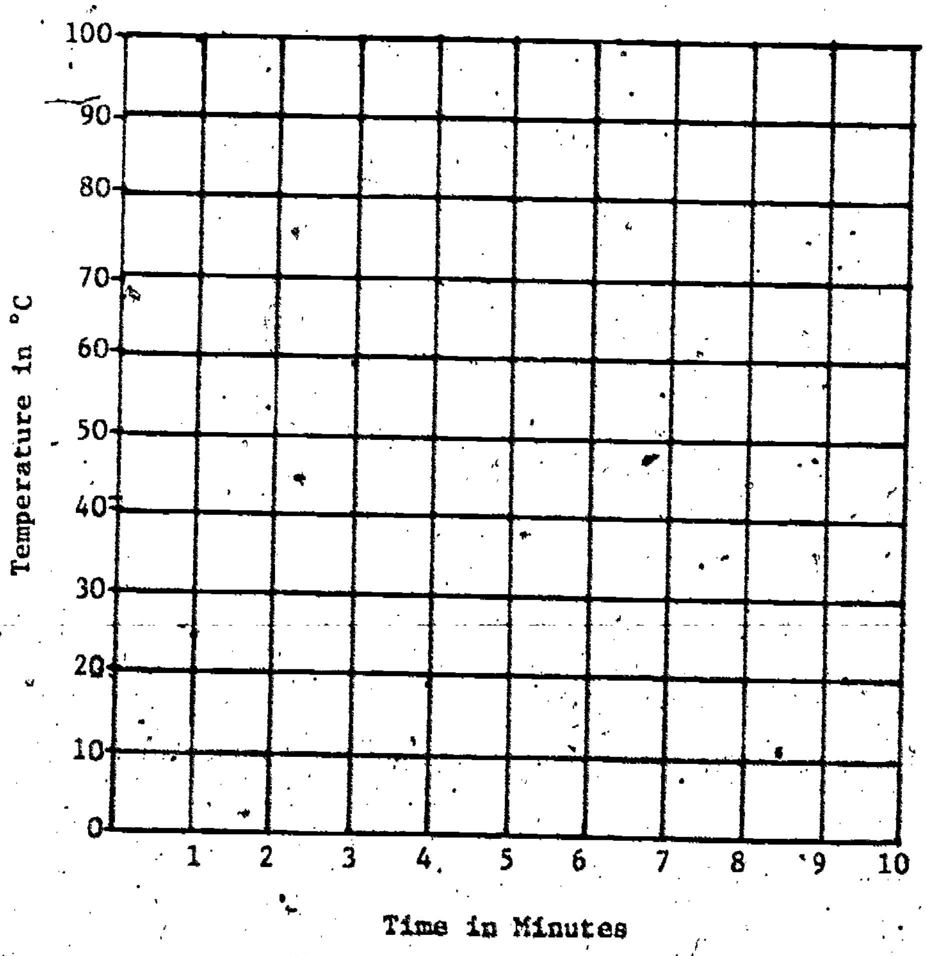
4. Note the absence of any temperature change.

5. Collect the data in tabular form.

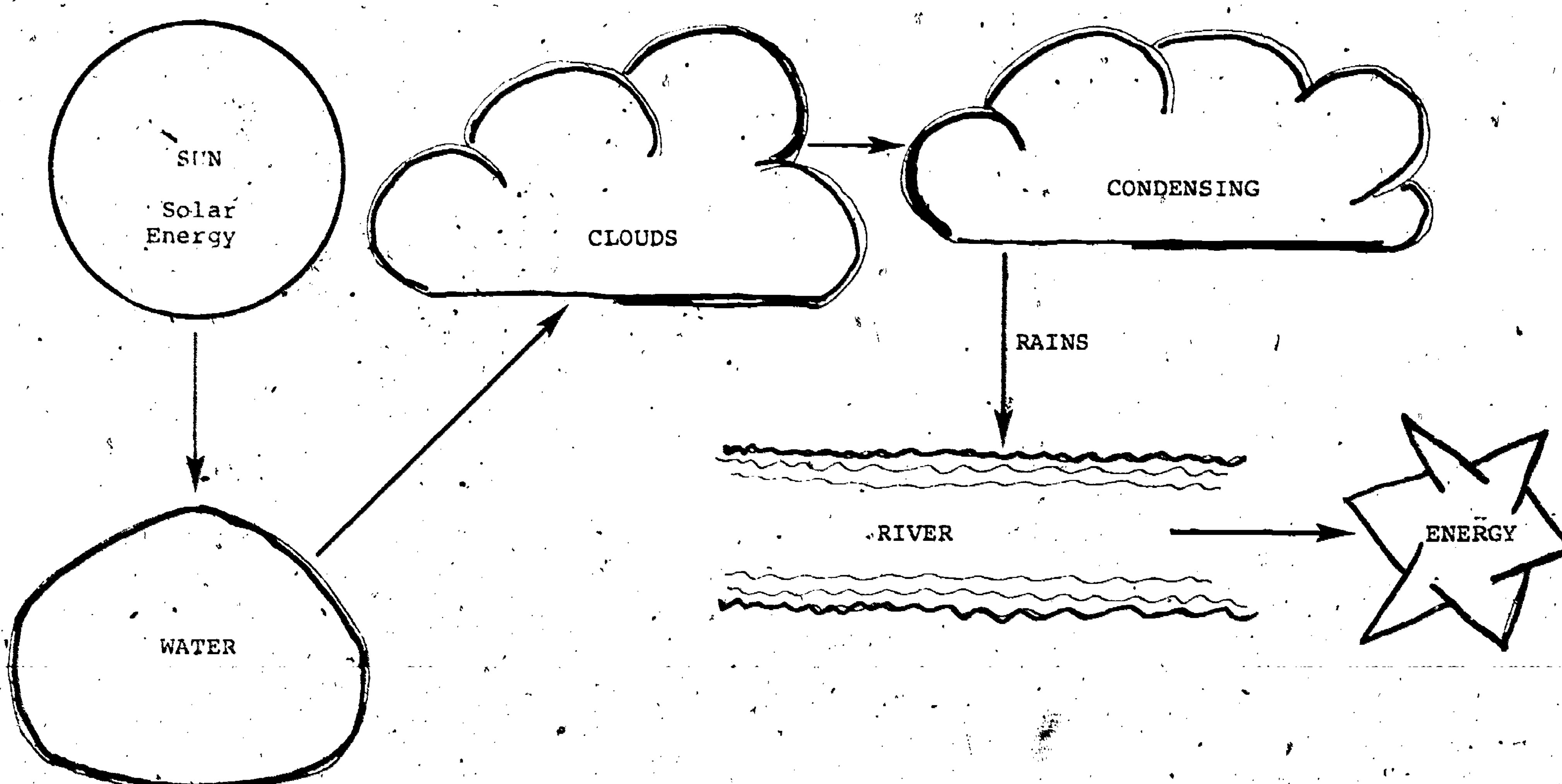
6. Make a graph on the next page.



Time in Minutes	Temperature in Degrees C
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	



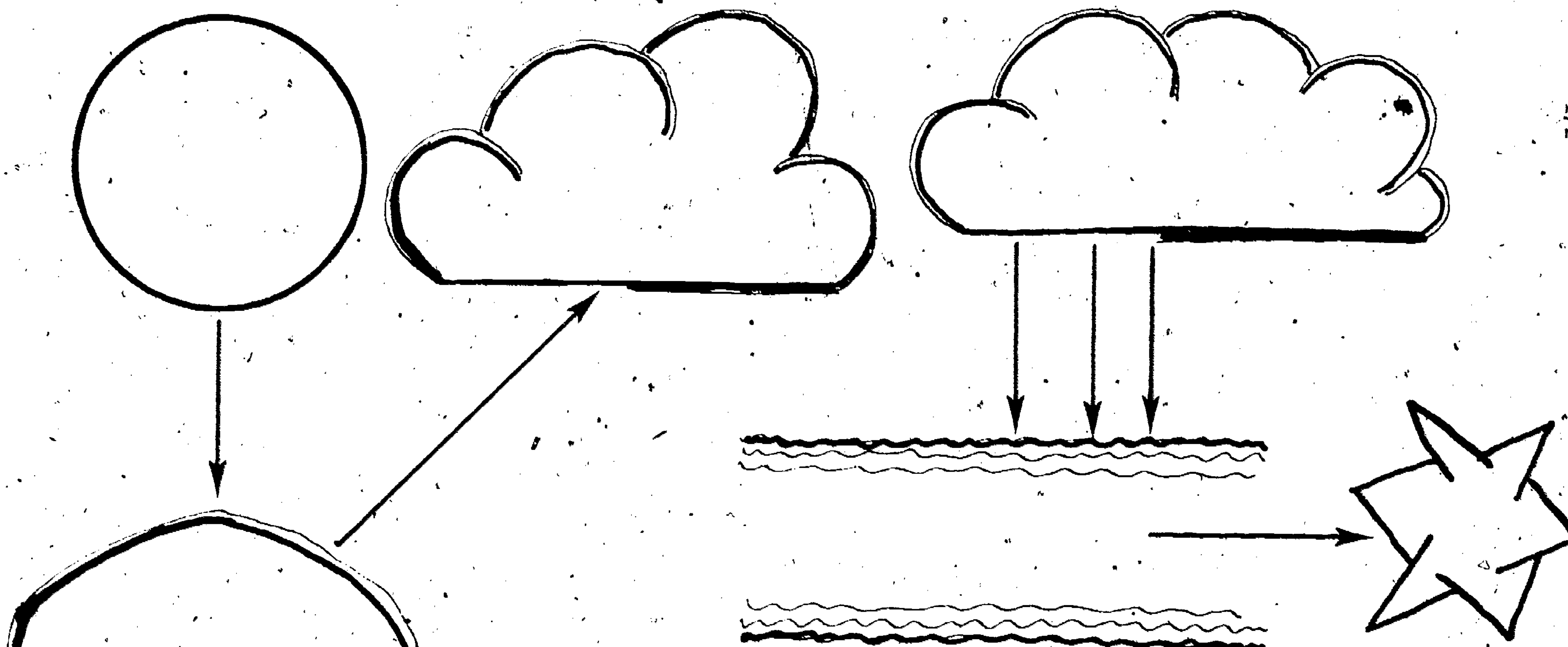
Activity 5--Teacher Edition
Water Evaporation Process

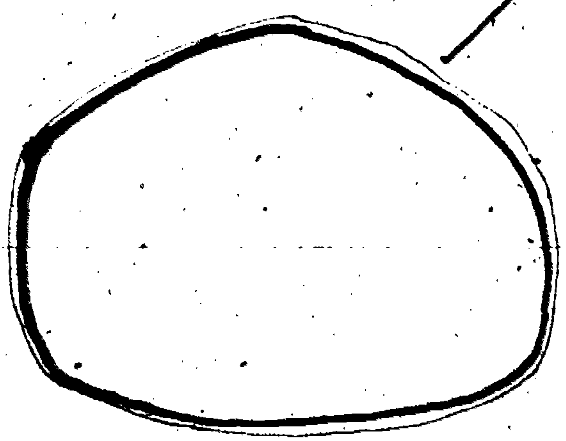


I/2

Activity 5--Student Edition

Water Evaporation Process

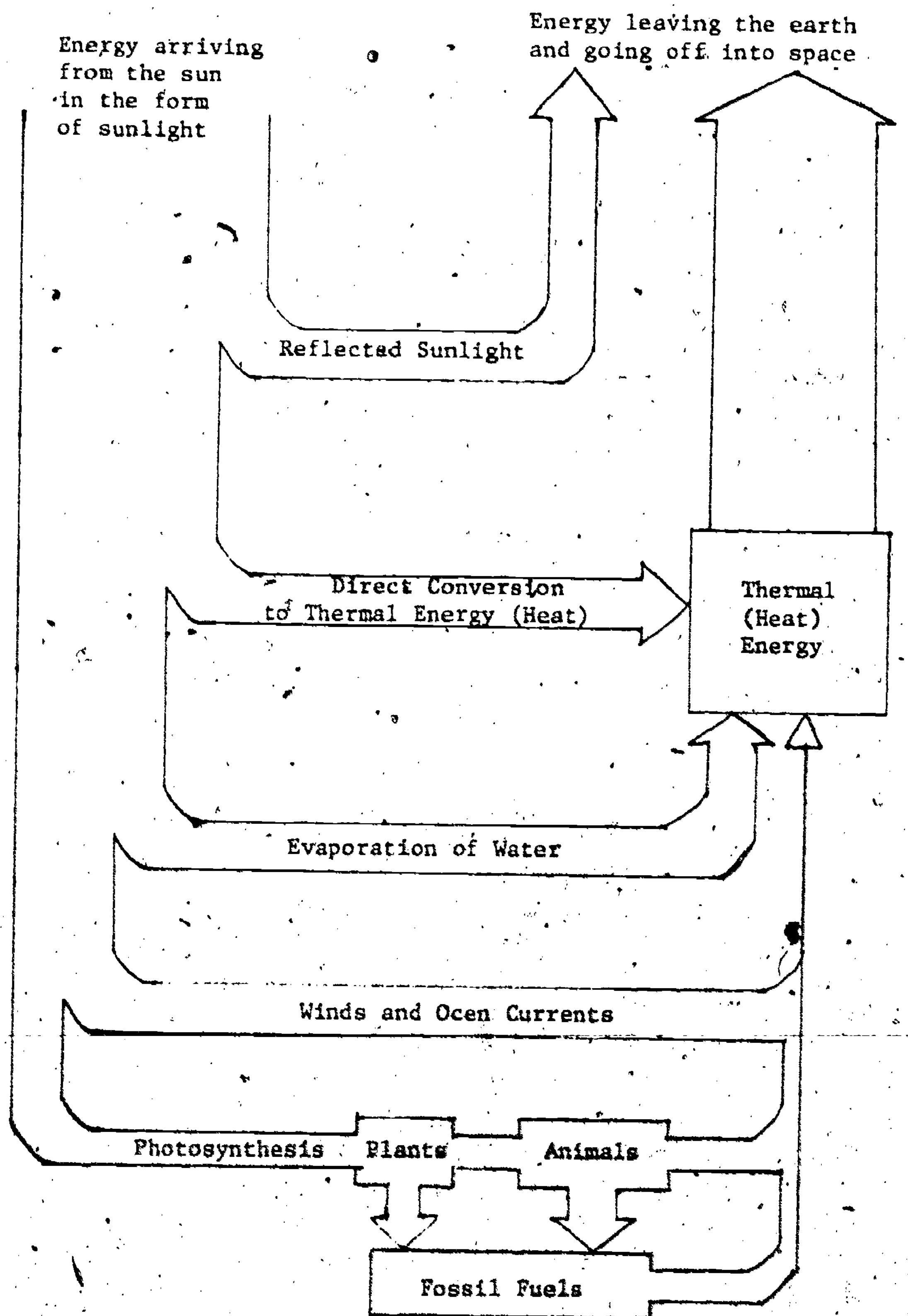




Put each label on the appropriate step in the flowchart.

CLOUDS	RIVER
SUN (Solar Energy)	CONDENSING
RAINS	ENERGY
	WATER

Figure 2--Teacher Edition
Solar Energy Flow Through the Planet Earth



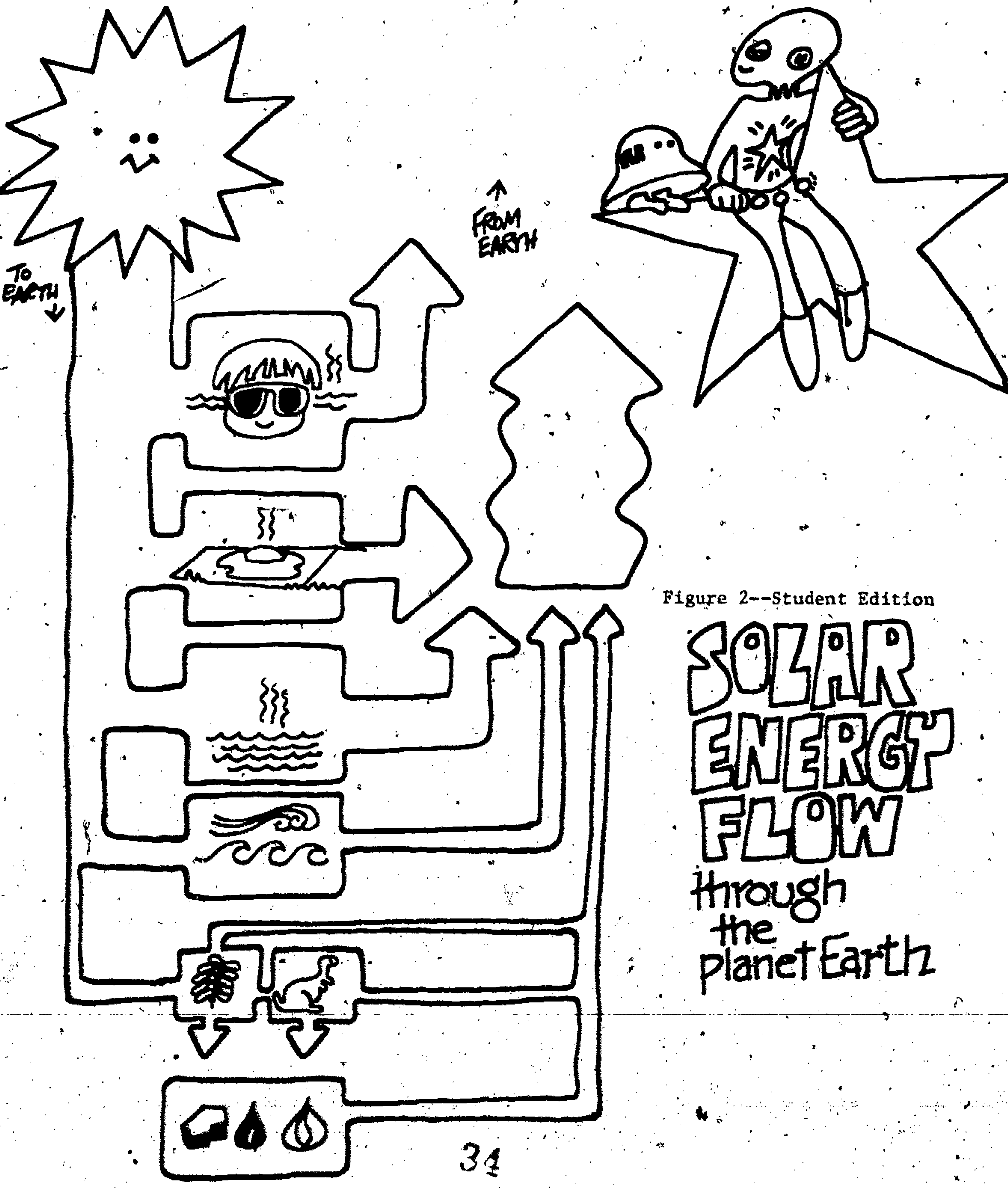


Figure 2--Student Edition

Unit I, Lesson 3: Energy Flow Through the U.S. Economy

Overview

This lesson examines the flows of energy from the primary sources through the various conversions to the end uses typical of the U.S. industrial economy. This examination of energy flow emphasizes the conversions that take place, the form (mostly heat and mechanical work) in which energy is used, and the losses or waste that inevitably occur.

Background Information

The flow pattern in this lesson has to be interpreted in terms of the Law of Conservation of Energy (the First Law of Thermodynamics). At several places the energy used and energy lost can be added up to show that the total is the same. This reinforces the students' understanding that "wasted energy" does not disappear, it is just no longer useful to us.

The last part of the lesson deals specifically with the flowchart for that part of the energy flow that goes into the production of electricity since the importance of this intermediate form of energy is growing so rapidly.

The main background information is contained in the two flowcharts, Figures 3 and 4. The first of these shows the total flow for the U.S. economy, the second selects those flows that lead into and out of electrical generation. The numbers on these diagrams were taken from 1976 figures. They will change each year, but the relative values change very slowly.

Objectives

Students should be able to:

1. Distinguish between sources of primary energy and end uses of energy.
2. Explain the conservation of energy within the energy flow system.
3. Explain that waste in the energy system does not disappear (is not lost) but is not useful.

Materials

1. Energy Flow Through the U.S. Economy (Figure 3, Teacher and Student Edition)
2. Recording Sheet for Figure 3 (Teacher and Student Edition)
3. Conservation of Energy Balance Sheet (Activity 6, Teacher and Student Edition)
4. Electricity as an Intermediate Energy Form (Figure 4, Teacher and Student Edition)

Teaching Suggestions	Commentary
1. Have the Solardroids discuss the great diversity of energy sources and uses on earth. Looking around the classroom, identify direct and indirect energy uses, e.g. lights (direct use), and clothing (indirect use).	1. Solardroid: "Say...you...guys...if...you...don't...use...star...power,...what...do...you...use?" Earthling: "Energy." Solardroid: "Show...us...what...is...this...energy..."

Divide the students into teams. Have teams line up in front of the board. Each team has a piece of chalk. On the board each team member will write a use of energy not already listed by their team mates. The team with the most uses (all different) within 5 minutes wins.

Show and discuss with the class Figure 3 and tell them that a flowchart such as this is sometimes referred to as a spaghetti chart. Use as a transparency or have students cut the chart into fourths.

The drawings represent the energy sources in the United States. What do you think each one represents? List possible responses on the chalk board. Students may label the sources in Figure 3.

The energy from the sources is, at this point, used in two ways:

1. to make electricity.
2. fuel used as an end use (examples, oil for heat, gasoline for cars).

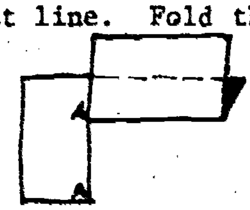
The two kinds of energy, electricity and fuel, are used by people for three major purposes:

1. Household and commercial (examples: in homes, apartments, stores, businesses)
2. Transportation (examples: cars, trucks, buses, planes, trains)
3. Industrial (example: manufacturing of the thousands of products we use)

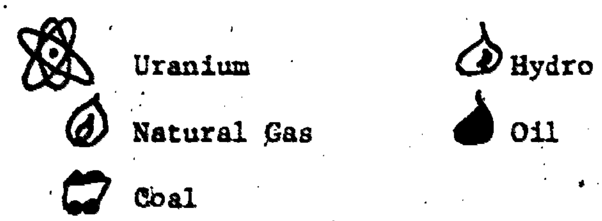
There is also an energy loss from the making of electricity. When the energy is used for the three purposes, some of it does useful work and provides useful heat. However, most of it escapes in heat form which is not useful to us.

Earthlings: Move around the class area pointing out uses of energy, e.g., lights, heating system, clock, bells, loud speaker, etc.

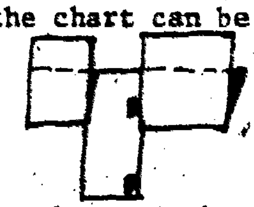
Draw a line between the two letter A's. Cut on that line. Fold the remainder of the page up.



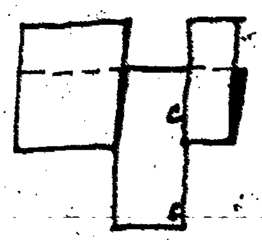
Responses:



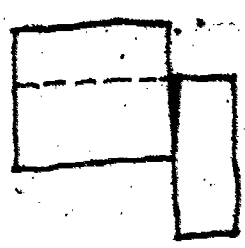
Draw a line between the two letter B's. Cut on that line. Fold page so only the second part of the chart can be seen.



Draw a line between the two letter C's. Cut on that line. Fold the page so only the third part of the chart can be seen.



Fold the page so only the last part of the chart can be seen.



2. Return to the first part of Figure 3, energy sources. These are the inputs to the energy flow through the U.S. economy. Name the fossil fuel inputs, What fuels were imported to the U.S.? Were there any fuels exported from the U.S.? What? Use Recording Sheet for Figure 3.	Gas, coal, oil. Some gas, oil. Yes, coal. Students may record and total the above information in part A on the Recording Sheet.
Of this grand total of fuel input, what is the percent in fossil fuels? What does this high percentage mean?	Part B, Recording Sheet That we are dependent on fossil fuels.
3. What happens to the fossil fuels? Have students trace a fossil fuel from input through the energy flow system to the output. Refer to Figure 3--Teacher Edition.	3. a) Choose a fossil fuel (example, oil). b) Choose an appropriate color to represent that fuel (example, black). c) Begin at the drawing of the oil drop. Color in all the pathways in the spaghetti chart that the oil goes through until it is either waste or useful output.
4. Use Figure 4, Electricity as an <u>Intermediate</u> Energy Form. What are the forms of primary energy that go into the production of electricity?	Oil, natural gas, coal, hydro, nuclear.
What are non-fossil fuel sources of energy?	Hydro and nuclear.
Both of these primary sources were used almost exclusively for generating electricity, which is an intermediate (non-primary) form of energy.	
Look at the first part of the electrical plant portion of Figure 4. Give the values for Figure 4 and have students calculate the total amount of primary energy which went into the generation of electricity.	Part C, Recording Sheet Oil, 4 + Natural Gas, 3 + Coal, 10 + Hydro, 1 + Nuclear, 2 = 20 EJ
What percent of the total are fossil fuels?	85%.
Which of the fossil fuels provide most of our electricity?	Coal.
Optional: What percent of the total energy input was used to generate electricity?	$\frac{\text{Total Energy for Electricity}}{\text{Total Energy}} = \frac{20}{74} = 28\%$
5. Large amounts of energy are wasted in the generation of electricity.	5. Solardroid: "That's...terrible! You... are...wasting...a...lot...of...the...energy.

We...don't...waste...any...energy. Why...do ...you...guys...want...to...make...electricity...anyway?"

Have students calculate total EJ going into producing electricity. Calculate EJ of use and waste.

Part D, Recording Sheet
17 + 2 + 1 = 20 EJ
65% x 20 = 13 EJ waste
35% x 20 = 7 EJ use

Have students paste pictures from bottom of Figure 4 in the correct end use position. Students may draw an end use of their own in the empty square.

Solardroid: "Ok...so...electricity...is... very...convenient..."

Converting from this intermediate energy form into what is wanted at the end is relatively simple, neat, and efficient.

Earthling: "Yeah, to use electricity is as easy as flicking a switch. For some things such as radios and TV's, there is no substitute available for electricity."

Solardroid: "Oh...but...a...disadvantage... to...electricity...is...that...it...must... be...used...immediately...once...it...is... produced."

Earthling: "Yeah, that's true."

6. Have students write a report letter (message) to planet X. In this message they will attempt to describe how Earthlings use energy.

CODE: YGRENE
TO: Planet X
FROM: Solardroids and friend Earthlings
SUBJECT: SESU

MESSAGE:

In Earthling houses energy is used to...

____

____

In Earthling factories energy is used to...

____

____

To move about on Earth, energy is used...

____

____

As students read their messages aloud to the class, have Solardroids list all the different energy uses on the chalkboard.

Solardroid: "Most...of...these...uses...are ...either...in...heat...or...mechanical... form."

There are some special electrical uses such as lighting, communication and some industrial processes.

7. Use Figure 3 and the Balance Sheet, "Conservation of Energy". Look at the right-hand column of the Figure 3. Notice that the top pathway here just represents the waste energy from the generation of electricity. Give the students the figures for each pathway leading to waste. Have them total the energy waste.

Loss in electricity, 14 + Loss in house, 6 + Loss in transportation, 17 + Loss in industry, 12 = 49 EJ

Now have them figure the energy use.

14 + 3 + 8 = 25 EJ

Look at the whole flowchart again and point out that in addition to the energy wasted in generating electricity, there is also energy wasted (shown in detail in the next lessons) when fossil fuels are used directly.

Tell the students that they should be able to get this same answer for the production at the left end of the chart. Actual conversions of energy from one form to another are involved here, but if the Law of Conservation of Energy is valid, then this answer should be the same as the others.

2	Nuclear
1	Hydro
20	Natural gas
21	Oil
15	Coal
1	Gas import
16	Oil import
76	

76	
− 2	Coal export
74 EJ	

Besides the addition of seven numbers, here is the problem of subtracting the value for the energy of the imported coal.

Ask them to calculate the percent of energy in the useful heat and work category and in energy wasted. This means 66% or 2/3 of the energy flowing through the U.S. economy is wasted.

Energy Wasted	48.8
+ Energy Used	+ 25.4
Total Energy Output	74.2

$$\frac{\text{Total Energy Used}}{\text{Total Energy Output}} = \frac{25.4}{74.2} = 34\%$$

100% (Percent Energy Output)
− 34% (Percent Energy Used)
66% (Percent Energy Wasted)

Solardroid: "I...see...you...guys...get...the...same...energy...in...output...as...you...had...in...energy...input. <u>But</u>...it's...not...all...useable. You...really...need...to...work...on...that!"

What ways might we try to use waste energy?

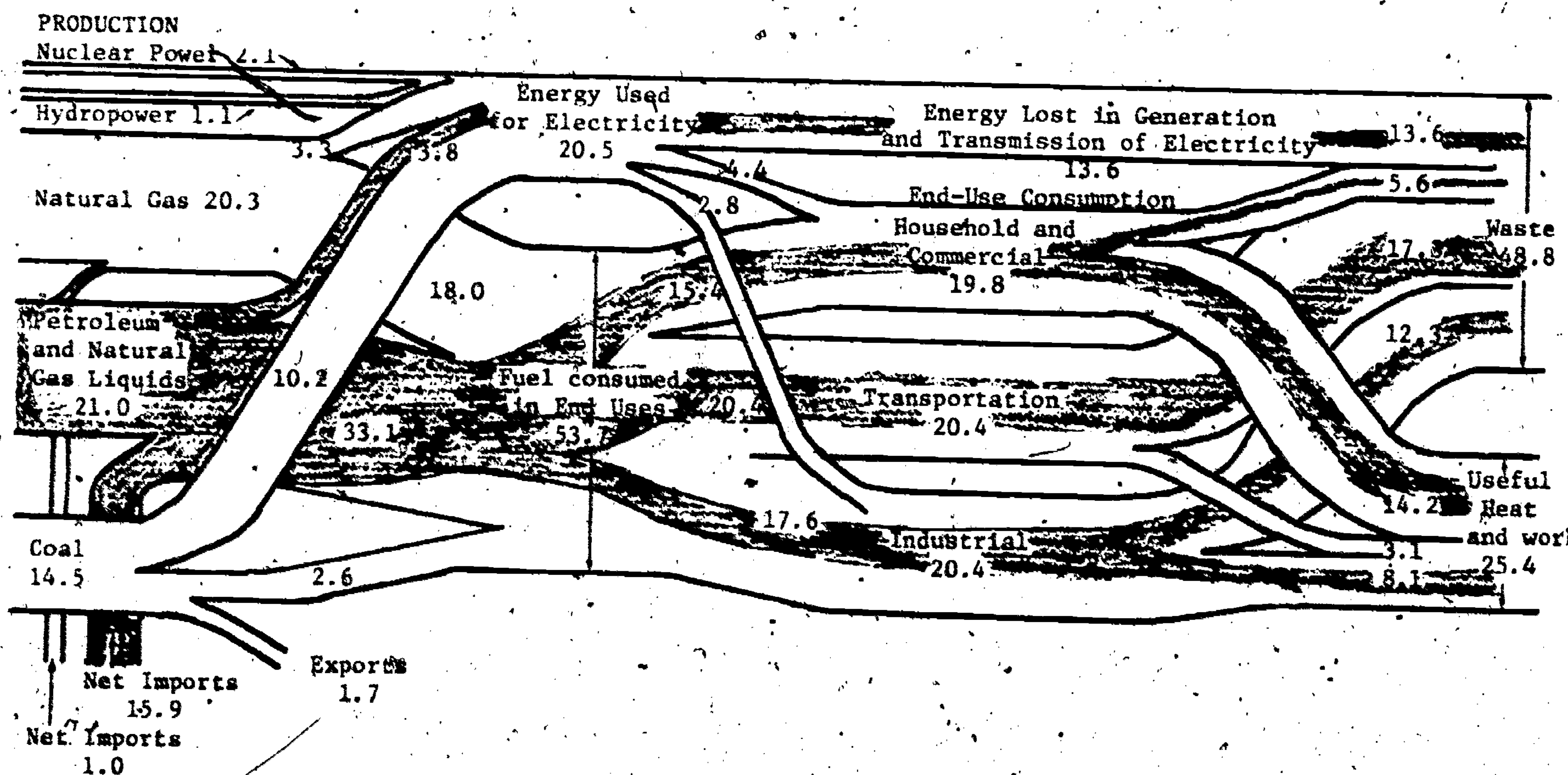
Possible responses: Use heat from cooking to heat space; use light fixtures that are cooler; build cars that do not waste so much energy (more miles per gallon, etc.).

Ask students to add the four values given in Figure 3 in the end-use consumption column (give students these figures) and compare that answer with the sum of energy used for electricity plus fuel consumed in end uses from Figure 4.

14	Electricity lost		
20	Household	20	Electric energy
20	Transportation	54	Direct energy
20	Industrial	74	EJ
74	EJ		

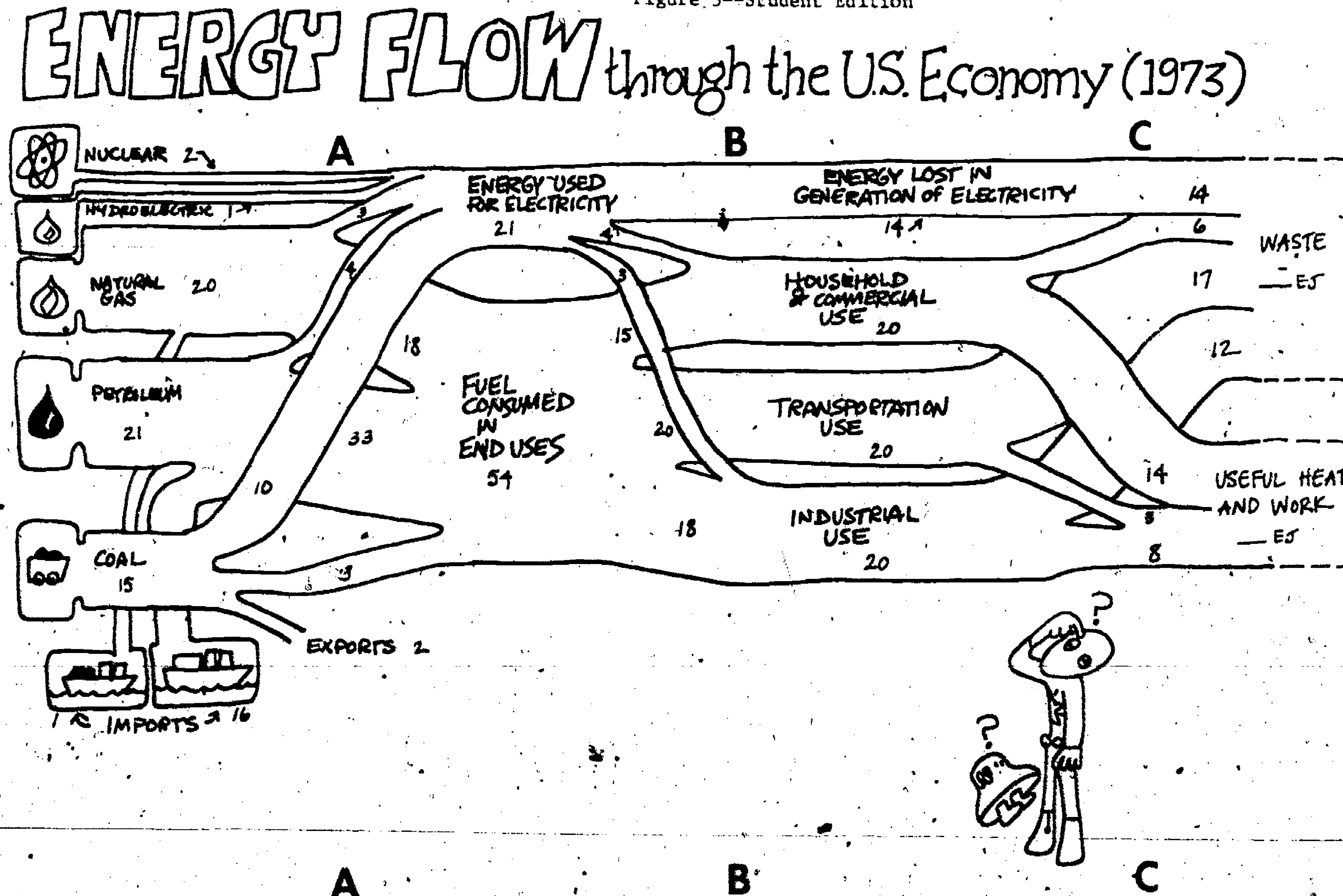
The answers are identical because this is just a matter of looking at the same overall flow of energy split up in different ways.

Figure 3--Teacher Edition
Energy Flow Through the U.S. Economy



Approximate flow of energy through the economy of the United States in 1976, exclusive of food energy. All figures are in exajoules (EJ or 10^{18} J).
All decimals are rounded to the nearest whole number for use on students' charts.

Figure 3--Student Edition



Recording Sheet--Teacher Edition
Energy Flow Through the U.S. Economy

A Energy Inputs

Fossil Fuels:

21	EJ	Natural Gas
21	EJ	Oil
16	EJ	Imported Oil
15	EJ	Coal
Total 73	EJ	

Other Energy Inputs

2	EJ	Nuclear
1	EJ	Hydropower
Total 3	EJ	

Grand Total Input 76 EJ

B Input Fossil Fuels 73 EJ

Subtract Fossil Fuel Export 2 EJ

Total Fossil Fuel Input 71 EJ

Grand Total Fuel Input 76 EJ

Subtract Fossil Fuel Export (Coal) 2 EJ

Difference 74 EJ

What percent of Energy Input is fossil fuel?

$\frac{71}{74}$ = .96 %

C Energy Input to Make Electricity

4	EJ	Oil
3	EJ	Natural Gas
10	EJ	Coal
1	EJ	Hydro
2	EJ	Nuclear
Total 20	EJ	

Fossil Fuel Energy Input (Oil + Natural Gas + Coal) 17 EJ

What percent of Energy Input to make electricity is fossil fuel?

$\frac{17}{20}$ = 85 %

D Total Energy Input to Make Electricity 20 EJ

Waste Energy 13 EJ

Useful Energy 7 EJ

What percent of Energy Input used to make electricity is wasted?

$\frac{13}{20}$ = 65 %

What percent is useful?

$\frac{7}{20}$ = 35 %

Recording Sheet--Student Edition

Energy Flow Through the U.S. Economy

A

Energy Inputs

Fossil Fuels	_____	EJ Natural Gas
	_____	EJ Oil
	_____	EJ Imported Oil
	_____	EJ Coal
Total	_____	EJ

Other Energy Inputs	_____	EJ Nuclear
	_____	EJ Hydropower
Total	_____	EJ

Grand Total Input _____ EJ

B

Input Fossil Fuels	_____	EJ
Subtract Fossil Fuel Export	_____	EJ
Total Fossil Fuel Input	_____	EJ
Grand Total Fuel Input	_____	EJ
Subtract Fossil Fuel Export (Coal)	_____	EJ
Difference	_____	EJ

What percent of Energy Input is fossil fuel?

$\frac{71}{74}$ = _____ %

C

Energy Input to Make Electricity

_____	EJ Oil
_____	EJ Natural Gas
_____	EJ Coal
_____	EJ Hydro
_____	EJ Nuclear
Total _____	EJ

Fossil Fuel Energy Input _____ EJ
(Oil + Natural Gas + Coal)

What percent of Energy Input to make electricity is fossil fuel?

$\frac{17}{20}$ = _____ %

D

Total Energy Input to Make Electricity	_____	EJ
Waste Energy	_____	EJ
Useful Energy	_____	EJ

What percent of Energy Input used to make electricity is wasted?

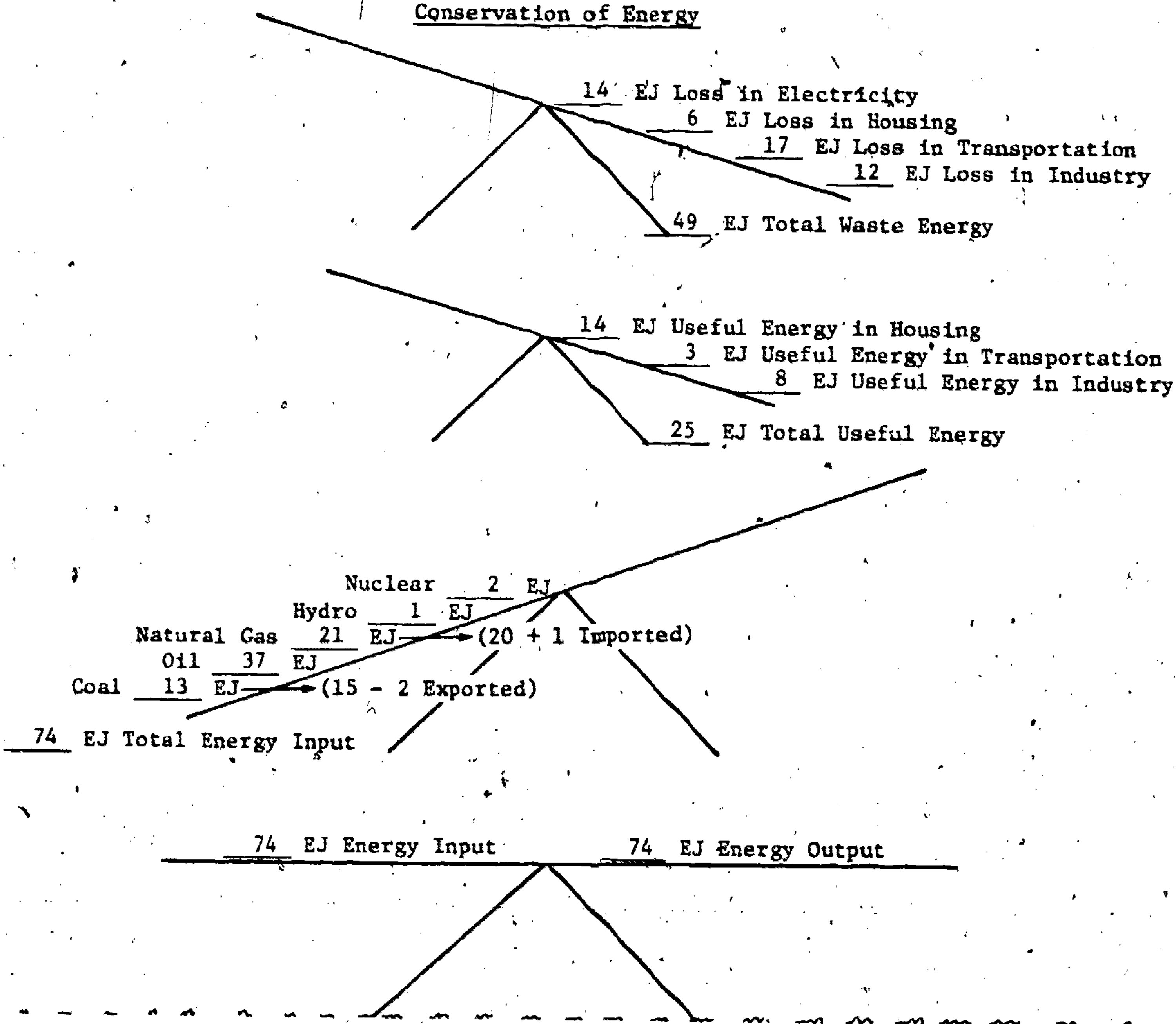
$\frac{13}{20}$ = _____ %

What percent is useful?

$\frac{7}{20}$ = _____ %

I/3

Activity 6
Balance Sheet--Teacher Edition
Conservation of Energy



How efficient is our energy system?

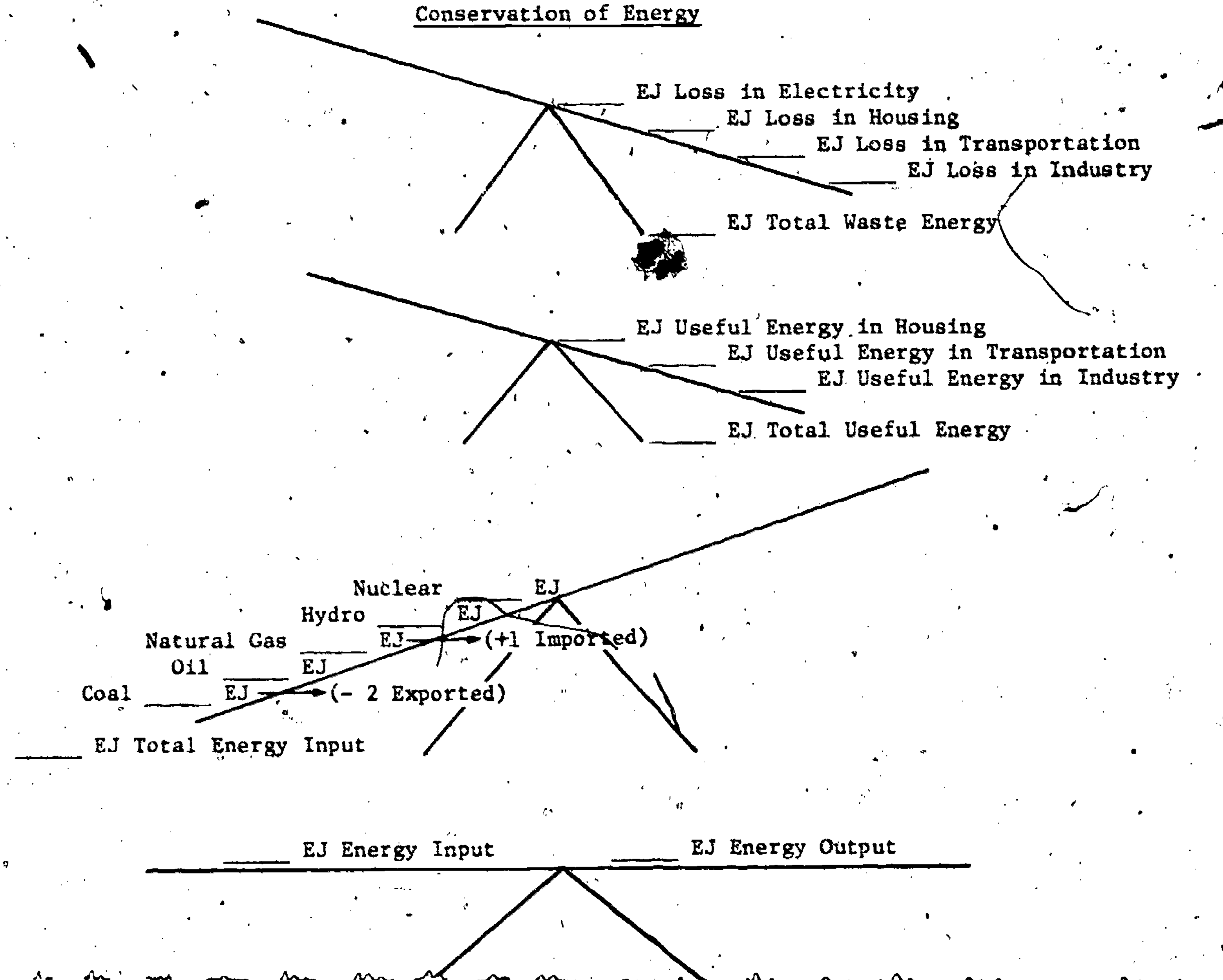
Energy Wasted	49	EJ
+ Energy Used	+ 25	EJ
Total Energy Output	74	EJ

$\frac{\text{Total Energy Used}}{\text{Total Energy Output}} = \frac{25}{74} = 34\ \%$

What percent of Energy is wasted (not used by people)?

Percent Energy Output	100	%
- Percent Energy Used	- 34	%
Percent Energy Wasted	66	%

Activity 6
Balance Sheet--Student Edition
Conservation of Energy



How efficient is our energy system?

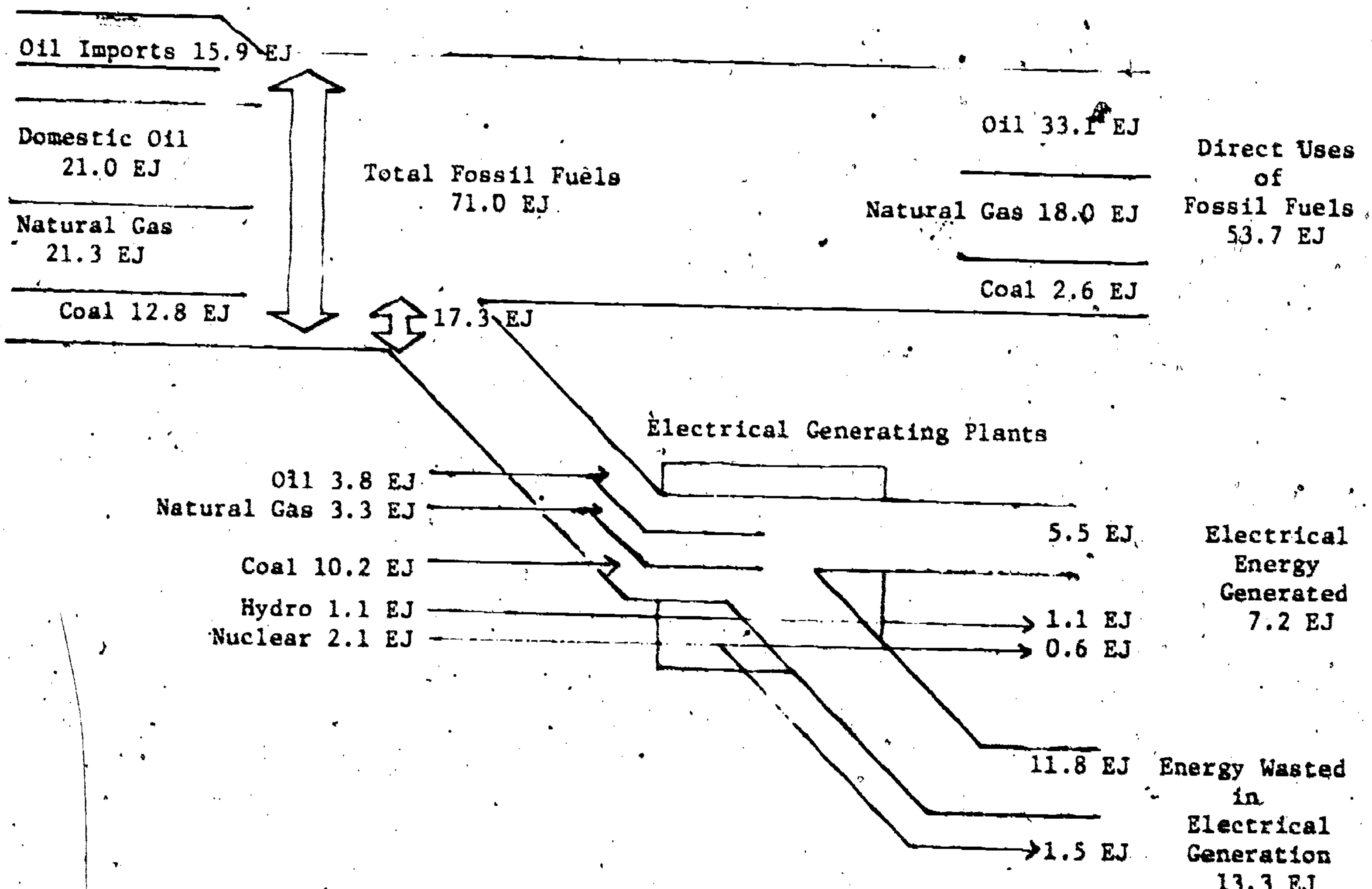
Energy Wasted	____	EJ
+ Energy Used	+ ____	EJ
Total Energy Output	____	EJ

$\frac{\text{Total Energy Used}}{\text{Total Energy Output}} = \frac{?}{?} = \_\_\_\_ \%$

What percent of Energy is wasted (not used by people)?

Percent Energy Output	____	%
- Percent Energy Used	- ____	%
Percent Energy Wasted	____	%

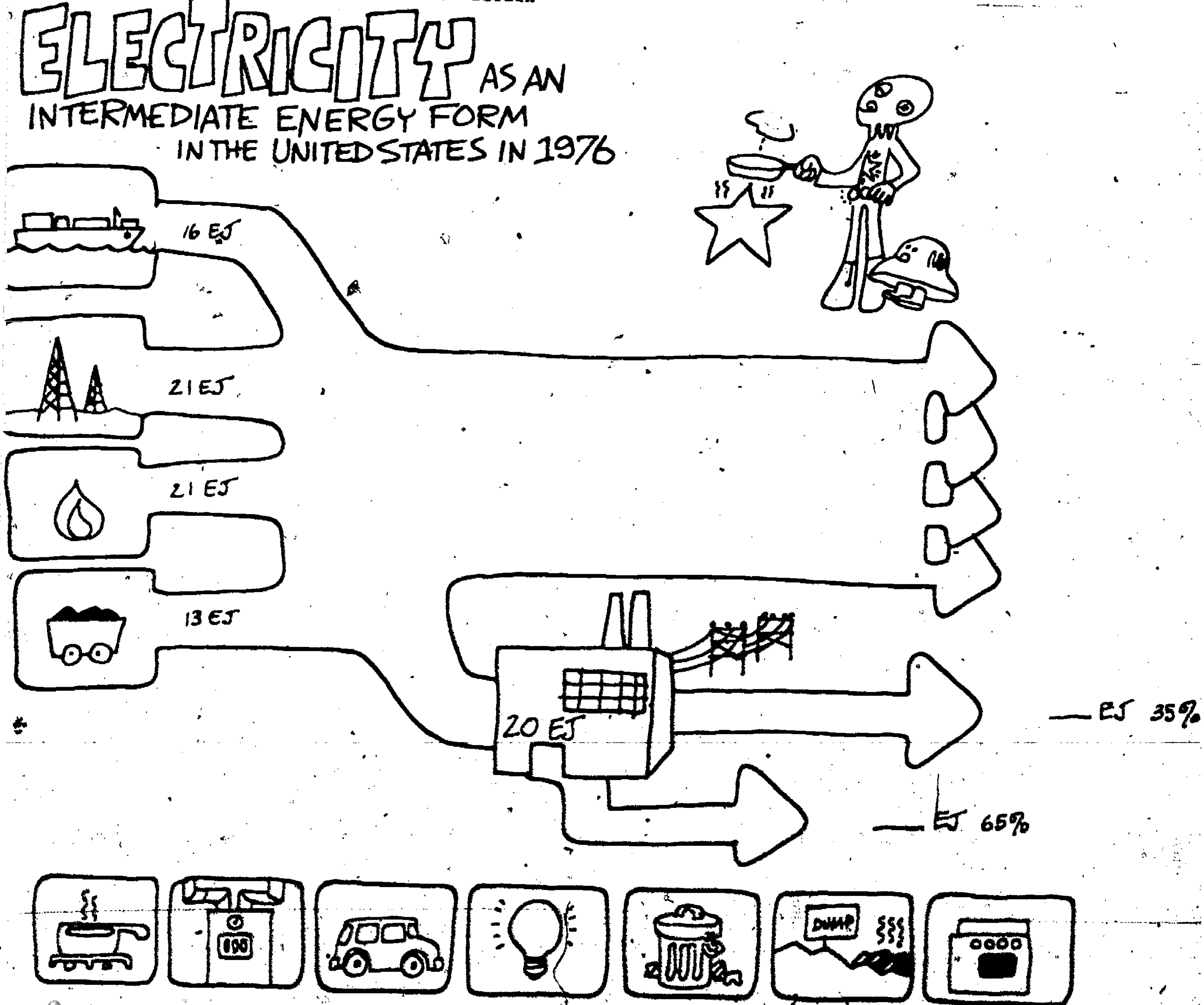
Figure 4--Teacher Edition
Electricity as an Intermediate Energy Form
in the U.S. in 1976



--EJ is the abbreviation for exa-joule, a unit of measurement for energy. The joule is the basic recommended metric unit for energy and the prefix exa- means 1,000,000,000,000,000,000 or 10^{18}. Thus, 71.0 EJ is the same as 71.0×10^{18} J or 71,000,000,000,000,000,000 J.

--All decimals are rounded to the nearest whole number for use on students' charts.

Figure 4--Student Edition



Unit II, Lesson 1: Electric Lighting from Coal

Overview

In this lesson the focus is on a specific energy flow. The potential energy of coal is followed through many conversions, supplementary energy inputs and losses that occur between the coal in the ground and the light produced from a light bulb. Experience is given with efficiency and the idea of overall efficiency of a system is introduced.

Background Information

At the present time coal supplies about as much of the primary energy used in the U.S. to generate electrical energy as all other primary energy sources combined. To show the steps required to produce electric lighting from coal, a flowchart similar to the food system flowchart is used. It is possible in this flowchart for electric lighting from coal to indicate explicitly only the energy input of the coal itself. There are other inputs (e.g., energy used to mine or transport coal). These are indicated in the flowchart as losses. That is, they are charged against the original energy input of coal.

Between the first two boxes of the flowchart in Figure 6 the decrease of 4 joules (J) of energy represents an input of energy needed to mine coal. Between the last two boxes in Figure 6, where electrical energy is being converted into light energy, 25 J of energy is lost as heat energy. This bookkeeping procedure is also used in the energy flowcharts in later lessons.

Regarding the specifics of coal mining, there are some misunderstandings. These may come out in student discussions. For instance, the mammoth draglines such as those shown in the picture set, Figure 5, are not used in strip mining for actually handling coal. They are used to remove the ground (overburden) above the coal seam and then smaller equipment is used to handle the coal. Strip mining can be done in such a way that the overburden removed from one strip can be directly deposited by the dragline into the trench of a previously mined out strip. Even though the resulting ridges can be later bulldozed level, unless special attention is given, the original topsoil is buried and the new ground surface will not support vegetation and serious problems can result. Over half of our current production of coal comes from strip mines and much of the Western coal which will be mined in the next decade is close enough to the surface to be strip mined.

If coal is to play an important role in the next decade or so, the economic/environmental problems of strip mining will have to be solved. Other environmental problems such as air pollution associated with coal combustion will also have to be solved.

Objectives

Students should be able to:

1. List five main steps in the flow of energy from coal to electrically produced light.
2. Demonstrate understanding of what accounts for the expenditure and losses of energy within this system.

3. (Optional) Discuss the waste products and other problems associated with each step in converting coal to light.

Materials
1. Picture set (Figure 5)
2. Energy Flowchart for Electrical Lighting from Coal (Figure 6, Teacher and Student Edition)
3. Electric Power Plant--Schematic Design (Figure 6a)
4. Precious "~~Jewel~~" Joule Game instructions (Activity 7)
5. Game score sheet, buttons, decks of cards

Teaching Suggestions	Commentary
Use Solardroids to introduce this lesson. Note: Suggested script for students to role-play. Students may expand the scene throughout all lessons and write their own script.	Solardroid: I...have...been...thinking. On...planet... X...we...directly...convert...energy. It... is...a...two-step...process. Both...are... 100%...efficient. One...converts...energy... of...starlight. It...becomes..."YGRENE". Second...step...converts...the...ygrene...to ...whatever...energy...we...need. Your... electrical...energy...works...like...ygrene... I...guess.
1. Use set of ten pictures, Figure 5. They show what is involved in obtaining electric lighting from the energy in coal.	1. Students work in pairs to discuss and put the set of pictures in sequence.
Have coal for the students to examine.	Some may never have seen it.
Discuss with the class the energy flow in Figure 5. Give order of pictures.	There are two pictures for each of the five main steps in the energy flow. Appropriate order would be: 1. A (dragline) — 1. I (miner) 2. B (railroad coal car) — 2. E (coal freighter) 3. C (steam turbine) — 3. F (power plant) 4. J (high voltage transmission lines) — 4. D (transmission lines with transformer) 5. G (incandescent light) — 5. H (fluorescent light)
2. The energy of coal is a kind of stored energy known as chemical energy. Essentially the burning of coal is a chemical reaction in which atoms of carbon in coal combine with atoms of oxygen from the air to form the gaseous substance called carbon dioxide. The amount of heat energy given off by this chemical reaction is what is meant by the energy of coal. See Figure 6a.	2. Solardroid: "Oh...I...see...the...power ...plant...eats...coal...like...you...Earthlings...eat...food!" Earthling: "No, no!" Solardroid: "Yes...I...show...you..." Solardroid: Hand out Figure 6.

Ask where there might be energy conversion evident on the flowchart, Figure 6. Have students mark on the chart where the conversions take place and what forms they take.

In Figure 6 there are energy conversions indicated--chemical to heat, heat to mechanical, mechanical to electrical, and electrical to light. In going from box 3 to box 4 heat energy (in steam) and mechanical energy (rotating shaft in the turbine generator) are implicit.

3. The amount of energy is smaller in the last boxes. Ask students to suggest where the energy goes as well as what form the "waste" energy takes.

3. Answers will refer to the energy required to operate the mining equipment and separate the waste rock, etc. Most "waste" energy takes the form of heat. Refer to the Energy Lost and Expended columns of Teacher Edition for Figure 6.

Have students calculate joules in boxes 2 through 6 by subtracting expended or lost energy shown in the small side boxes.

100 - 4 = 96; 96 - 3 = 93; 93 - 31 = 62; etc.

<u>OR</u> Optional:

Step 2 is 97% efficient. Ask students to calculate 97% of 96 J. Ask how many joules are lost or expended in this step.

The step from Box 3 to 4 is 33% efficient. Have students calculate 33% of 93 J for Box 4. How many joules were lost or expended in this step?

These calculations may be done for each step.

Box 1 to Box 2: 96% of 100 J = 96 J
100 - 96 J = 4 J
Box 2 to Box 3: 97% of 96 J = 93 J
96 J - 93 J = 3 J
Box 3 to Box 4: 33% of 93 J = 31 J
93 J - 31 J = 62 J
Box 4 to Box 5: 85% of 31 J = 26 J
31 J - 26 J = 5 J
Box 5 to Box 6: 5% of 26 J = 1.3 J (round to 1 J)
26 J - 1 J = 25 J.

4. Each of the steps in energy flow from coal to electric lighting involves two kinds of waste. One is an energy waste in the form of heat as was discussed earlier. The other is waste products released into the environment. What are some of the waste products and environmental problems associated with each step?

4. Have student pairs talk about and list what they would consider to be one problem for each step. These problems are in the right-hand column of the Teacher Edition for Figure 6.

5. <u>Precious "Jewel" Joule Game (Activity 7)</u> A fast moving game which allows students to attempt to save energy. The element of chance does not allow it to simulate a real energy flow system, but does provide the idea of energy expenditure and waste from prime energy source to end use of energy.

5. Refer to game directions on page 51.

Materials needed for game:
- buttons
- decks of cards
- score sheet
- pencils

SAVING DOLLARS

6. Optional: "Saving Dollars" can be used with this lesson or with solar energy, Unit IV, Lesson 2. This also makes a good home assignment. The concepts involved in this activity apply to other situations such as solar heating in which payback times are longer, but the annual savings are greater.

Incandescent lighting has an electrical energy conversion efficiency of 5% while fluorescent lighting has a 20% efficiency.

For example, if it costs $28.00 per year for the electricity to illuminate a kitchen with incandescent lighting, it would cost $7.00 per year for the electricity to provide that same amount of illumination using fluorescent lighting. Why do you think this is so?

Have apparatus for students to plug in both types of lights (or locate the two types of lights in the school). After allowing the lights to be on 10-15 minutes, check for heat given off by holding hands 3 cm from each light.
Fluorescent lights do not produce much waste heat, burn cooler. They will last longer.

Assume that the incandescent and fluorescent bulb replacement costs could be the same. The fluorescent fixture would have a higher cost because it needs to contain more complicated parts.

Assume that the required fluorescent fixtures have an installation price of $50.00 while the figure is $29.00 for comparable incandescent fixtures. This means that in the construction of a new house choosing fluorescent rather than incandescent lighting would cost $21.00 more for the initial installation (a one-time expense), but $21.00 less for electricity each year.

In a new house, which type of electric lighting would save you the most money over 5 years? How much? Why?

Fluorescent.
$21.00 x 5 yrs = $105 - $21 extra installation fee = $84 saved
In this example one year would be called "payback time" when the total costs for fluorescent and incandescent lighting would be the same. Each year after the first one you would be saving $21.00 if you had chosen to have fluorescent lighting.

When replacing the incandescent lighting in an existing house with fluorescent lighting, the installation price of the fluorescent lighting would be more than in new construction, let's say, $63.00 instead of $50.00. What would be the "payback time" in this case?

This would make the payback time three years. ($21.00 savings per yr for 3 yrs = $63.00 savings on electricity).

Figure 5

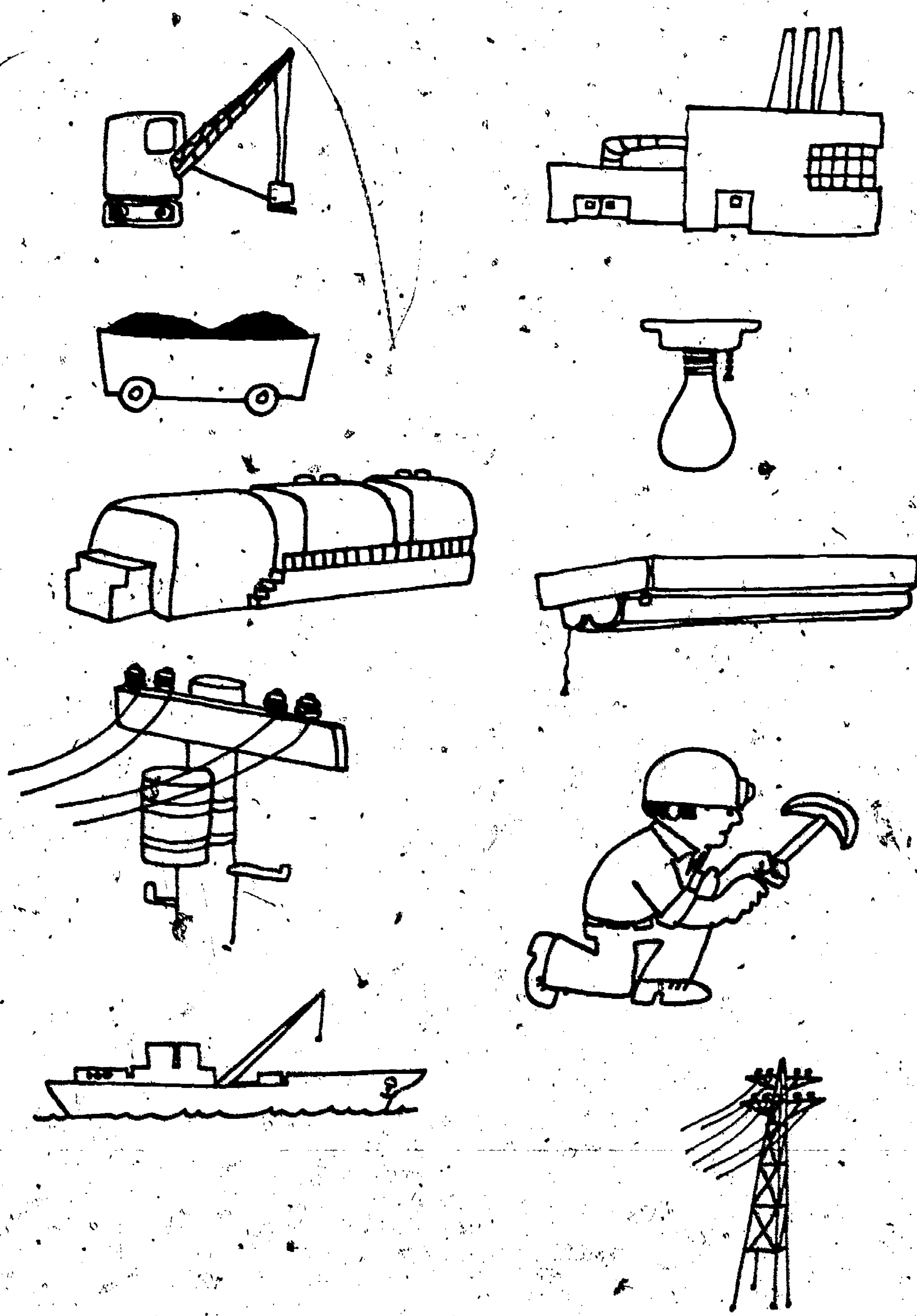


Figure 6--Teacher Edition
<u>Energy Flow Sheet for Electric Lighting from Coal</u>

Energy Lost and Expended		Waste Products and Other Problems
	100 J of chemical energy in coal which is in seams in geological formations in the ground	
96% Step efficiency Energy expended in mining, preparation for mining, land reclamation, coal processing	↓	1. unproductive, unattractive ground surface 2. water contamination by mine acids 3. subsidence 4. underground fires 5. fatalities, injuries, and black lung disease among miners
	96 J of chemical energy in coal ready for use there or for transport to another location	
97% Step efficiency Energy expended in transportation of coal by train, ship, truck, coal slurry	↓	1. coal litter along transportation route 2. equipment 3. right of way requirements 4. water requirements for coal slurry
	93 J of chemical energy in coal in the storage pile at the electric power plant	
33% Step efficiency Energy expended in operating the power plant; heat lost up smoke stack; heat lost to the cooling water in the turbine condenser	↓	1. stack and cooling water heat losses 2. air pollution by particulates and gases from stack 3. appearance of coal pile 4. fish get in cooling water intake tubes
	31 J of electrical energy (derived from burning coal) leaving the power plant	
85% Step efficiency Energy expended as heat loss produced by electrical resistance in the wires of the transmission power line; in the manufacture and maintenance of transmission towers, lines, transformers, etc.	↓	1. unsightly and dangerous overhead transmission lines 2. peak energy demand periods determine generating capacity requirements
	26 J of electrical energy at a home or other place of end use	
5% Step efficiency Energy expended to maintain the filament of the light bulb at a high temperature (incandescent); energy lost as heat to air	↓	1. bulb replacement 2. waste heat can be a problem in closed spaces during hot weather
	1.3 J of light energy (electromagnetic radiation)	

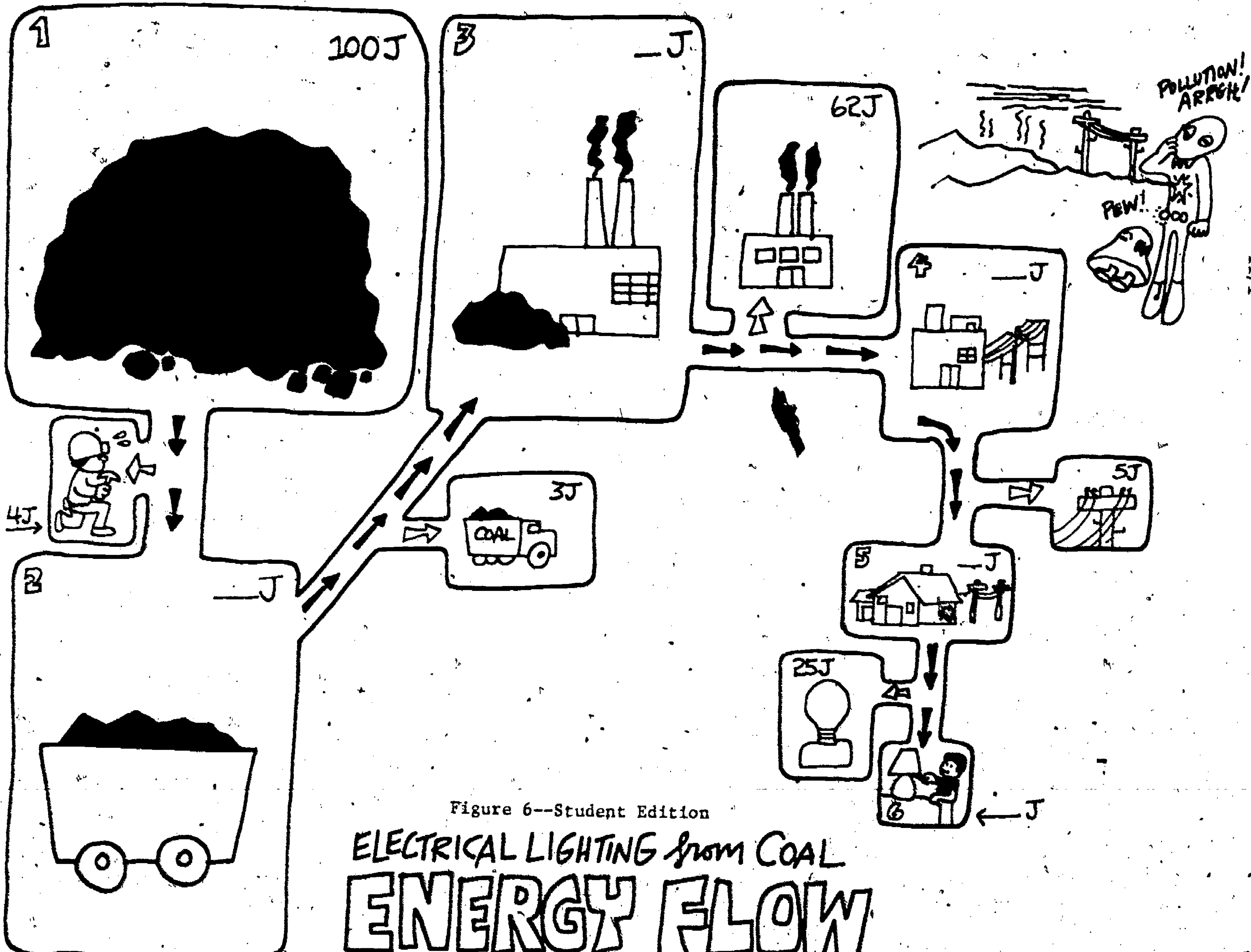
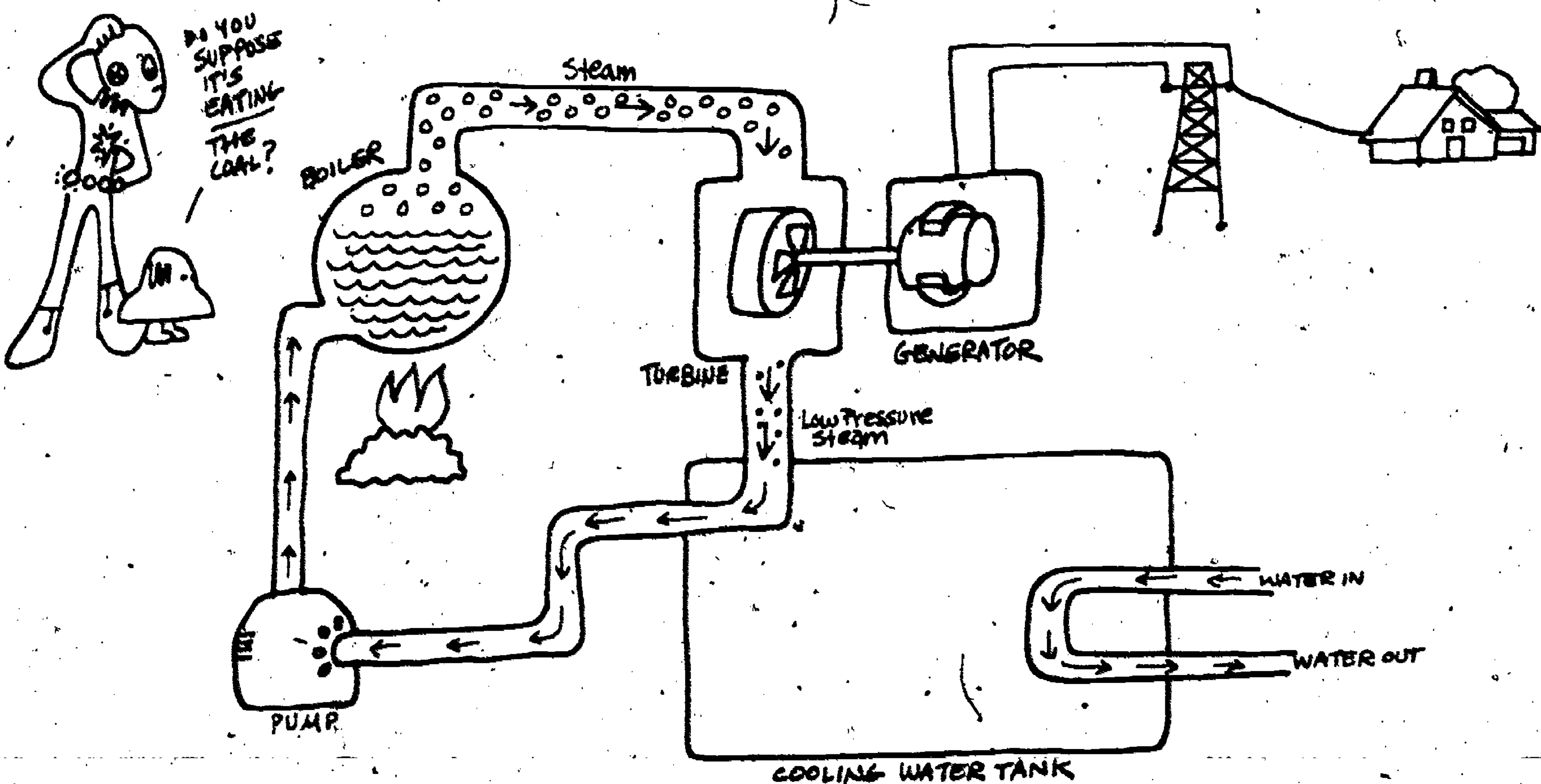


Figure 6--Student Edition

ELECTRICAL LIGHTING from COAL

ENERGY FLOW

II/I



ELECTRIC POWER PLANT (Schematic Design)

Activity 7
Precious "Joules"

The Set Up

1. For 4 to 6 players.
2. Use Figure 6, Student Edition, as gameboard.
3. Each player choose a game marker (use buttons, coins, paper squares).
4. Use a deck of cards to determine numbers.
5. There is no advantage to being the first player.

Object of the Game

1. Each player starts with 100 J in Box 1.
2. First player draws a card from the deck.
3. If the card is from Ace to Ten, the player moves to Box 2 and subtracts the face value of the card from his/her 100 J. Use score sheet. Ace = one (1).
4. However, if the card is a face card the player may not move to box 2. Instead s/he must be placed in the small side box. The player still subtracts from the 100 J. S/he subtracts 10; face cards = 10.
5. A player may get out of a small box only be drawing a non-face card.
6. Players must subtract from their remaining joules the number on every card they draw even those drawn in an attempt to get out of a small box.
7. Each player in turn draws a card.
8. The game continues until each player has successfully moved through all boxes, 2 to 6.
9. The WINNER is the player with the largest number of remaining joules.

PRECIOUS "JOULES" SCORE SHEET

PLAYERS	1	2	3	4	5	6
Box 1	100	100	100	100	100	100
Box 2						
Box 3						
Box 4						
Box 5						
Box 6						

Unit II, Lesson 2: Energy Flow for Automobile Fuel

Overview

The class examines a four step energy flowchart which starts with crude oil in the ground and ends with a moving automobile. The least efficient step is studied in greater detail beginning with the automobile engine and continuing on to its other parts. Other means of transportation are examined primarily from an energy efficiency point of view.

Background Information

Teachers wishing background material on oil and transportation systems may find useful the discussion on pages 23-25, 115-116, and 138-140 in The Energy-Environment Source Book, by John M. Fowler, National Science Teachers Association, Washington, D.C., 1975. For this lesson it is assumed that the students' experience in reading energy flowcharts in the earlier lessons makes it appropriate to put the students more on their own in reading and interpreting the flowchart on automobile fuel.

Objectives

Students should be able to:

1. List the four energy conversions in the flowchart for the transportation system involving the automobile and identify the least efficient conversion process.
2. Identify some of the environmental problems associated with this energy flow.
3. (Optional) Compare and/or discuss relative to life style the energy efficiencies of the different forms of transportation.

Materials

1. Energy Flowchart for Automobile Fuel (Figures 7 and 7a, Teacher and Student Edition)
2. Energy Flowchart for a Moving Car (Figure 8, Teacher and Student Edition)
3. Relative Energy Efficiencies of Some Kinds of Transportation (Figure 9, Teacher and Student Edition)
4. Mural paper, caryons, etc.
5. Magazines, scissors

Teaching Suggestions

1. Present the material on crude oil and refineries to students and have them produce a wall mural depicting the major steps in refining oil. The mural should be done to explain the processes to Solardroids.

Have Solardroids write a script in which they are intrigued by the "eating" (or in this case "drinking") analogy of the car using this liquid. They wonder what it is and how it is used.

Commentary

1. Mural Background Information:
The crude oil which is found in the ground is believed to be the remains of both plants and animals which did not decay in the usual way. Instead they sank to the bottom of large bodies of water tens of millions of years ago, were covered by layers of earth, and subjected to great pressure and heat. Over the years this produced the crude oil which slowly flowed through porous rock until it was trapped in pools under non-porous rock.

Oil is different from coal in several ways. For example, coal is roughly ten times as old as oil and has had almost everything removed except the carbon atoms from the original living plants. Besides carbon atoms, there are hydrogen atoms still left in oil. In oil these two kinds of atoms are combined in units known as molecules. Crude oil is mostly a mixture of many different kinds of these "hydrocarbon" molecules.

Oil wells are holes in the ground which have been drilled and lined with pipe through which this crude oil mixture of hydrocarbons is brought to the surface. Initially in some wells, the pressure is great enough to force the crude oil up the pipe, but ordinarily pumping is required. Once this mixture of hydrocarbons is at the earth's surface, it goes to an oil refinery. Here the different kinds of hydrocarbon molecules are separated from each other.

2. Use Figure 7. Have students figure the reduction in joules for each process step. Where is the largest joule loss?

2. 100 J - 4 J = 96 J; 96 J - 12 J = 84 J
84 J - 3 J = 81 J; 81 J - 74 J = 7 J
In the car itself.

Have students construct an alternative flowchart based on imported oil. Use Figure 7a. Use data on energy used in tanker transportation and on oil spills found in the <u>Energy-Environment Source Book</u>, by John M. Fowler, National Science Teachers Association, Washington, D.C., 1975.

3. The engine of the automobile is where most of the 74 J loss occurs in the last step of Figure 7. Ask them to suggest some ways in which energy is lost or used in the operation of the <u>engine</u>. Potential expansion to capitalize on student interest in cars may be incorporated here. Use Energy Flowchart for a Moving Car, Figure 8.

3. The friction between moving parts in the engine generates some of the heat energy which is removed from the engine by the radiator cooling system. The engine exhaust system removes additional heat energy and is the major heat energy lost.

4. Use car ads to locate places other than the engine where energy is lost or used in the operation of an automobile. How much energy is left in the system to move the car?

4. Other important losses are indicated in Figure 8.

7 J.

Bring in advertisements for cars. Examine the ads to see where they claim to save energy. Relate the claims to the energy uses in Figure 8.

Have pairs of students "build a better car" by drawing a fictional car which eliminates parts of real cars which waste energy.

5. Optional: Transportation means more than just automobiles. It means more than just moving people around. In considering our country's energy problems it is certainly appropriate to examine the energy efficiencies of the various alternative means of transportation. To be most useful, a separation should be made between the transportation of people and of "stuff".

Use Figure 9. Looking first at the transportation of people, we see that efficiencies vary depending on a number of different factors. What factors? Why do people make the transportation choice they make? Produce a list/chart and pictures of choices.

Possible responses: the distance of travel, a rough classification of this is "within a city" and "between cities"; the load factor, four people in a car; etc.

Despite the more frequent and shorter trips within a city to stores, school, work, etc., the total miles traveled is greater between cities and these longer trips tend to be <u>more</u> energy efficient. Why?

Possible responses: not as many stops and starts; slower; more turns; etc.

Have students in groups prepare three wall graphs from the information in Figure 9.

Graphs: place methods of transportation relative to:

1. most passengers carried
2. farthest distance easily traveled
3. easiest to use (based on group's rationale)

Solardroid: "You...move...people...to... places...so...slow. We...can...go...by... what...you...call...'time...machines'."

Brainstorm about the Future:
When we move stuff rather than people, what additional types of transportation are added to the list of possibilities?

Pipelines can be used to transport oil and gas (and even coal in the new slurry method). Wires transmit electrical energy.

Solardroid: "What...do...you...send...now... wireless?"

Earthling: Radio, TV, etc.

By stretching your minds a little further, think of "information" as ~~a~~ kind ~~of~~ stuff ~~that we~~ need to transport. ~~How~~ might this "stuff" be transported?

Rather than using the mail service, it may be more energy efficient to send information using wires, radio and microwaves, and even laser light in the new optical fiber systems.

Figure 7--Teacher Edition
Energy Flowchart for Automobile Fuel

Energy Lost and Expended		Waste Products and Other Problems
	100 J of chemical energy in crude oil in the ground	
96% Step Efficiency Energy expended in exploration, production well, transportation to refinery by pipeline and tanker	↓	Dry holes; accidental blowouts, fires, spills; flaring; imports
	96 J of chemical energy in crude oil at the refinery	
87% Step Efficiency Energy expended in the refinery and lost as heat in the separation and other processing of the crude oil	↓	Odors, accidental fires and explosions
	84 J of chemical energy in gasoline at the refinery	
97% Step Efficiency Energy expended in the transportation to service stations (pipeline, railroad, truck) and in storage and pumping	↓	Much less odor and danger of fire than at refinery; hydrocarbons evaporate and add to air pollution
	81 J of chemical energy in gasoline in the gas tank of an automobile	
9% Step Efficiency Energy expended in the engine and other parts of the car	↓	Engine exhaust is a major cause of air pollution in heavily populated areas; used crankcase oil disposal
	7 J of mechanical energy in the motion of the automobile	

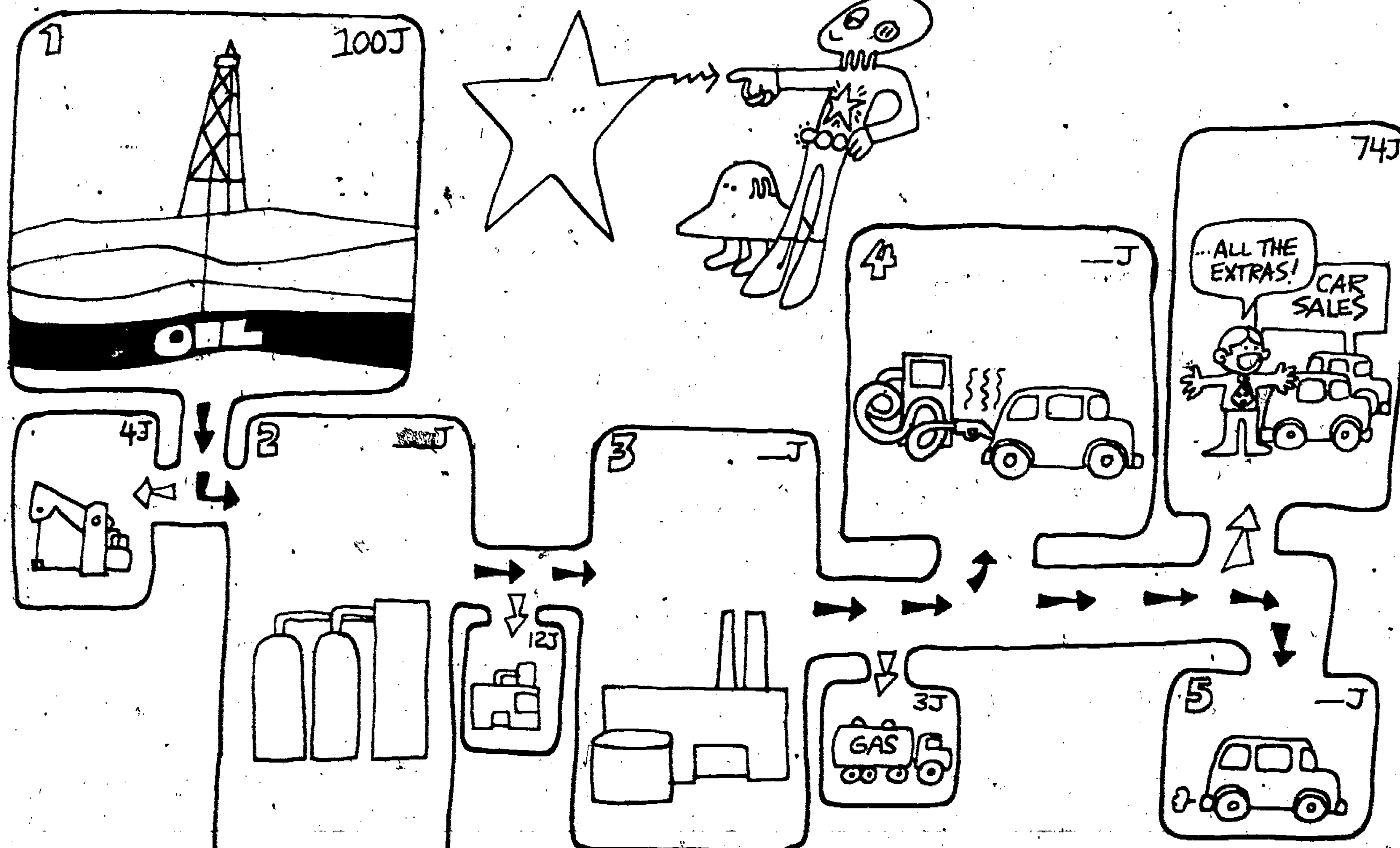


Figure 7--Student Edition

AUTOMOBILE FUEL ENERGY FLOW

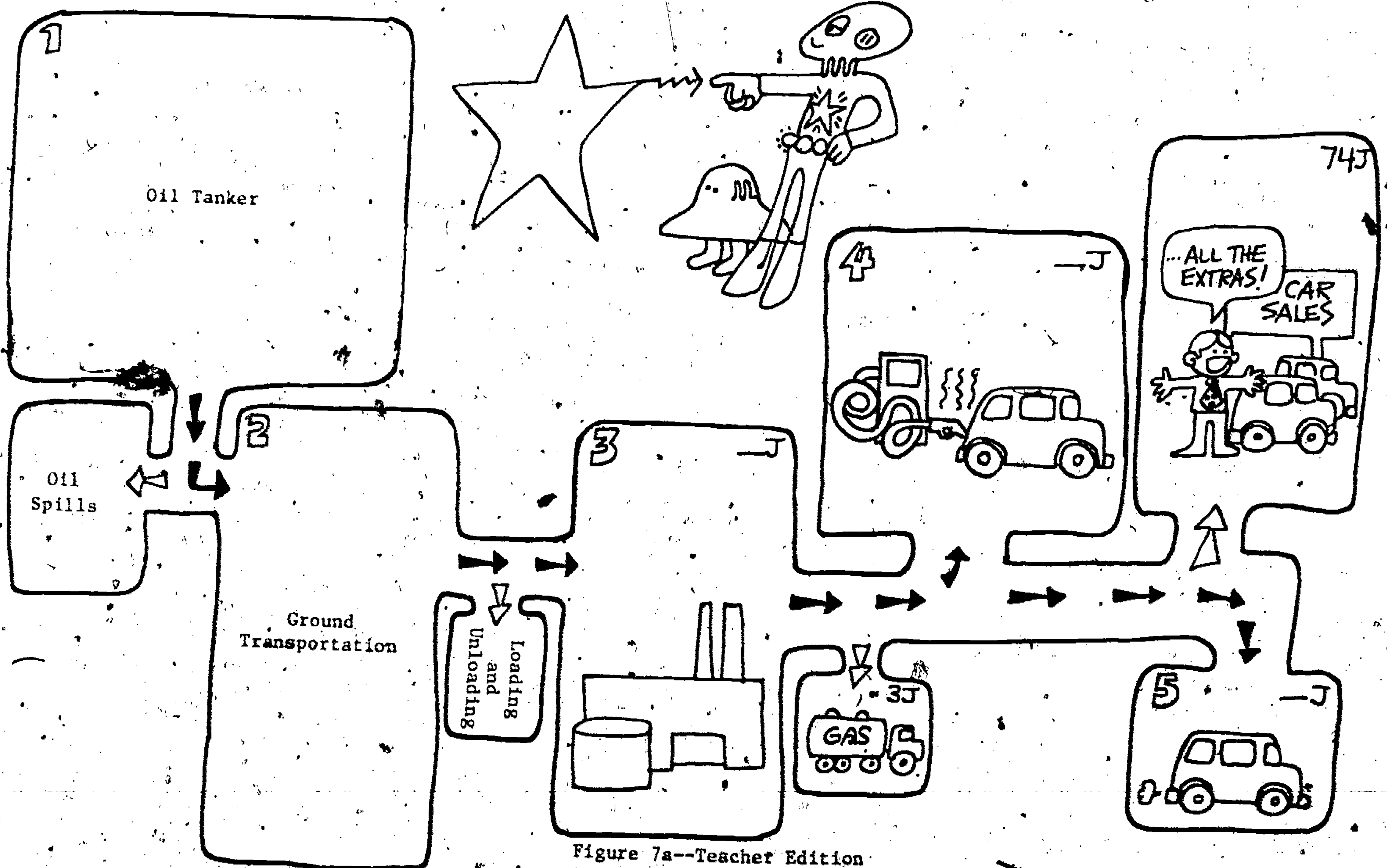


Figure 7a--Teacher Edition

AUTOMOBILE FUEL ENERGY FLOW

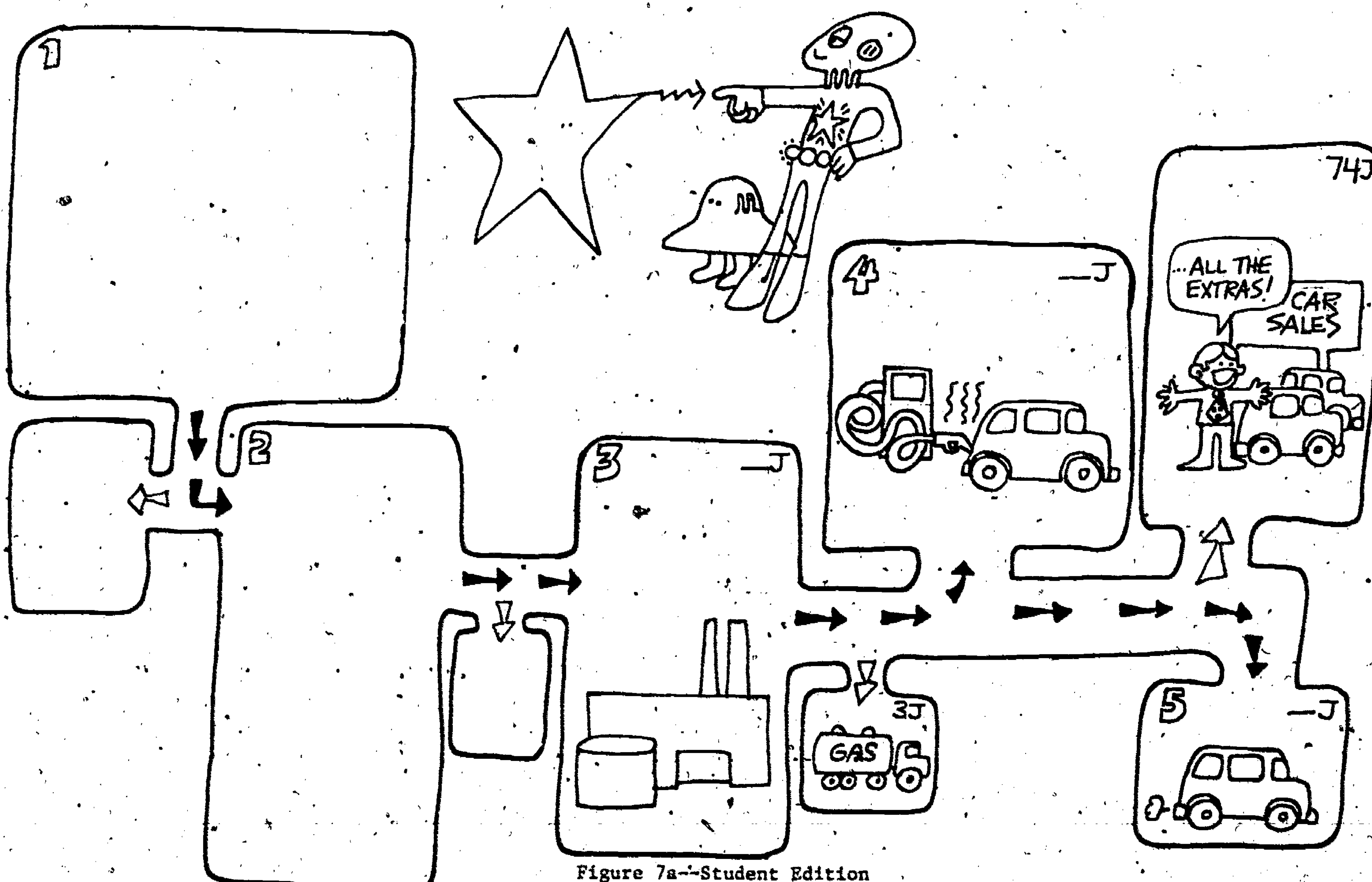


Figure 7a--Student Edition

AUTOMOBILE FUEL ENERGY FLOW

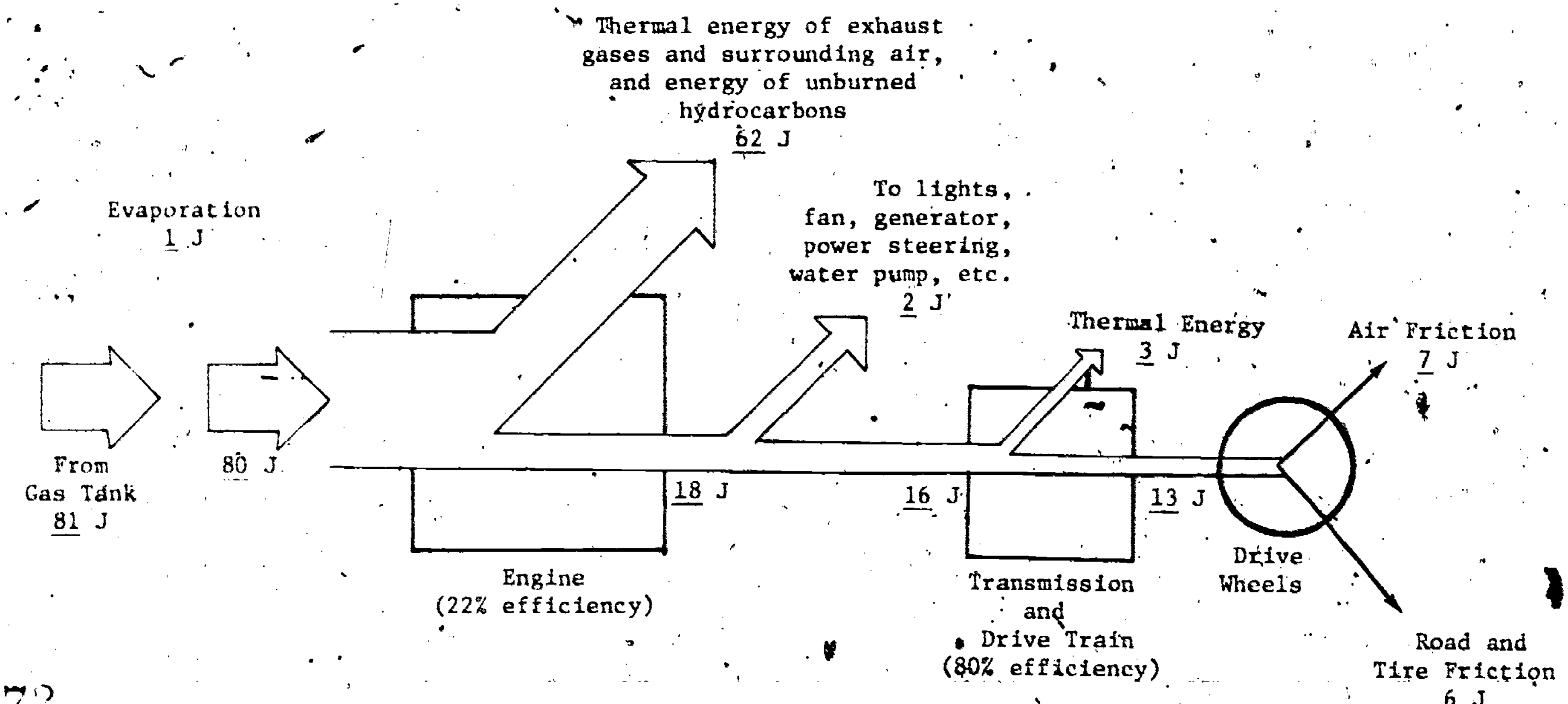
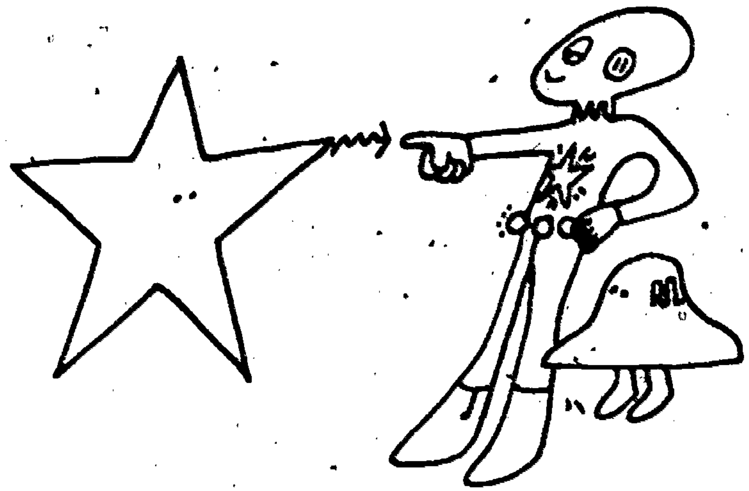


Figure 8--Teacher Edition
Energy Flowchart for a Moving Car



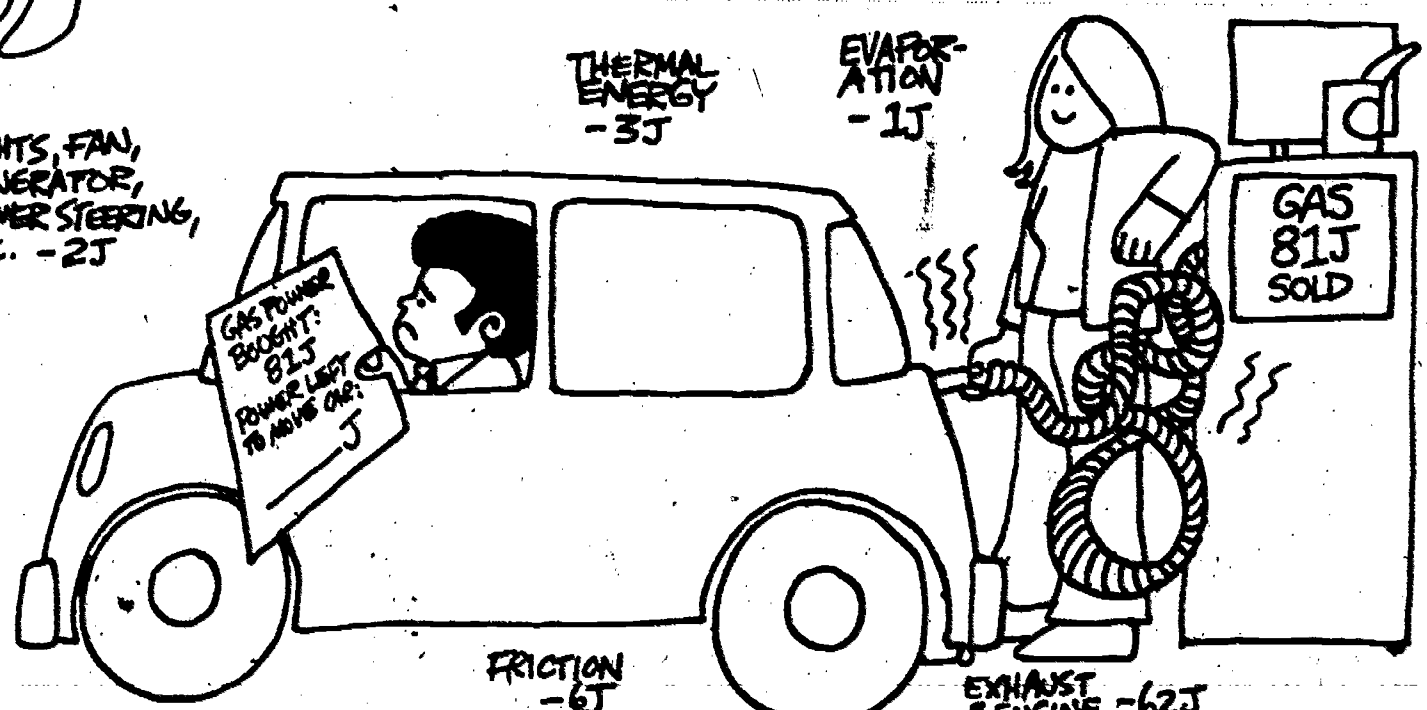
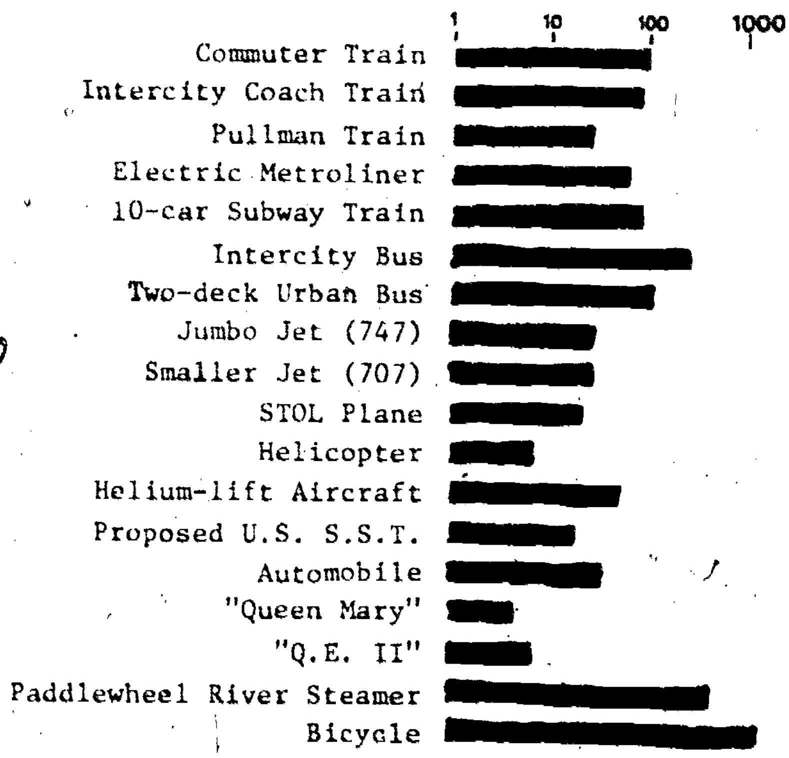


Figure 8--Student Edition
Energy Flowchart for a Moving Car

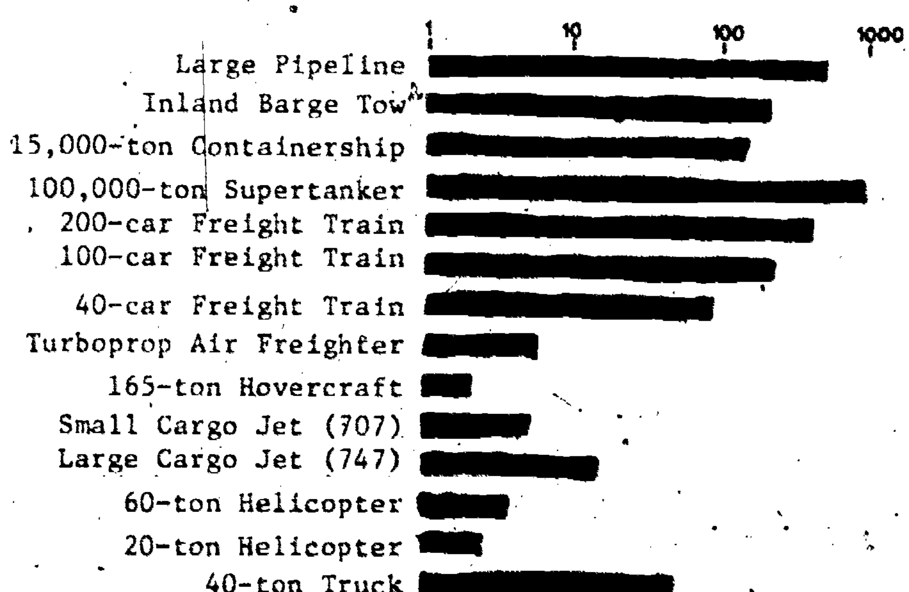
Lesson 3

Graph 1:
Relative Energy Efficiencies of Some Kinds of Transportation
(energy costs given in units of passenger miles per gallon or ton miles per gallon)

Transportation of People
(per person with average load)

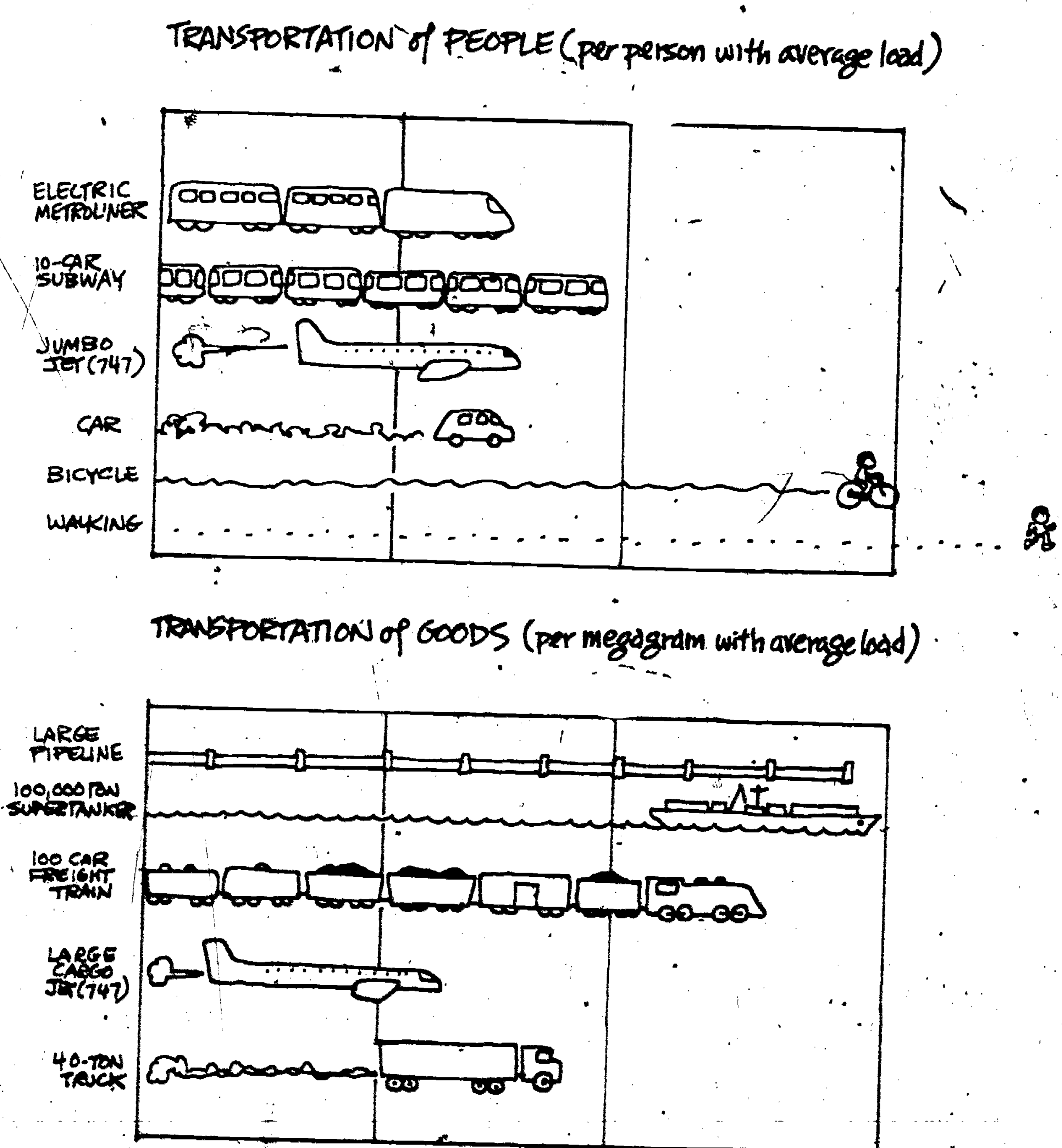


Transportation of Goods
(per ton with average load)



Source: "System Energy and Future Transportation." Richard A. Rice, Technology Review, January 1972.

Figure 9--Student Edition



RELATIVE ENERGY EFFICIENCIES

OF SOME KINDS OF TRANSPORTATION

(energy costs given in units of joules per kilometer)

Unit II, Lesson 3: Heat Leaks and Heat Engines

Overview

An analogy is presented between the temperature in a heated house and the water level in a leaky bucket. The lesson goes on to consider heat losses from infiltration and by conduction. Student activities involve detecting drafts and the insulating qualities of different materials.

Background Information

The term infiltration refers to the passage of air into and out of a building through any openings. Infiltration accounts for about 55% of the heat losses from well constructed and insulated homes, so the students' work with the "draftometer" is right on target. The other home heat losses are essentially conductive with 24% through the walls, 14% through the windows, 4% through the ceiling, 2% through the floor, and 1% through doors. (Although less heat escapes through one square meter of wall than through one square meter of window, the total wall area is much greater than the total window area.) Inadequate insulation can change these percents considerably and double the non-infiltrative heat losses. Additional background information can be found in the U.S. Department of Energy's publication EDM-1028 entitled, Energy Conservation in the Home.

Objectives

Students should be able to:

1. Identify space heating as the largest residential end use of energy.
2. Describe how heat is lost from a building by infiltration and conduction and how to reduce such losses.

Materials

1. Home Uses of Energy (Figure 10, Teacher and Student Edition)
2. Water Level in a Leaky Bucket Diagram (Figure 11; with a #10 tin can punctured with nail holes, a tub or basin, and some water)
3. Draft Check Sheet (Activity 8)
4. Challenge: "Save the Ice Cube" (Activity 9)
5. Variety of potential insulating materials
6. Ice cubes, clock
7. Directions for an Experiment on Insulation (Activity 10)
8. 100 watt light bulb in ceramic socket, cord and plug
9. A variety of insulating and non-insulating materials such as wood, aluminum foil, fiberglass, glass, newspaper, heavy cloth, etc.
10. Cardboard box with four openings cut in it
11. Four thermometers, masking tape, a watch

Teaching Suggestions	Commentary
1. Use Figure 10. After giving the class an opportunity to look at it for a minute, ask which of the uses in the home consumes the greatest amount of energy. By how much?	1. Space heating or heating the living area in the home uses more energy than all others combined.
Have Solardroids discuss the problem of heating a house. Do the leaky bucket demonstration, Figure 11.	Solardroid: "You...have...problems...with...keeping...heat...energy...in...your...houses. Let...us...show...you...your...problem."

The higher water level in the bucket relative to the outside is analogous to the higher temperature in a heated house relative to the temperature outside. The analogy even extends to the increased rate at which heat (water) leaks out when a greater difference in temperatures (water levels) is maintained inside and outside.

Look at Figure 10 again. Which energy uses are necessities and which might not be necessary? Which uses could be reduced?

Necessities: heat, hot water, stove, refrigerator, light, washer;
Not Necessities: Air conditioning, TV, etc.
Reduced: ALL

Students can draw in other energy users in the house, i.e., their favorites: hair dryers, stereo, etc.

2. Have Solardroids show the class a homemade draftometer, but not name it. Ask one of the students how this device might be used to help locate where heat is being lost from a house or classroom. Have students make draftometers. Checking drafts at home and/or in school will demonstrate heat losses. Have students record the location of drafts on a map of each room checked, and/or on the Draft Check Sheet (Activity 8).

2. The draftometer can be made quickly by attaching the shorter edge of a piece of thin plastic food wrap (approximately 12 cm by 25 cm) along something like a pencil with scotch tape. The hanging plastic responds to quite gentle air movements and can indicate air leaks around doors and windows. Holding this device near the edges of windows and doors, by baseboards, and by electrical outlets and switches allows you to test for drafts or air leakage. It should be clear that hot air moving out of the house and cold air moving in represents a heat loss.

What might help reduce such heat losses?

Weather stripping, insulation, storm windows, drapes, etc.

Do Activity 9, "Save the Ice Cube".

You might bring into the classroom samples of different kinds of weatherstripping and describe how each of these and caulking are used to cut down on heat losses. An appropriate activity would be to have students check the air temperature near the ceiling and near the floor at home and/or at school.

Probable findings: warmer temperatures near ceiling and cooler ones near floor.

Ask the class to suggest the possible causes of air movement inside a house.

People just moving around, the fans in forced hot air systems, the air movement which results from warm air rising in a room because it is less dense than cold air.

3. Heat energy leaks out of a house through the walls and ceiling. In this kind of situation where one side of a material object like a wall is at one temperature and the other side is at a different temperature, the heat energy is conducted by the material itself. Poor conductors are known as good insulators. Have students do the insulation experiment, Activity 10.

Solardroids challenge Earthlings to design houses as leakproof as those on planet X. Students may describe, draw or make models of their leakproof houses.

Figure 10--Teacher Edition
Home Uses of Energy

Space Heating	57%
Water Heating	15%
Cooking	5%
Refrigeration	6%
Air Conditioning	4%
Lighting	3%
Television	3%
Clothes Drying	2%
Food Freezing	2%
Other	3%
	100%

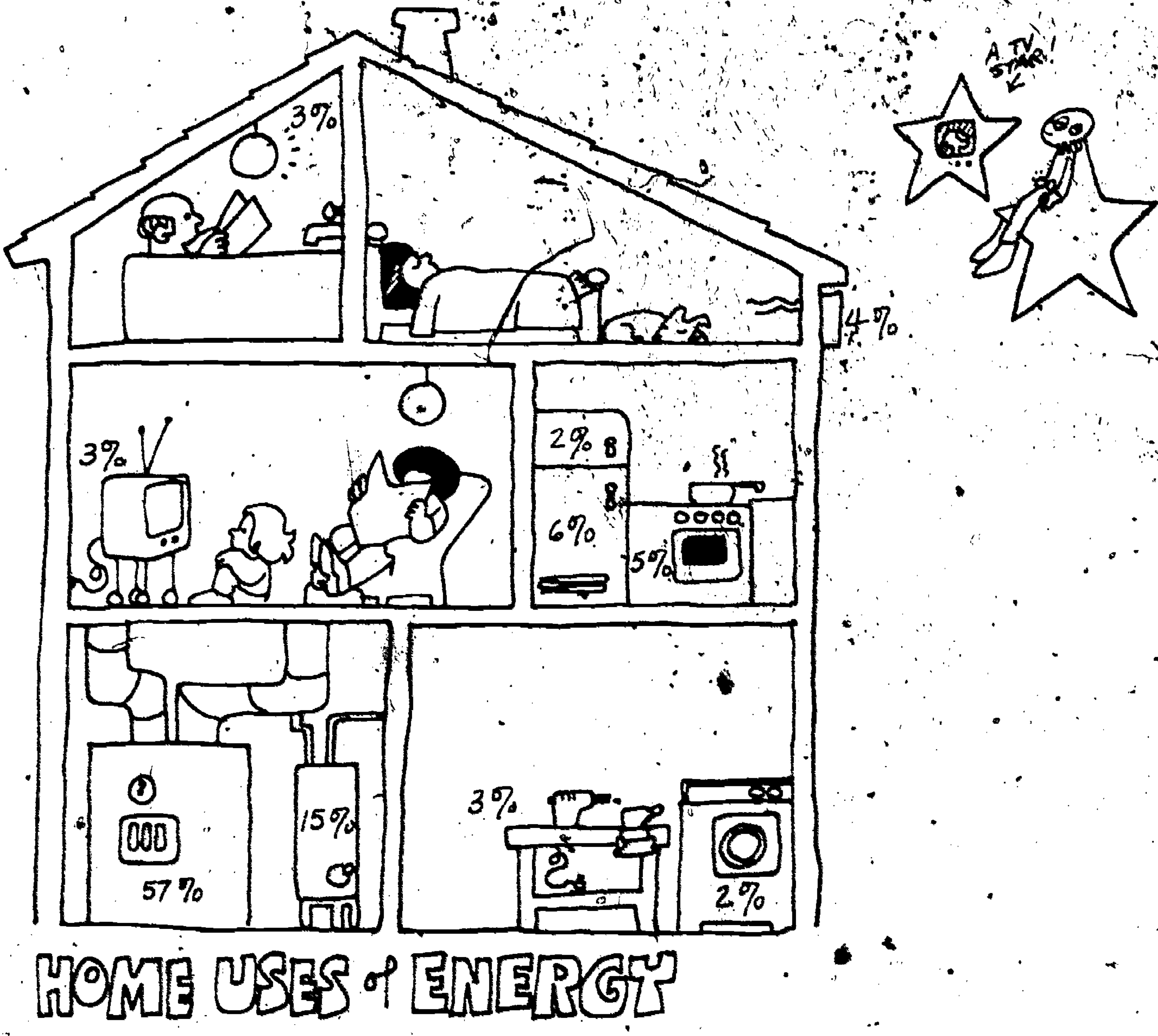
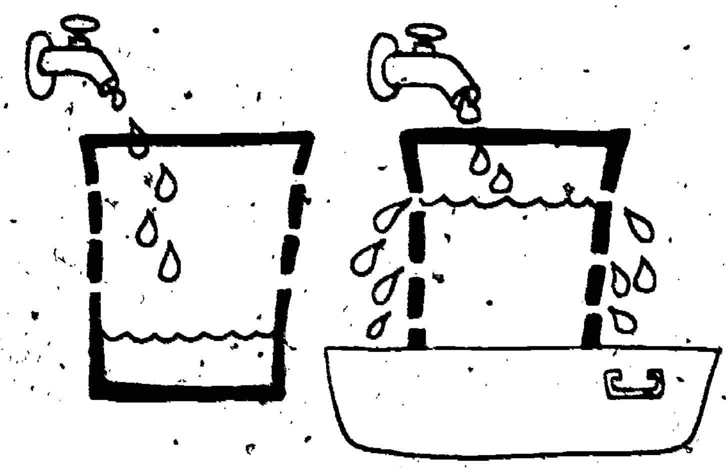


Figure 10--Student Edition

Figure 11
Water Level in a Leaky Bucket Diagram



Questions:

1. How is the water in the bucket like heat in a house?
2. What happens when water (heat) is added?

Activity 8
Draft Check

DATE	LOCATION	DESCRIPTION	AMOUNT OF DRAFT

Activity 9
Challenge: "Save the Ice Cube"

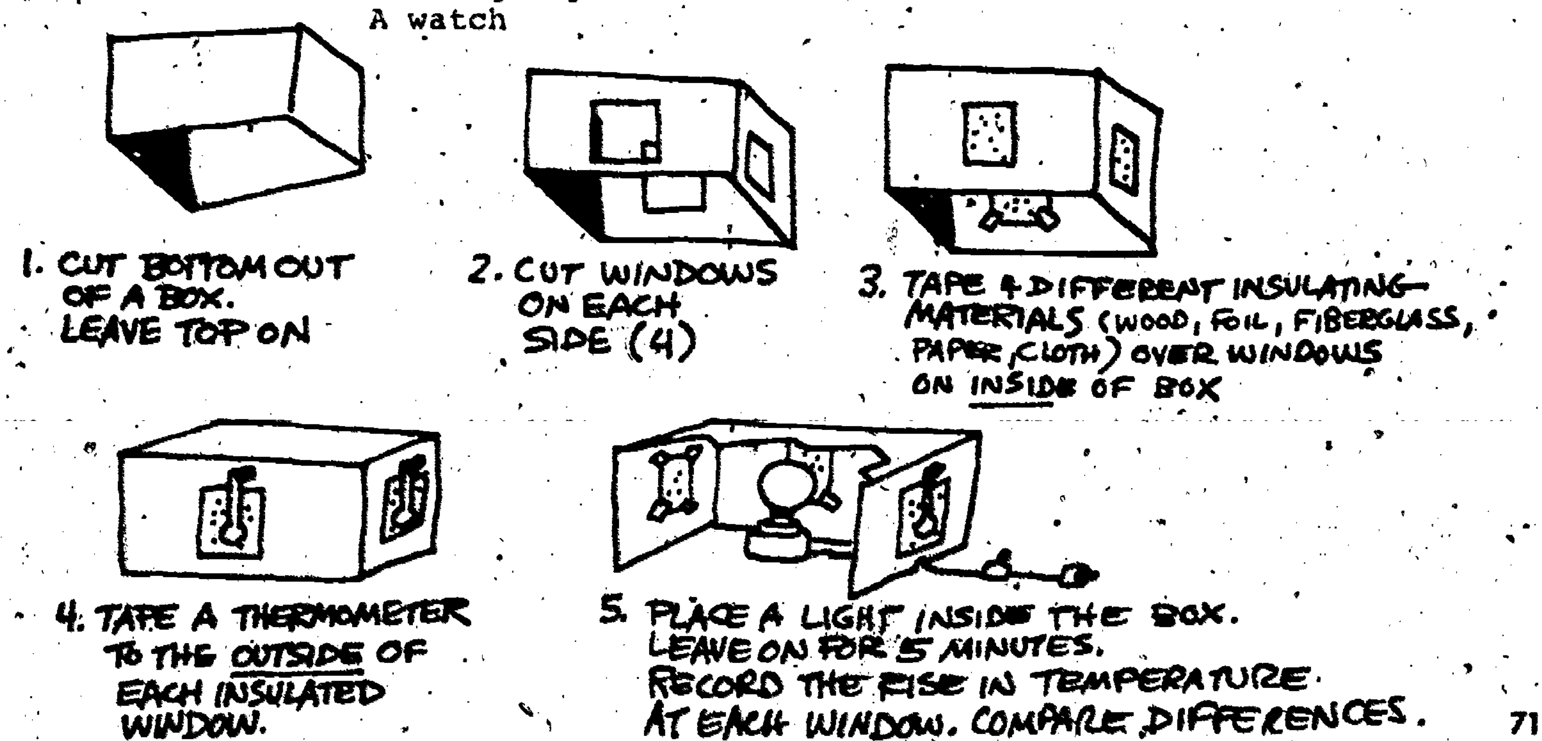
Materials
- A variety of potential insulating materials
- Ice cubes
- Clock

1. Students bring in any material they wish from home (they may share; work in pairs).
2. Students are to insulate an ice cube to see who can keep the ice cube "alive" the longest.
3. Students prepare their ice cubes and record time of the life of the ice cube.
4. Discuss: those cubes who "went first".
   those cubes who "lived longest".

Relate this to insulating problems.

Activity 10
Experiment on Insulation

Materials
- 100 watt light bulb in ceramic socket
- A variety of insulating and non-insulating materials such as wood, aluminum foil, fiberglass, glass, newspaper, heavy cloth, etc.
- Cardboard box with four openings cut in it
- Four thermometers
- Masking tape
- A watch



6. Now calculate the change in temperature for each material, using the recording tables below.

7. Decide which would be the best insulating materials. Explain your reasoning.

Materials

Temperature	WOOL	FOIL	FIBER-GLASS	METAL	GLASS	PAPER
Before						
After						
Change						

Materials

Temperature	WOOL	FOIL	FIBER-GLASS	METAL	GLASS	PAPER
Before						
After						
Change						

Unit III, Lesson 1: Limits of Energy Resources

Overview

This lesson distinguishes between renewable and depletable energy resources and goes on to look at the amounts of the depletable resources we have in the U.S. and in the world. The number of joules of energy these depletable resources contain are compared to the total number of joules of energy the U.S. will probably use in the next 25 years.

Background Information

The amounts given for the U.S. natural gas and oil resources in Figure 22 include the amount expected from enhanced recovery. Enhanced recovery makes use of a number of techniques, including pumping various things down some wells in order to get more production from other wells in an otherwise exhausted field. Figure 22 does not include oil shale and geothermal as energy resources of some possible significance. However, optimistic estimates of these resources are 6.1×10^{21} J and 3.6×10^{21} J respectively, but in each case extensive research and development are required to bring these resources into anything near this amount. For comparison purposes, the renewable solar resource can provide 45×10^{21} J of energy per year.

Objectives

Students should be able to:

1. Distinguish between renewable and depletable energy resources.
2. Compare the magnitude of some primary energy resources with the expected energy use in the U.S.

Materials

1. Graph of Annual U.S. Energy Use (Figure 12)
2. Energy Requirements and Resources (Figure 13)

Teaching Suggestions

1. A Solardroid can make the distinction between renewable and depletable resources.

Commentary: 1. Solardoird: Your assignment is to help introduce this lesson on the difference between energy resources which can be used up (that is, are depletable or non-renewable) and energy resources which are renewable,

"On...planet...X...the...only...energy...resource...used...is...starlight. Starlight...is...the...kind...of...thing...that...can-not...be...used...up...completely. If...you...use...it...all...today...there...will...still...be...some...tomorrow. If...there...was...something...useful...to...do...with...your...fingernail...trimmings,...you...could...consider...them...a...renewable...resource. Each...week...you...could...trim...some...more."

Sunlight is like starlight, both are renewable resources. Hydro energy is renewable. But most of the energy being used on earth today is non-renewable or depletable. If and when any fossil fuel gets used up, it is depleted; it is gone; it will not be renewed.

Earth's present use of depletable energy resources must someday come to an end.

2. Use the Graph of Annual U.S. Energy Use (Figure 12). Ask why the use of energy has been going up.

Commentary: There has been both an increase in the number of people and an increase in the amount of energy used by each person.

Ask how to go about predicting the U.S. energy use for the future.

Current energy use would be a good starting point and looking back in time at the past energy use could suggest a trend for the future.

From 1850 to 1900, what happened to energy use?

It doubled. 5 EJ to 10 EJ

What happened from 1900 to 1950?

It tripled. 10 EJ to 30 EJ

Now students are ready to project what might happen in energy use from 1950 to 2000. Have students draw in their projection on the graph.

It could quadruple. 30 EJ to 120 EJ

Raise these questions:
- Why are we talking about new and different energy sources?
- What are we using now?
- What is wrong with just continuing on as we are doing?

This is at the heart of our national energy problem. Importing oil is creating economic and political problems. We are running out of our own national resources of natural gas and oil. We may need to switch to using much more coal.

3. Drilling wells to find new pools of natural gas and oil is an uncertain business. Nevertheless, there is sufficient information to make some reasonable estimates of probable new discoveries. When these are added to the estimated production left in known fields we come up with the following resource figures for gas and oil in terms of the energy they contain.

Use Figure 13.
Natural gas resources in the U.S. total about 1.1×10^{21} J. (There is about 11 times this amount in the whole world.) Have students draw in 11 more blocks to represent the total world gas reserves. The oil resources in the U.S. total about 1.2×10^{21} J. (There is about 15 times this amount in the whole world.) Have students draw in 15 more blocks to represent the total world oil reserves.

The estimated total energy use in the U.S. for the next 25 years is more than gas and oil together which supply about 75% of the energy we use today. The other fossil fuel is coal and the amount of this energy resource is known with greater certainty than any of the others. The coal resources in the U.S. total about 14.0×10^{21} J.

3. Students may create a panel of "experts" on depletable and renewable energy resources. The panel should include a Solardroid, an expert on coal, one on oil, one on natural gas, and one on uranium. Each student, after having researched her/his area of expertise, will give a 2 minute introduction on the fuel and the reason it is needed now.

The class audience will ask questions of the panel members. These questions should be directed toward the future use of each fuel.

This activity will provide information for #5, concluding the lesson.

(There is about 10 times this amount in the whole world.) Make some comparisons in Figure 13. Have students draw 10 more blocks to represent the total world coal reserves.

4. Resources are of interest because of their possible use in the future. A depletable resource is one that we could run out of in the future. Of course, whether you run out of something or when you run out of something depends in part on how much of it you use. The U.S. is currently using about 17×10^{21} J of energy each year. The U.S. uses one third of world energy requirements per year. Have students show on Figure 13 how much the world will use in energy in the next 25 years if this rate of use continues.

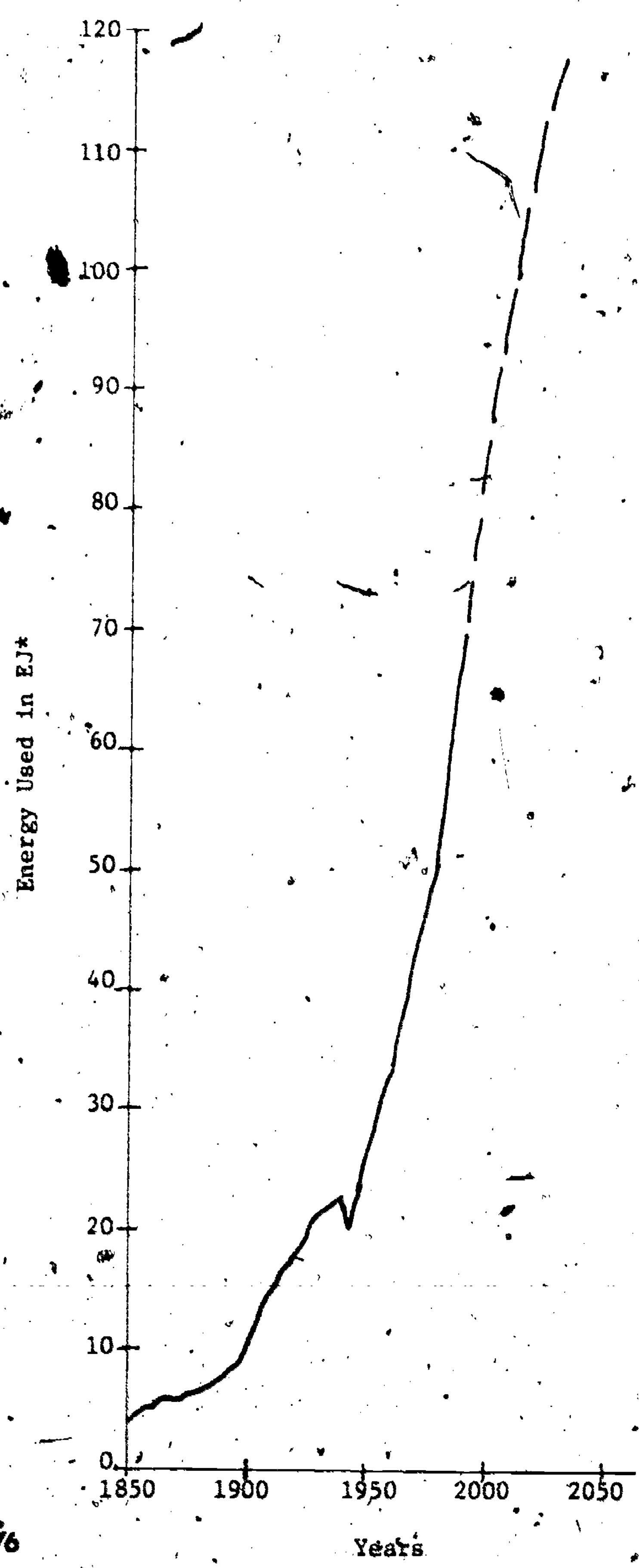
5. Conclude this lesson by having students identify different ways to proceed if we are not satisfied with the present situation or not yet ready to make a far-reaching decision.

Possible responses:

Look for other alternative energy sources (oil shale, geothermal, solar, etc.).

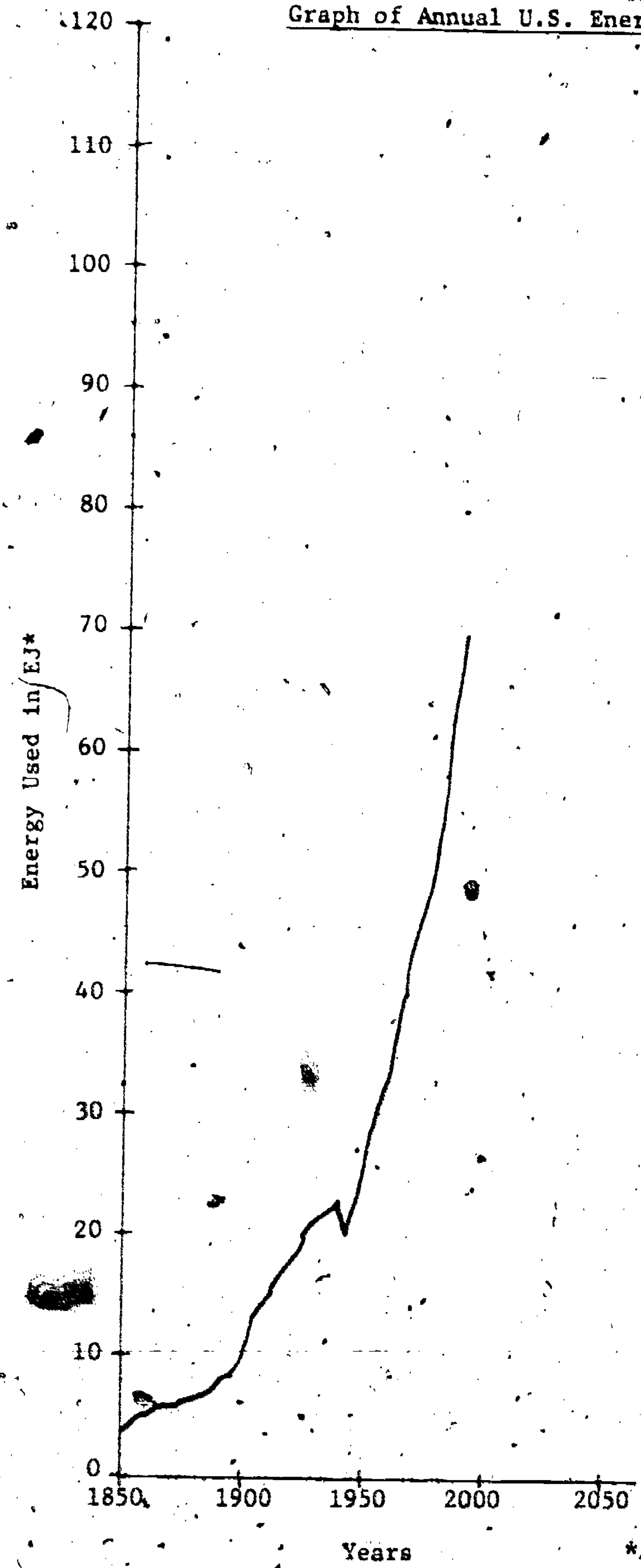
Look for ways to cut down on the amount of energy we use.

Figure 12--Teacher Edition
Graph of Annual U.S. Energy Use



*An EJ is an exajoule or 10^{18} J.

Figure 12--Student Edition
Graph of Annual U.S. Energy Use



*An EJ is an exajoule or 10^{18} J.

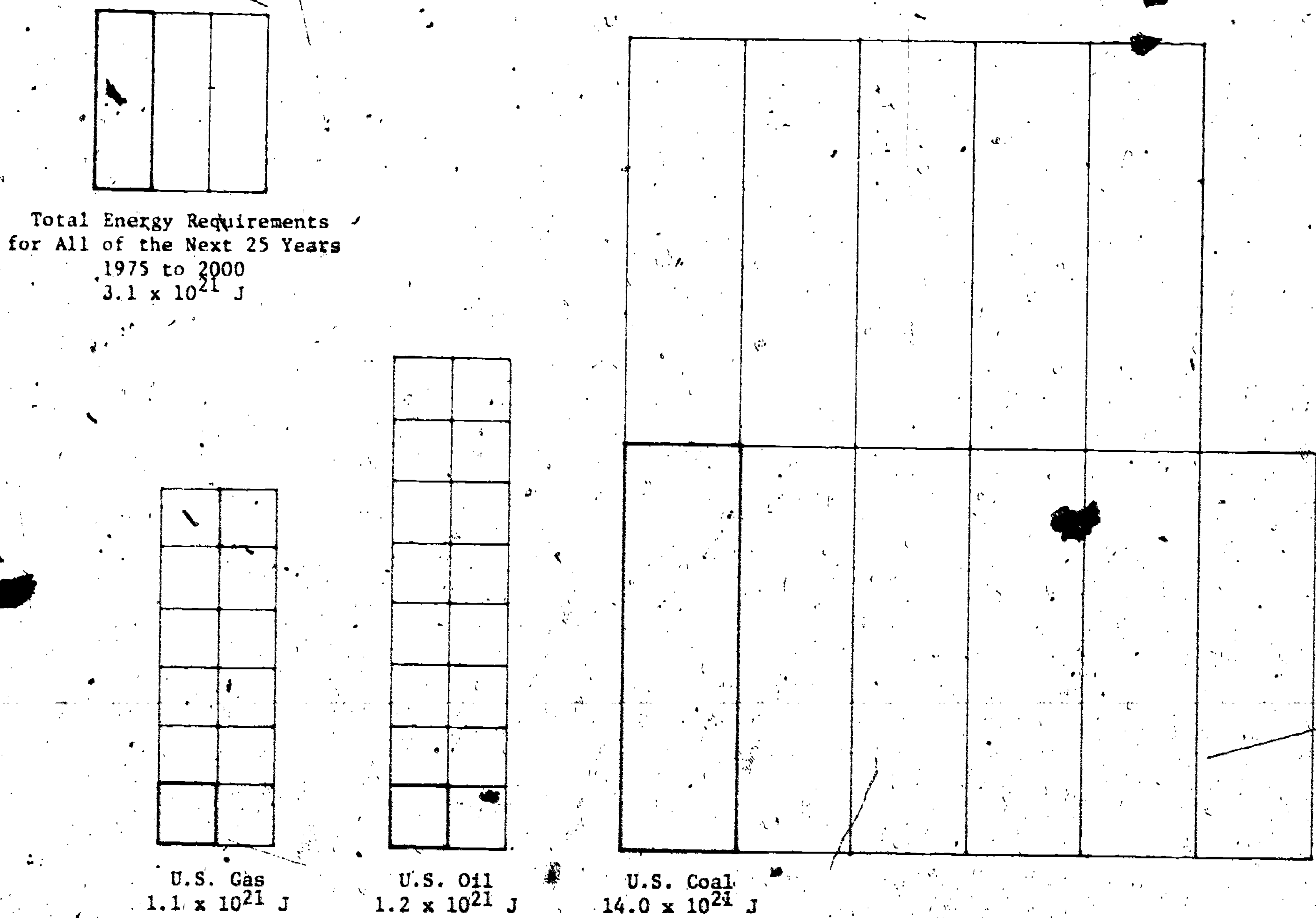
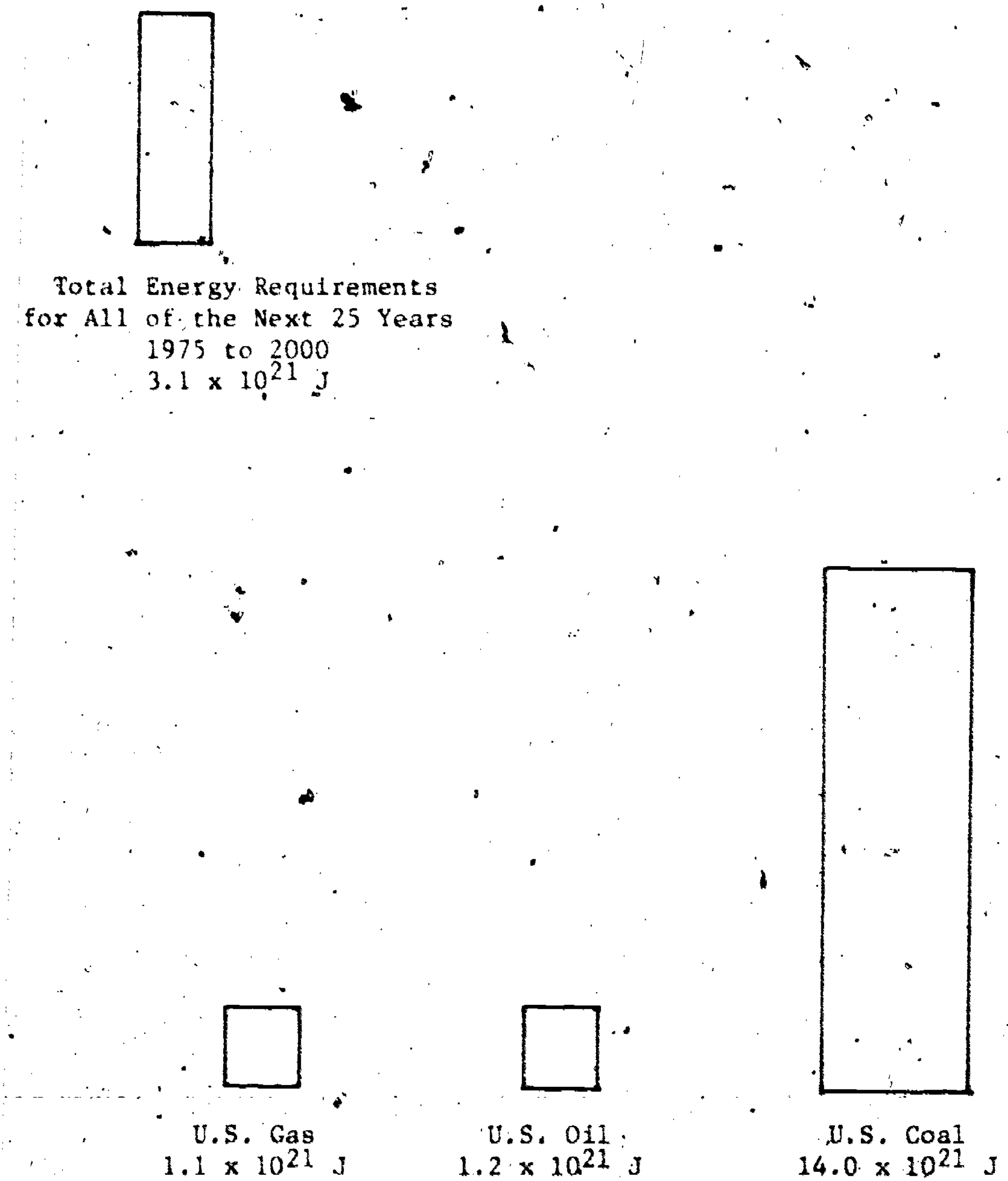


Figure 13--Teacher Edition
United States and World Energy Requirements and Resources

Figure 13—Student Edition
United States and World Energy Requirements and Resources



Unit III, Lesson 2: Conserving Energy

Overview

This lesson attempts to stimulate students to think about ways to conserve in use of energy. It begins with each student completing an Energy Attitude Survey. The more immediate reasons for energy conservation are suggested. Energy waste is considered both in relationship to conversion efficiency and to the personal desires of people.

Background Information

Material may be found in National Science Teachers Association Fact Sheets #9 (Energy Conservation: Homes and Buildings); #10 (Energy Conservation: Industry); and #11 (Energy Conservation: Transportation).

Objectives

Students should be able to:

1. Explain the importance of conserving energy.
2. List daily ways to conserve energy.

Materials

1. Energy Attitude Survey (Figure 14)
2. Analysis Form for Responses on Energy Attitude Survey (Activity 11)
3. Some Ideas for Conserving Energy (Figure 15)

Teaching Suggestions	Commentary
1. Begin this lesson by having each student in the class fill out the Energy Attitude Survey, Figure 14. Have students compile the results of this survey. The results can be distributed to the class for discussion now or during Unit IV, Lesson 3. Students might want to give the survey to some other groups (e.g., parents, teachers, students in other classes not studying energy) and compare the results of those surveys with their own. Activity 11 may help you in compiling and analyzing the responses.	Use graphing techniques for comparisons between students and adults, students and students and before and after results.
2. What happens when there is a fuel shortage (coal, gas or oil)?	We've had the problem of factories closing because of the shortage of natural gas. At times there have been long lines at the gas stations. There have also been shortages and increased prices for other related things such as fuel oil, oil based paints, and plastics.
The importing of oil has disrupted our economy--putting people out of work, spurring inflation. If we use less energy we may be able to minimize the adverse effects and buy time in which to come to grips with the energy problem.	Solardroid: "We...do...not...experience...such...inconvenience...because..." Solardroid can point out the advantages of the direct conversion process.

Have students fold a piece of paper in half 3 times. Have them draw in each of the 8 boxes, things made of plastic. Students will pass the papers 6-7-8 times to other students. On each pass, ask them to cross out a picture of a plastic object which is NOT necessary for them to survive. At the end of the activity, discuss items that are left (if any); discuss the relationship of the items to oil.

3. Divide students into teams. Hang a large sheet of paper on the wall for each team. Have students list ways in which we might reduce the amount of energy we use every day. Have a three or five minute limit. Do not declare a winning team until the class has looked at each team's items and found them acceptable.

Some of their suggestions might be among those listed in Figure 15.

A variety of conservation measures can be initiated in the school by your students, e.g., a long term project: obtain copies of the monthly school electric bill. Check to see if the students' campaign has possibly reduced the bill.

Students may wish to launch a campaign at school to reduce energy use, i.e., turn off lights when not needed.

4. Discuss energy conservation in industry. Students may respond with examples such as a, b, and c.

(a) Optional: To expand their lists of industry's conservation of energy, have students inspect flow charts (Figures 6, 7, 16).

(a) Industrial response to energy conservation suggestions was substantial and rapid where it could be shown that reduction of wasted energy would result in greater company profits. Much of this savings was achieved by waste heat recovery, greater use of insulation, using waste materials as fuels, and changes in manufacturing processes.

(b) Optional: Have students list all the appliances that they own, e.g., hair dryers, stereos, curling irons. Take a count of each appliance. Are they necessary for survival?

(b) Greater emphasis has been placed on the energy efficiency of the appliances being produced by industry. It is up to us consumers, however, to choose to buy these more energy efficient home appliances. Their initial cost is often greater but their overall cost is generally lower as in the case of fluorescent versus incandescent lighting.

(c) Optional: Students may go on a recycling trip, collecting aluminum cans and bottles. This may be done on the school grounds or in the neighborhood areas.

(c) There has been a modest increase in the use of recycling. For example, 4% of our aluminum is now being recycled, but 60% to 75% could be recycled. About 90% of the energy required to produced a kilogram of aluminum could be saved with recycling. The

5. Optional: A Solardroid can make a contribution here by way of a summary which introduced a broader examination of the meaning of waste energy.

Energy used unnecessarily is wasted. If two methods for accomplishing the same thing are known, does the extra energy used by the less efficient method represent wasted energy? For example, all other things being equal in mining coal, if method A uses 3 J and method B uses 2 J, then does method A waste 1 J? If so, this means that when a more efficient way of doing something is discovered or developed at that point the older ways become wasteful. With so many losses being shown in the energy flow charts for particular systems, there is great opportunity for finding new, more efficient ways which can reduce the losses.

recycling by refilling bottles has also seen modest increases with some states passing laws to bring it about. It has been calculated that in 1972 if all beverage containers had been refillable and had been refilled 10 times, the savings in energy would have been over 2×10^7 J.

5. Solardroid: Discuss the relationship between energy waste and energy conversion efficiency.

"The...system...for...the...direct...conversion...of...energy...that...we...Solardroids ...use...is...100%...efficient. In...a... sense...this...means...that...we...conserve... energy...completely...and...perfectly. We... waste...no...energy...at...all...by...losses ...at...the...steps...along...an...energy... flow...system...like...here...on...earth. But...I...have...been...wondering...is...it ...fair...to...call...all...those...energy... losses...wasted...energy?

"Isn't...it...true...that...some...losses... must...occur...in...those...energy...flow... systems? For...instance...isn't...it...absolutely...necessary...to...lose...or...use ...some...energy...in...the...steps...for... mining...coal? Is...this...energy...truly... wasted? Is...all...the...heat...energy... given...off...at...an...electric...power... plant...wasted? What...do...you...think?"

Figure 14
Energy Attitude Survey

1. Is there an energy crisis (problem)?	___ yes	___ no	___ don't know
2. Are most Americans energy "wasters"?	___ yes	___ no	___ don't know
3. Are Americans "spoiled" in their energy uses?	___ yes	___ no	___ don't know
4. Are Americans reluctant to take responsibility for energy use in the future?	___ yes	___ no	___ don't know
5. Is it the responsibility of every U.S. citizen to conserve energy voluntarily?	___ yes	___ no	___ don't know
6. Will Americans conserve energy only when government controls are imposed?	___ yes	___ no	___ don't know
7. Are most Americans energy "conservers"?	___ yes	___ no	___ don't know
8. Would you be willing to change the way you live to conserve energy?	___ yes	___ no	___ don't know
9. Would you conserve energy to save money?	___ yes	___ no	___ don't know
10. Would you save energy so that people 50 years from now can live the way you do?	___ yes	___ no	___ don't know
11. Do you feel science and technology will "bail us out" of the energy shortage?	___ yes	___ no	___ don't know
12. Do you have any input or participation in the energy usage decisions made by your family?	___ yes	___ no	___ don't know
13. Are you going to do something to save energy?	___ yes	___ no	___ don't know

Activity 11
Analysis Form for Responses on Energy Attitude Survey

Item	Yes	Per cent	No	Per cent	Don't Know	Per cent
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

Tally each response for each item. Calculate percentages for each response.

Example: question 1, 30 students respond; 15, yes; 10, no; and 5, don't know. Yes, $\frac{15}{30}$ = 50%; No, $\frac{10}{30}$ = 33%; Don't Know, $\frac{5}{30}$ = 16%.

1. Survey your class before and after use of this packet to see if this study of energy has had an effect on students' answers.
2. Survey other classes.
3. Print your results in the school newspaper.
4. Survey teachers and administrators. Compare their responses with students' responses.

Figure 15
Some Ideas for Conserving Energy

Home/Commercial:

1. Use appropriate amounts of insulation, storm windows, weatherstripping, caulking.
2. Avoid unnecessary opening of doors and windows.
3. Turn thermostats down to 18 C (65 F) or less and wear warmer clothes inside.
4. Set thermostat at 26 C (78 F) or above during the cooling season. Use an attic fan.
5. Use only lights necessary for the task being done.
6. Consider using fluorescent light.
7. Turn off lights and appliances when not in use.
8. Use energy efficient appliances.
9. Do not use self defrosting refrigerators, instant-on T.V. sets.
10. Keep frost on refrigerators and freezers less than 0.6 cm (¼ in.) thick.
11. Set refrigerator for 4 C (40 F) and freezer for -18 C (0 F).
12. Keep light fixtures and radiators clean.
13. Humidify air for greater comfort at lower temperatures.
14. Be sure the furnace is properly adjusted.
15. Set hot water heater temperature at 60 C (140 F) or less.
16. Use cold water whenever possible.
17. Make sure the water heater is adequately insulated.
18. Keep good gaskets on doors of refrigerators, freezers, and and ovens.
19. Operate washing machines and dishwashers with full loads.
20. Completely thaw frozen foods before cooking.
21. Avoid eating too much meat.
22. Use flat-bottom pans of the same size as the burner on the stove.
23. Use window coverings such as drapery, shades, blinds, shutters.
24. Close fireplace damper when not in use.
25. Repair leaky faucets promptly.

Transportation:

1. Consider walking.
2. Consider bicycling.
3. Use and help develop mass transit.
4. Remember buses and trains are more energy efficient than airplanes.
5. Use a small, high MPG automobile and keep it adjusted for efficient operation.
6. Try to arrange car pools.
7. Organize activities to reduce the number of trips taken.
8. Encourage the transportation of freight by railroads.

Industry:

1. Support recycling of metals, paper, and glass.
2. Support the use of refillable beverage containers.
3. Choose paper packaging products rather than plastics.

Unit III, Lesson 3: Nuclear Energy

Overview — This lesson is an introduction to the processes in nuclear energy from mining uranium to the power plants.

Background Information — Two sources of background material are: (a) National Science Teachers Association, Energy Fact Sheets, #12 (Conventional Reactors), #13 (Breeder Reactors), and #14 (Nuclear Fusion) which are available from the Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830; and (b) National Science Teachers Association, Energy-Environment Source Book, by John M. Fowler, pages 38-43, 108 and 263-270.

Objectives — Students should be able to:

1. Show the energy flow for electrical lighting from nuclear energy.
2. Describe the general operation of currently operating nuclear power plants in the U.S.

Materials

1. Energy Flowchart for Electrical Lighting from Nuclear Energy (Figure 16, Teacher and Student Edition)
2. Diagram of the Nuclear Fusion Process (Figure 17)
3. Note cards
4. Diagram of the Nuclear Fission Process (Figure 18 in Report A)
5. 30 marbles
6. Boiling Water Reactor (Nuclear Power Plant) Diagram (Figure 19)
7. Large bar or household magnets
8. Nuclear Energy Crossword (Activity 14)

Teaching Suggestions

1. Use Figure 16. Discuss steps on the energy flowchart as in previous lessons. Have students calculate total joules for each step by subtracting lost or expended joules. Optional: calculation of efficiencies.

2. Solardroids state that being space travelers gives them special qualifications to report on stellar processes such as nuclear fusion.

Use Figure 17.

In nuclear energy the word nuclear refers to the structure of an atom. The more massive elementary particles called protons and neutrons are concentrated in a very small region called the nucleus at the center of an atom. Different kinds of atoms have nuclei containing different numbers of protons and neutrons which are held together by the strongest kind of forces known. When the number of

Commentary

1. See Teacher Edition of Figure 16 for efficiencies and joule loss.

Solardroid: Since you are an extraterrestrial and have had experience bumming around in space seeing things, you have been asked to describe what's going on in stars that are like the sun.

"We...are...Solardroids. Solar...is...your...star's...name. Your...sun...is...a...star. In...stars...like...the...sun...the...energy ...which...is...given...off...results...essentially...from...the...nuclei...of...four ...hydrogen...atoms...coming...together...in ...a...series...of...steps...and...forming... the...nucleus...of...a...single...helium... atom. For...such...a...fusion...type...nuclear...reaction...to...occur...the...atoms...

particles in a nucleus is changed, large amounts of energy are sometimes given off.

must...be...very...close...together...and... the...temperature...very...high...which...are ...the...conditions...found...in...the...sun."

3. Based on the following information, a student discussion centered around nuclear safety would be appropriate.

*Information from the Energy-Environment Source Book, John M. Fowler, National Science Teachers Association, 1975, pp. 40-41.

3. *Reactors are carefully designed against failure. Safety systems and back-up systems anticipate almost any conceivable failure. Safety is also built into the reactor, the stainless steel pressure vessel around the core will withstand a small explosion, and the entire core is surrounded by a concrete containment structure also able to withstand small explosions. Finally, at least to date, the reactors are required to be built at some safe distance from any large population center. This last requirement, under the pressure of energy needs, may be the first to be abandoned...

The accident most feared is a loss of coolant, which would result from a double break in the large pipes that carry the cooling water to and from the reactor core. It is unlikely, but an earthquake, or sabotage, or carelessness could cause it...If this were to happen, the water would be blown out of the reactor by the steam pressure. While the loss of moderator...would shut off the reactor, the core, because of the high levels of radioactivity in it, would quickly heat up. Within a few minutes, it would begin to melt, unless the back-up emergency core cooling operated at once and successfully. If the core remained hot, a pressure explosion might occur which would rupture the containment vessels, or it could melt through them and perhaps melt its way down into the ground exhibiting what is called the "China Syndrome".

It is not known what will happen. The core cooling is backed up by an emergency core cooling system, and there is great controversy as to whether it will work as well as the theoretical calculations say it will. It has (fortunately) never been tested in actual practice, and it may never be.

4. Set up the room in a "stations" approach. At each of the five stations A, B, C, D, and E, have a card with the directions and all materials. Divide students into five groups. These groups will proceed through the stations doing all five in the class period. The teacher should give the signal when s/he wants the groups to move to the next station.

4. Solardroids staff the learning stations giving instructions, materials, etc.

Figure 16--Teacher Edition
Energy Flowchart for Electrical Lighting from Nuclear Energy

Energy Lost or Expended

100 J of nuclear energy in uranium ore in the ground

95% Step Efficiency
Energy used in mining and in preparation for mining

95 J of nuclear energy in uranium at the mouth of the mine

90% Step Efficiency
Energy represented in the discarded material and used in "milling" the ore

86 J of nuclear energy in "yellowcake", a somewhat purified uranium ore

69% Step Efficiency
Energy used in transportation, uranium enrichment, pellet production, and fuel bundle fabrication

59 J of nuclear energy in enriched uranium fuel pellets which are in metal tubes and assembled in fuel bundles

26% Step Efficiency
Energy expended in operating the power plant equipment and heat lost to the cooling water in the turbine condenser

15 J of electrical energy leaving the nuclear power plant

85% Step Efficiency
Energy lost as heat which was produced by the electrical resistance in the wires of the transmission power lines, etc.

13 J of electrical energy at a home or other place of end use

5% Step Efficiency
Energy expended to maintain the filament of the light bulb at a high temperature (incandescent) but lost as heat to the air

0.65 J of light energy

*This flowchart is written as if all the energy in the uranium fuel were converted to heat energy in the reactor. In fact, only about 1% of this energy is converted. Since the unused fuel can, in theory, be recycled, this low conversion efficiency is not considered in this chart.

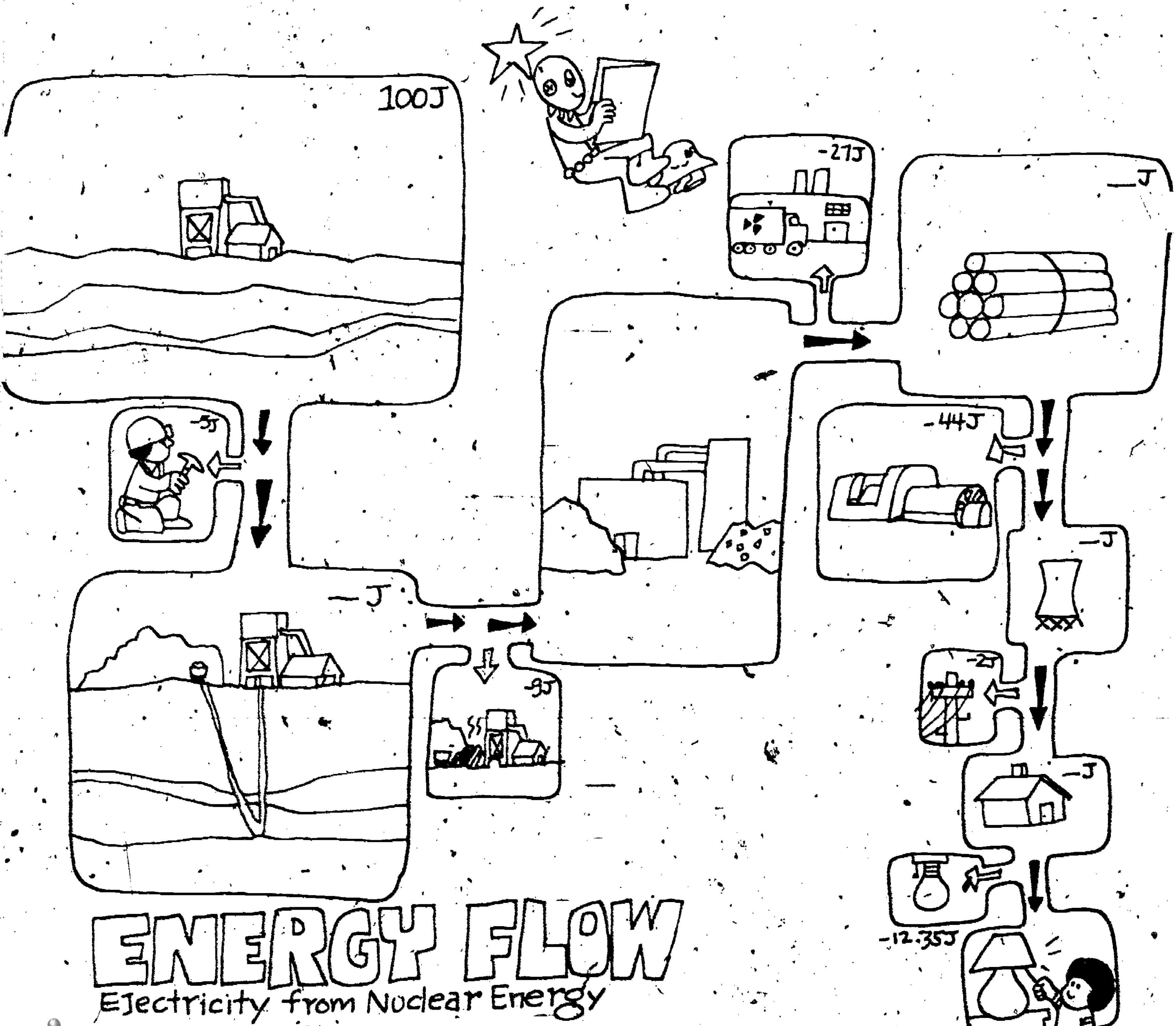
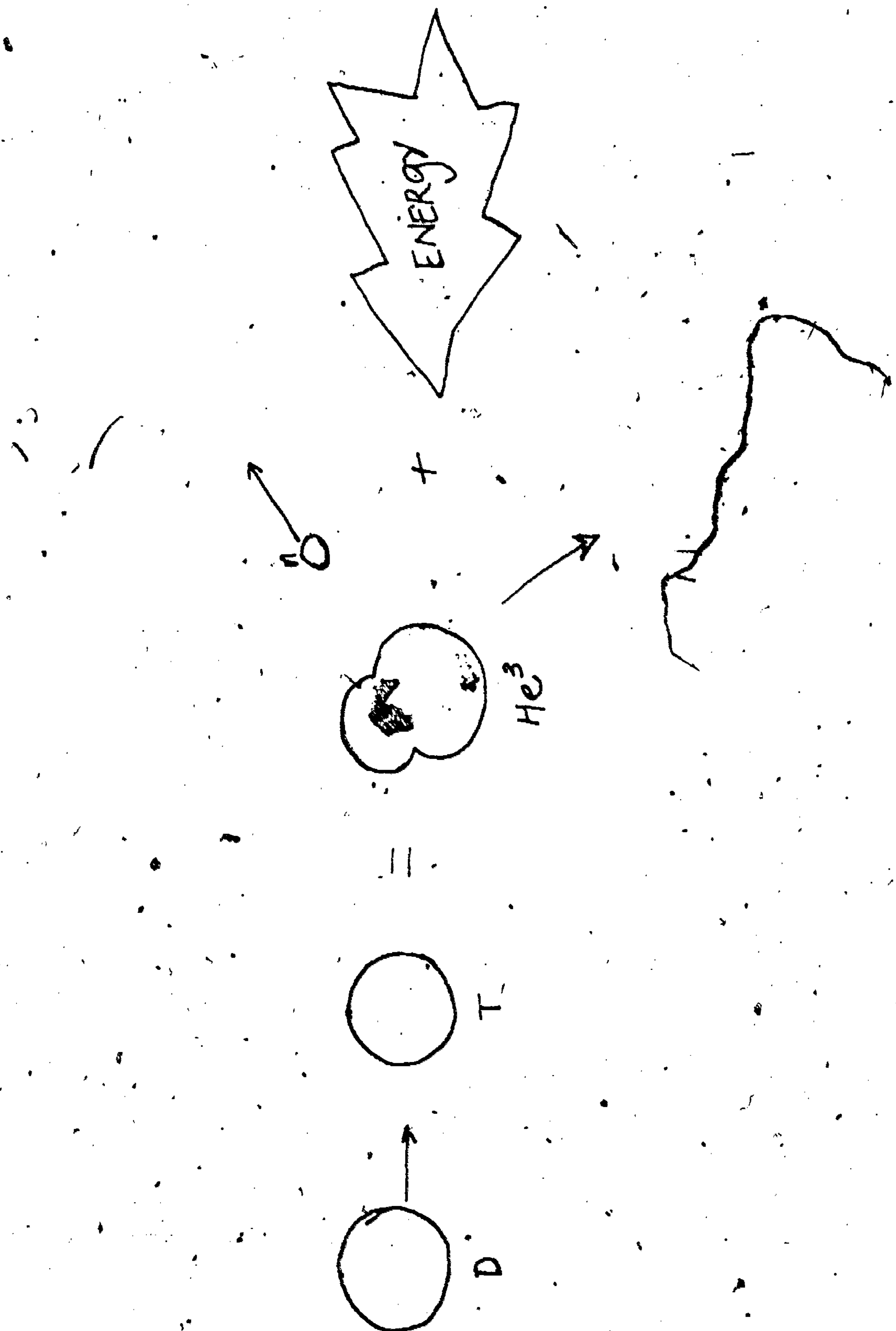


Figure 16--Student Edition

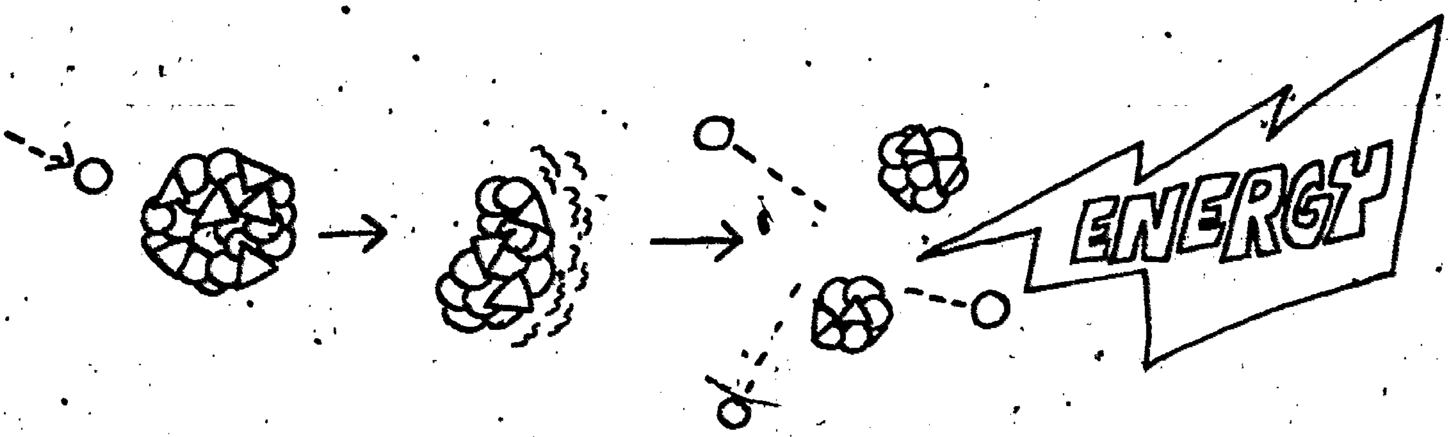
Figure 17
Nuclear Fusion Process



Report A

All nuclear power plants in operation today make use of a process called nuclear fission. It involves the splitting of particular kinds of atomic nuclei roughly in half. A kind of uranium atom known as U-235 is commonly used. When the nucleus of this atom is struck by a neutron traveling at the proper speed the nucleus breaks up to produce two smaller nuclei. Also produced are a small number of neutrons and a large amount of energy which is shown in the form of heat energy. Each of the neutrons which are produced can be slowed down or moderated so that they can cause another U-235 nucleus to undergo fission. In this way one fission reaction leads to another in what is called a chain reaction. In present commercial nuclear power plants the production of too many fission reactions at the same time is prevented by the insertion of control rods which capture the desired number of neutrons. Even if the control rods completely failed to function, the nuclear plants would not produce a nuclear explosion because the concentration of U-235 is too low. However, if the cooling system failed and the reactor melted, the deadly contents would infect the countryside.

Figure 18
Nuclear Fission Process



Activity 6 for Station A

Chain reaction can be acquired through use of several groups of marbles.

Materials · Marbles

1. Cluster 5 marbles.
2. Place 6 groups of marbles separately (see diagram).
3. Shoot a "free" marble at the cluster in an attempt to strike another "free" marble with one from the cluster.

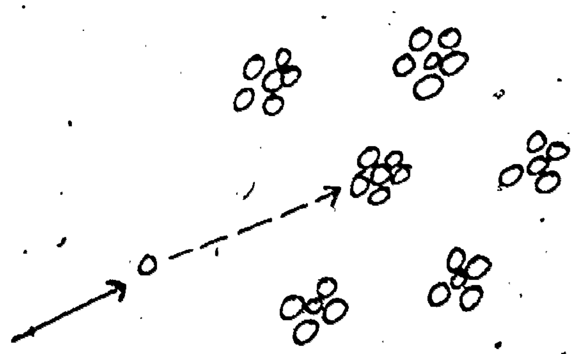
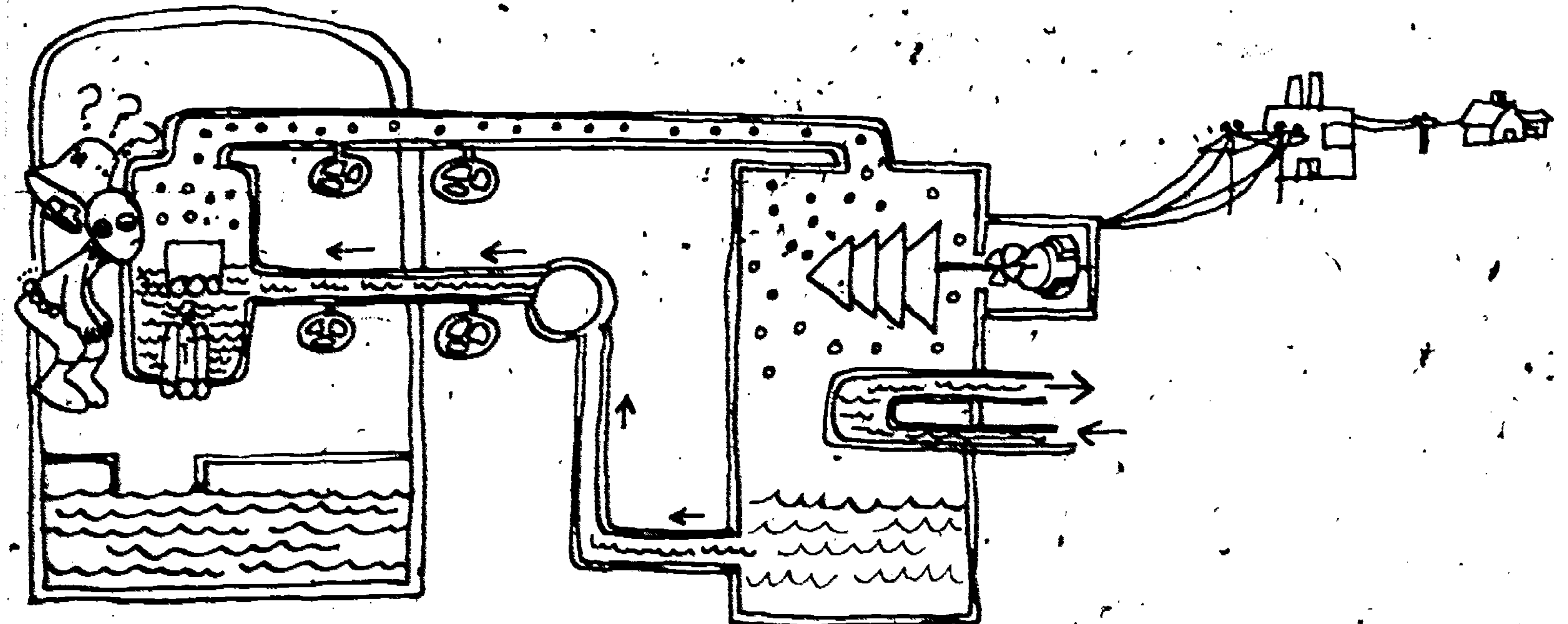


Figure 19



BOILING WATER REACTOR

Station B

Work together. Write the numbers of the steps in the energy flow on Figure 19. 1, 2, and 3 are already placed in the reactor.

1. Inside the reactor the chain reaction starts.
2. Heat is given off when energy is produced from the atoms splitting.
3. Water removes this heat.
4. Water boils.
5. Water leaves the reactor as steam.
6. The steam turns a turbine.
7. The turbine turns a generator.
8. The generator produces electricity.
9. The steam condenses into water.
10. The water is cooled by outside water.
11. The water is pumped back into the reactor.
12. The water flow begins again.

Report C

Use Figure 19 to help describe the general operation of a nuclear power plant. The fuel for current U.S. nuclear power plants is uranium which has been slightly enriched with U-235. Typical nuclear power plants such as diagrammed in Figure 19 operate at lower steam temperatures, which means a lower energy efficiency in generating electricity. Therefore, compared with a fossil fuel plant generating the same amount of electrical energy, a nuclear plant produces more waste heat energy. Also, since a nuclear plant has no smokestack through which waste heat can be released, the condenser cooling water system must handle a much bigger load.

Activity 13 for Station C

Look at Figure 19. As a group, list four "far-out" uses for the waste heat of a nuclear energy plant. Example: Put a green house there to use the heat.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________

Station D

Have each student in your group work on the Nuclear Energy Puzzle. Hidden in the puzzle are 11 energy terms that you can relate to nuclear energy. Try to find as many as you can. Circle them as you find them. The words go across, down, and diagonal as well as backward.

Activity 14--Student Edition
Nuclear Energy Crossword

```
N Y Y G R E N E O P L
N E O Z F E U N D R U
G U R G Y P D E G H W
A R C X B J M E C N S
Q A T L V X I T E N K
U N O R E M N M E R I
E I P T N A G S T U B
L U I S S I R O N E R
B M E D E R N I S S O
R E G N I N I M I F I
P R T N E U O I I T K
N O I S S I F N W N E
P L W A N T P I O O G
S F N E T V E S N I R
S I O N R O R N E S G
N E R Y G P R E N U E
E R T G Y F L E U F U
O E U S S N O A U F E
R N E I I F I S N O L
O E N O N N U E T T R
```

Which word means "survival" for Solardroids and Earthlings? Clue: Backward and foward.

Activity 14--Teacher Edition
Nuclear Energy Crossword

```
    Y G R E N E
N         E
  U         D
  R C         E
  A   L         E
  N O R E         R
  I       A         B
  U         R
  M
    G N I N I M
P
N O I S S I F    N
   W             O
   N E           I
   O   R         S
   R     P       U
   T       L E U F
   U         A
   E           N
   N             T
```

YGRENE -- ENERGY

Report E

Fusion uses "fuels" which are and will be available for billions of years. It appears to be safe and will not harm the environment. One kind of atom used in making fusion energy is deuterium. Energy is needed to get the deuterium atom and in addition, money and materials are needed to build the complicated plant and machinery.

Fusion is a nuclear reaction. In a way, it is the opposite of fission. The fusion reaction combines two very small nuclei to make a larger one. When this is successfully done, energy is released. However, the nuclei repel each other. Fusion reactions occur in the sun where the nuclei are held together ar very high temperatures (100 million degrees C), by gravitational forces. Since this extremely high temperature is needed, the scientists have not found any containers to use to do the reaction in. Regular can, bottles, or tanks won't work.

Activity 15--Student Edition
Station E

Refer to Report E. Locate in the report and list below three problems that need to be solved in order for people to use fusion reactions as an energy source.

1.
2.
3.

List three "pluses" that make people want to use fusion reactions as an energy source.

1.
2.
3.

Activity 15--Teacher Edition
Station E

Refer to Report E. Locate in the report and list below three problems that need to be solved in order for people to use fusion reactions as an energy source.

1. (Energy, money and materials are needed.)
2. (Nuclei repel, so extreme heat is needed.)
3. (There is no container to hold the reaction.)

List three "pluses" that make people want to use fusion reactions as an energy source.

1. (Available for billions of years.)
2. (Safe.)
3. (Won't do much damage to the environment.)

Unit IV, Lesson 1: Solar Home Heating

Overview Student experiments involving Collecting Solar Energy and Storing Solar Energy are included in this lesson. A system for heating a building with solar energy is presented with details and possible modifications.

Background Information See the discussion on the two activities, 16 and 17. Information on solar heating and cooling may be found in NSTA Fact Sheet #7, Solar Heating and Cooling.

Objectives Students should be able to:
1. Describe how solar energy can be collected and stored.
2. Explain how energy flows through a solar home-heating system.

Materials
1. Collecting Solar Energy (Activity 16)
2. 3 styrofoam meat trays
3. 2 thermometers
4. Transparent plastic food wrap
5. Water
6. Black ink and medicine dropper
7. Watch
8. Sunlamp (optional)
9. Storing Solar Energy (Activity 17)
10. Cardboard box painted black
11. 2 small metal cans
12. Rubbing alcohol and water
13. Diagram of a Solar Heating System (Figure 20, Teacher and Student Edition)
14. Activity 18
15. Flashlight
16. White paper pasted on cardboard
17. Activity 19
18. 6-10 cola cans
19. Heat source
20. Drawing of a Flat Plate Solar Collector (Figure 21, Teacher and Student Edition)

Teaching Suggestions

1. Solardroid students can do the experiments on Collecting Solar Energy (Activity 16) and Storing Solar Energy (Activity 17).

The Storing Solar Energy experiment should be set up so that the cans are heating in the box half an hour or more before removing the cans and taking the temperature measurements.

Commentary

1. Solardroids: "Earthlings...go...through...so...much...to...get...energy. Looks...like...a...lot...of...star...energy. What...do...you...call...it?"

Earthling: "Solar Energy. Sol is another name for our star, the sun. Remember, that's why we called you Solardroids--because you go on star power!"

Solardroid: "Oh...yes...well...why...don't...you...use...more...of...old...Sol?"

Earthling: "We don't have it all worked out yet--how about helping us?"

Solardroid: "We'll...give...it...a...try."

Have students predict the outcome of Activity 16. Compare the results of the activity with the prediction. Discuss the comparisons.

In the Collecting Solar Energy experiment, the plate in the shade will probably not show much increase in temperature, while the covered plate will probably show the greatest increase.

As the temperature of the water in a plate increases, there is a more rapid flow of heat energy our of the plate into the air. The cover interferes with this heat flow and acts like the glass or glazing on actual solar energy collecting panels. A wind would make the effect of the cover more noticeable.

2. Again have students predict, record results and make comparisons for Activity 17 as in Activity 16.

2. Water is good for storing heat energy.

3. Describe a system for heating a house using solar energy. Use Figure 20. Have students trace the general overall flow of energy in the system by coloring a path from the sun to the air in the room.

3. A. The energy in sunlight enters the system through a solar collector where it is changed into heat energy.
B. This heat energy is transported to an energy storage area.
C. From the energy storage area the heat is removed and--
D. Transported as required to--
E. Where it is used to heat a room.
The energy storage area makes it possible to heat a room at night with solar energy which was collected during the day.

4. Use Figure 20. Where is the solar collector located? Why is it there?

4. It is on the roof where there is less problem with shadows.

The collector needs to point south and up at a particular angle to be most efficient in collecting solar energy.

Do Activity 18. Discover what allows for maximum light on a given surface.

5. The sunlight falls on a black metal surface where it is converted into heat energy which increases the temperature of the metal. What do you think happens next in the energy flow?

The heat energy in the metal is transferred or conducted to the circulating water with which it is in contact. The temperature of this water is thereby increased and the temperature of the metal decreased.

Do Activity 19. Discover conduction of heat energy.

6. The heated water is pumped down into a water tank where heat energy flows from the circulating water into the water in the energy storage tank.

Solardroid: "Ok...so...when...this...water...is...going...through...the...energy...storage...tank...it...cools...off. Why?"

Earthling: "It gave its heat to the water in the storage tank--get it?"

Solardroid: "Ok...so...it...then...goes... back...to...the...solar...collector...where ...it...starts...all...over."

This cycle transfers heat energy from the solar collector to the energy storage atnk. But, what must be true about the temperatures for this to happen?

The metal in the solar collector must be at a higher temperature than the circulating water entering the solar collector and the temperature of the circulating water in the loop passing through the energy storage tank is at a higher temperature than the water in the energy storage tank itself.

When do these conditions occur?

When the sun is shining.

Solardroid: "Ok...what...happens...to...the ...heat...in...the...energy...storage...tank?"

Earthling: "The other loop of circulating water transfers heat from the storage tank to the air in a room in exactly the same way as the first loop operates. The temperature of the water in the energy storage tank must be greater than the temperature of the air in the room in order for this transfer to occur."

When this in not the case and the temperature of the room still needs to be raised, an auxiliary system is used. Practically all solar heating systems have an auxiliary or back-up system because this is the most cost effective overall to ensure that the house is kept heated at all times.

7. What happens in freezing weather? What could you do? (Hint: Cold weather help for cars.)

The water may freeze. To provide for this problem some water systems add antifreeze to the water and other systems drain the water out of the collector when the pump is not operating.

Have students make class lists of advantages and disadvantages of solar energy. Accept most entries to the list. Let students take the lists and rank each item from most advantageous to least advantageous in each list. Discuss their reasons for their ranks.

Solardroid: "What...happens...in...summer? How...do...you...not...have...a...heated... house?"

Earthling: "Well, we could use vents."

Advantages	Disadvantages
1. lots of sunlight	1. Roof is ugly
2. Sunlight is not expensive	2. No sun at night
3. Etc.	3. Etc.

8. Divide into teams to do student projects:
   1. Make blueprints of solar heated house.
   2. Make a model of a solar heated house (use cardboard boxes, etc.).
   3. Make an artist's view of a solar heated building (to present an aesthetically positive picture).
   4. Make a scrap book of clippings about solar houses and other solar energy uses.
   5. Make a solar marshmallow cooker.
   6. Sun shower
   7. Solar oven

For 5, 6, and 7 refer to the following sources:

Paine, Carolyn and Bruce Raskin. "Energy for Today and Tomorrow." *Learning: The Magazine for Creative Teaching* (January, 1978): 48.

Merrill, Richard, Chuck Missar, Thomas Gage, James Bukey, eds. *Energy Primer: Solar, Water, Wind, and BioFuels*. Fremont, California: Fricke-Parks Press, Inc., 1974.

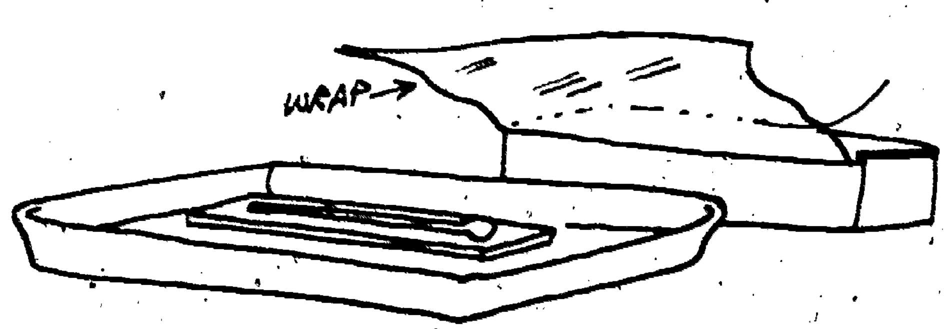
Halacy, D.S. *Solar Science Projects*. Englewood Cliffs, New Jersey: Scholastic Book Services, 1974.

Activity 16
Collecting Solar Energy

Materials

3 styrofoam meat trays
Thermometer
Piece of transparent plastic food wrap
Water Black ink and medicine dropper
Watch
Sunlamp (optional)

1. Fill three identical styrofoam meat trays 3/4 full with water which is at a temperature about that of the air.
2. Add five drops of black ink to each.
3. Cover the top of one of the trays with transparent plastic food wrap held in position with a rubber band.
4. Place the covered tray and one of the others in direct sunlight and the third tray in the shade.
5. After about 25 minutes, measure and record the temperature of the water in each of the trays. Offer explanations for any temperature differences observed. (A sunlamp may be substituted for the real sun.)



Activity 17
Storing Solar Energy

Materials

Cardboard box painted black or covered with black paper
2 small metal cans
2 thermometers
Watch
Water and rubbing alcohol

1. Fill 2 small metal cans; one with water and one with rubbing alcohol.

2. Place a thermometer in the center of each can.

3. Put all the cans in a box (from Unit I, Lesson 2) which has been painted or covered in black and set in the sun.

4. Close the box and leave it in the sun for at least half an hour.

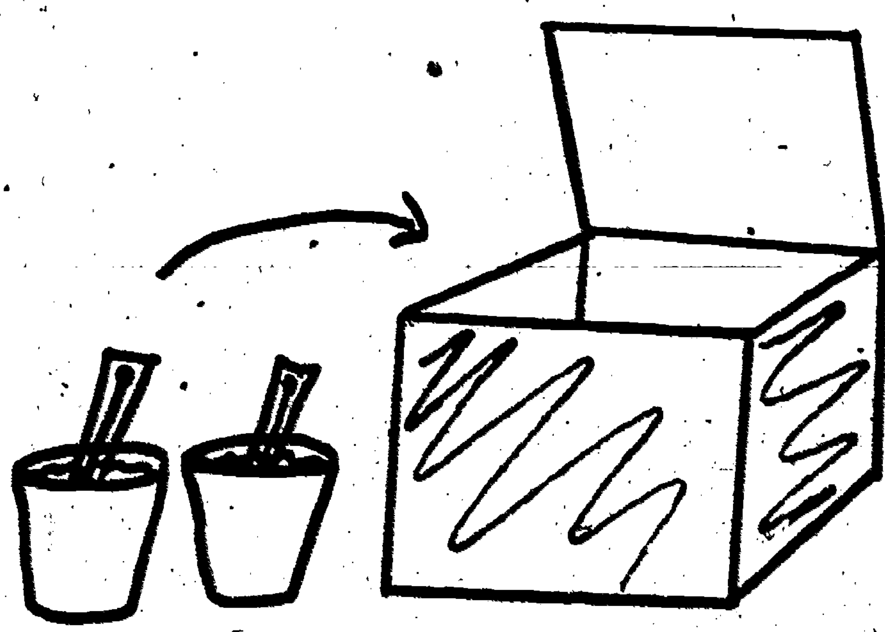
5. Remove the cans and read and record the temperature of each.

6. After five minutes, stir each can and read and record each temperature.

7. Repeat again after ten minutes.

8. Repeat again after fifteen minutes.

Discuss: Which temperature falls the slowest?
Which material might be the best for storing solar energy as heat?



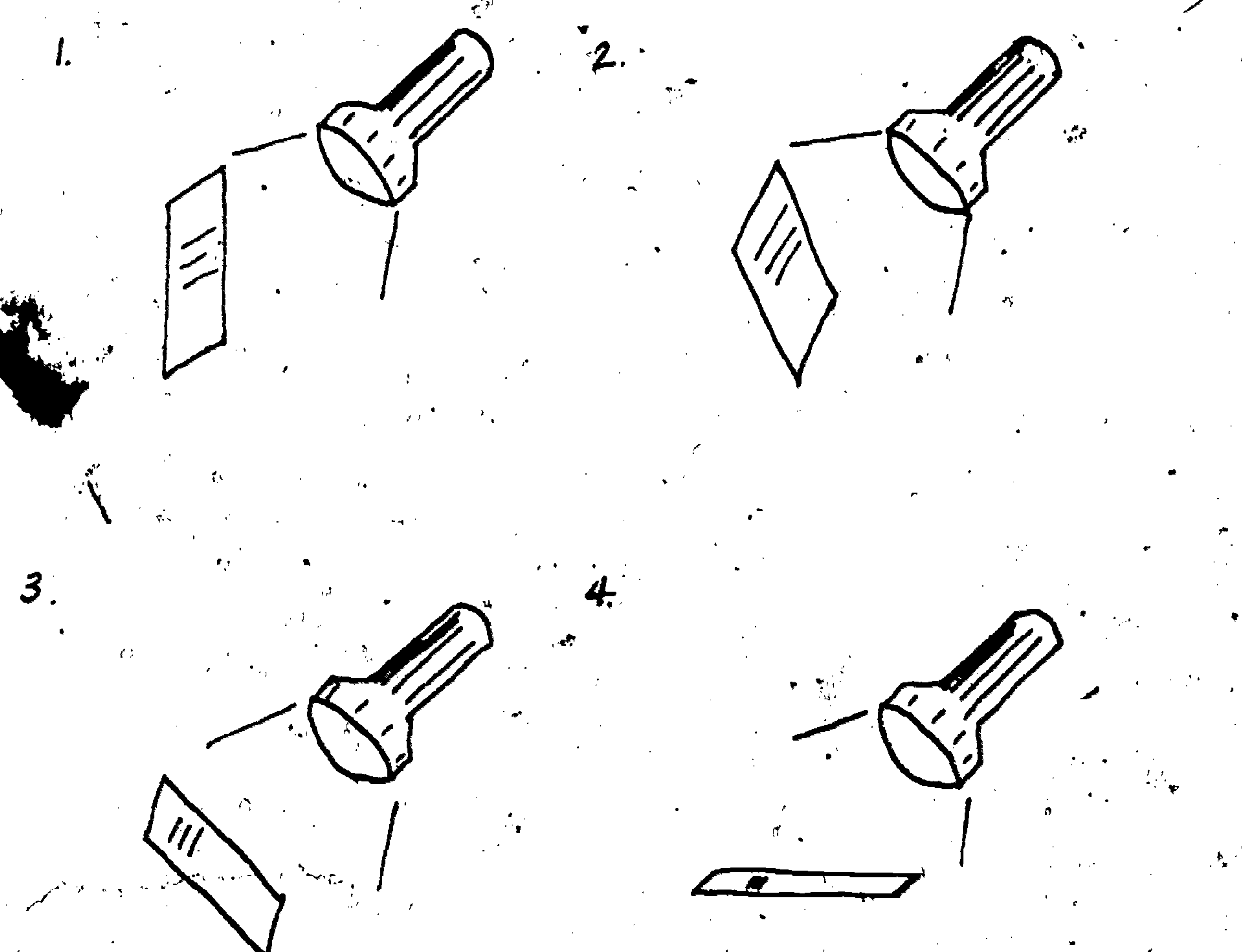
Activity 18

Materials Flashlight
White paper pasted on cardboard

1. Have a student hold the flashlight as below, keeping it in the same place.

2. Have another student hold the paper at different angles.

3. You might try to measure the angle of the paper from the perpendicular to the floor.



What angle allows for the most light to shine on the paper?
How is this related to the roof of a solar house?

Activity 19

Materials   6 to 10 cola cans
             Heat source

1. Fill cans with water.
2. Line the cans up side by side as shown below.
3. Heat the water in can 1.
4. Record the temperature in can 6 (or can 10) every five minutes.

Discuss: Is there a change in the temperature of the water in can 6 (or can 10)?
If so, what made it change?

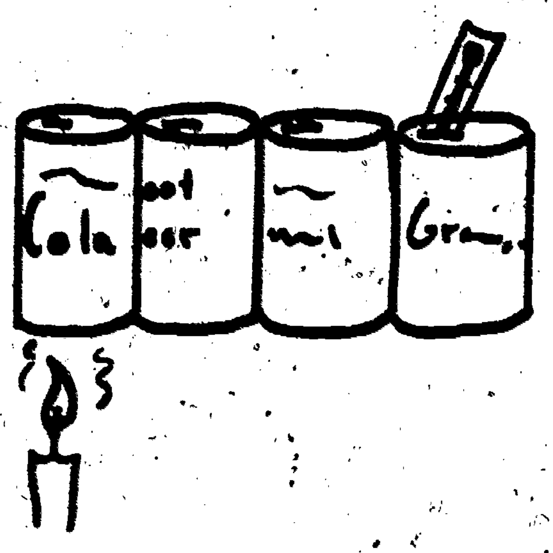


Figure 20
Solar Heating System

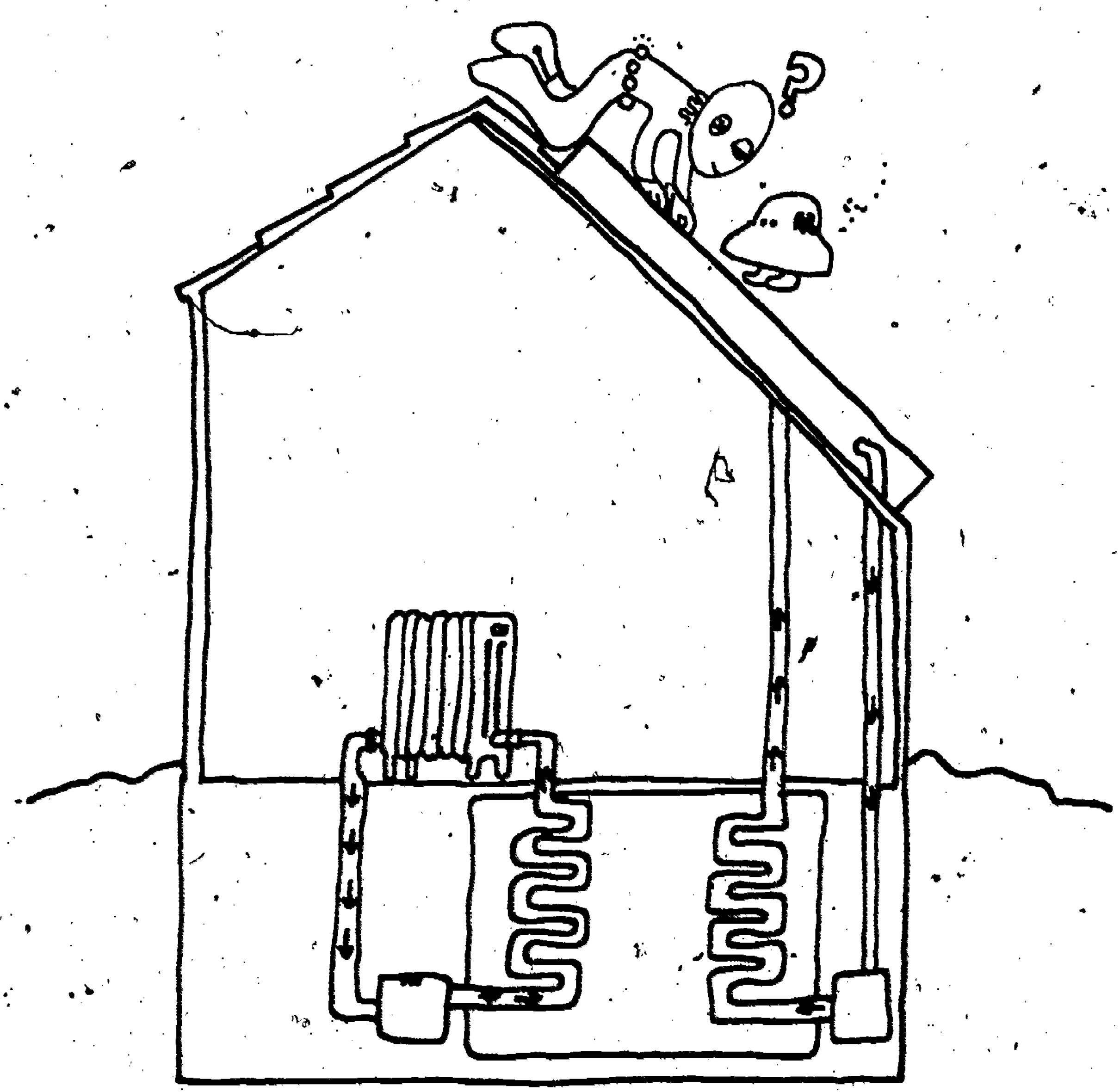
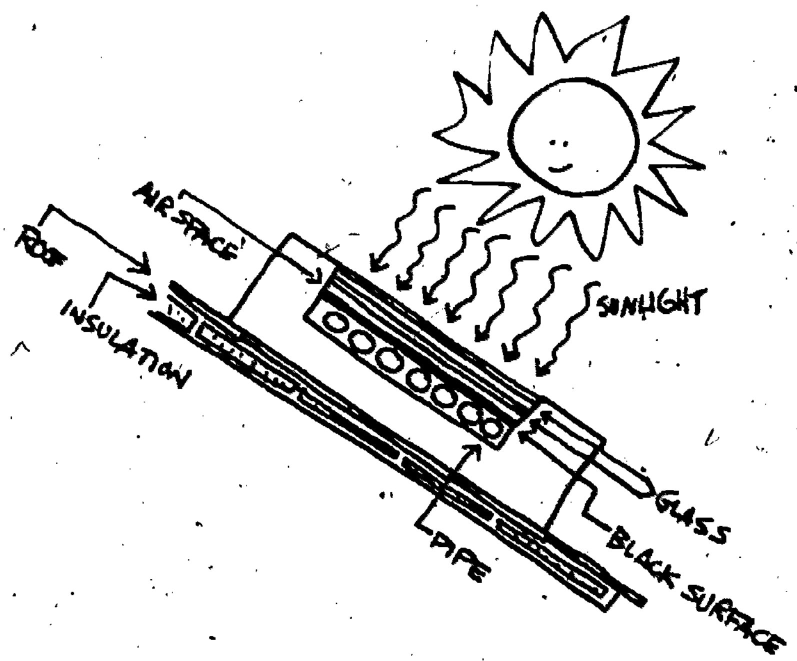


Figure 21
Flat Plate Solar Collector



Unit IV, Lesson 2: Electricity from Solar Energy

Overview

This lesson includes two experiments, each involving a different system for converting solar energy into electrical energy. One system is a central receiving power station in which light is reflected by mirrors onto a steam boiler on top of a tower. The other uses solar cells to make the conversion directly. The Peter Glaser proposal for an Earth Satellite Solar Power Plant is presented as an optional topic.

Background Information

Rather widely circulated artist's pictures show a system with a focusing-mirror-collector shaped like a trough with a central pipe to receive the sunlight. A heat transfer material such as liquid sodium flows through the pipe in the collectors and delivers the collected energy to a central electrical generating plant. At the electrical generating plant the heat energy in the sodium is used to produce steam from which electricity is generated. This system has advantages such as a capacity for short term energy storage and disadvantages such as lower operating efficiencies.

Solar cells are also referred to as solar batteries (an incorrect term) and as photovoltaic cells.

Objectives

Students should be able to:

1. Describe two different systems for converting solar energy into electrical energy.

Materials

1. Solar Power Tower (Figure 22)
2. Dowel, 50 cm long
3. Foam ball
4. 20 mirrors, 10 cm x 15 cm
5. Large mural paper
6. 20 popsicle sticks, tape
7. crayons
8. Solar Cell Powered Motor demonstration (Activity 21)
9. Solar cell
10. Motor with spinner disc
11. 100 watt light bulb
12. Earth Satellite Solar Power Plant drawing (Figure 23)
13. Glue, paper, cardboard, bars, twine, hangers

Teaching Suggestions

1. Show the drawing of a Solar Power Tower, Figure 22. This is a device which produces steam from sunlight. Describe how the mirrors are aimed individually so that they reflect sunlight to the boiler on top of the central column. Tell the class that as the sun moves across the sky the position of each mirror is automatically adjusted. Ask how the steam which is produced can be used to make electricity.

Commentary

Solardroid: "A...bit...large...but...you're ...on...the...right...track...in...collecting ...sunlight."

The very same kinds of steam turbines driving electric generators which are used in fossil fuel and nuclear plants make the electricity here.

An important advantage of this kind of central receiver solar power plant is the high temperatures which can be achieved in the boiler. These higher temperatures should result in greater operating efficiencies. A plant to test this design idea is being built in New Mexico.

Have students make a mural size flowchart to show how they think sunlight makes electricity in this process. Refer to Unit II, Lesson 1, for electricity generator plant.

2. Activity 20: This activity deals with the adjustment of the mirrors. The activity could be done in one class period with only one mirror check or it could last a longer part of the day with more mirror checks.

3. Some of the electricity used in earth satellites is produced by solar cells which convert light directly into electricity. Solar cells were located on the outer surface of satellites until so much electric energy became required that large numbers of solar cells had to be mounted on panels which were extended from the satellite after launching. Have the Solar Cell Powered Motor experiment, Activity 21, performed by a Solardroid and/or other students.

4. Optional: Two presentations follow:
   a) Solar cell make-up
   b) Earth satellite solar power plant

Students could write role-playing skits to present a) and b).

Solardroids: "Now..Earthlings...are...beginning...to...think...of...ways...to...use...solar...energy...directly."

Students could build models of the proposed satellite-to-be and hang as mobiles in the classroom.

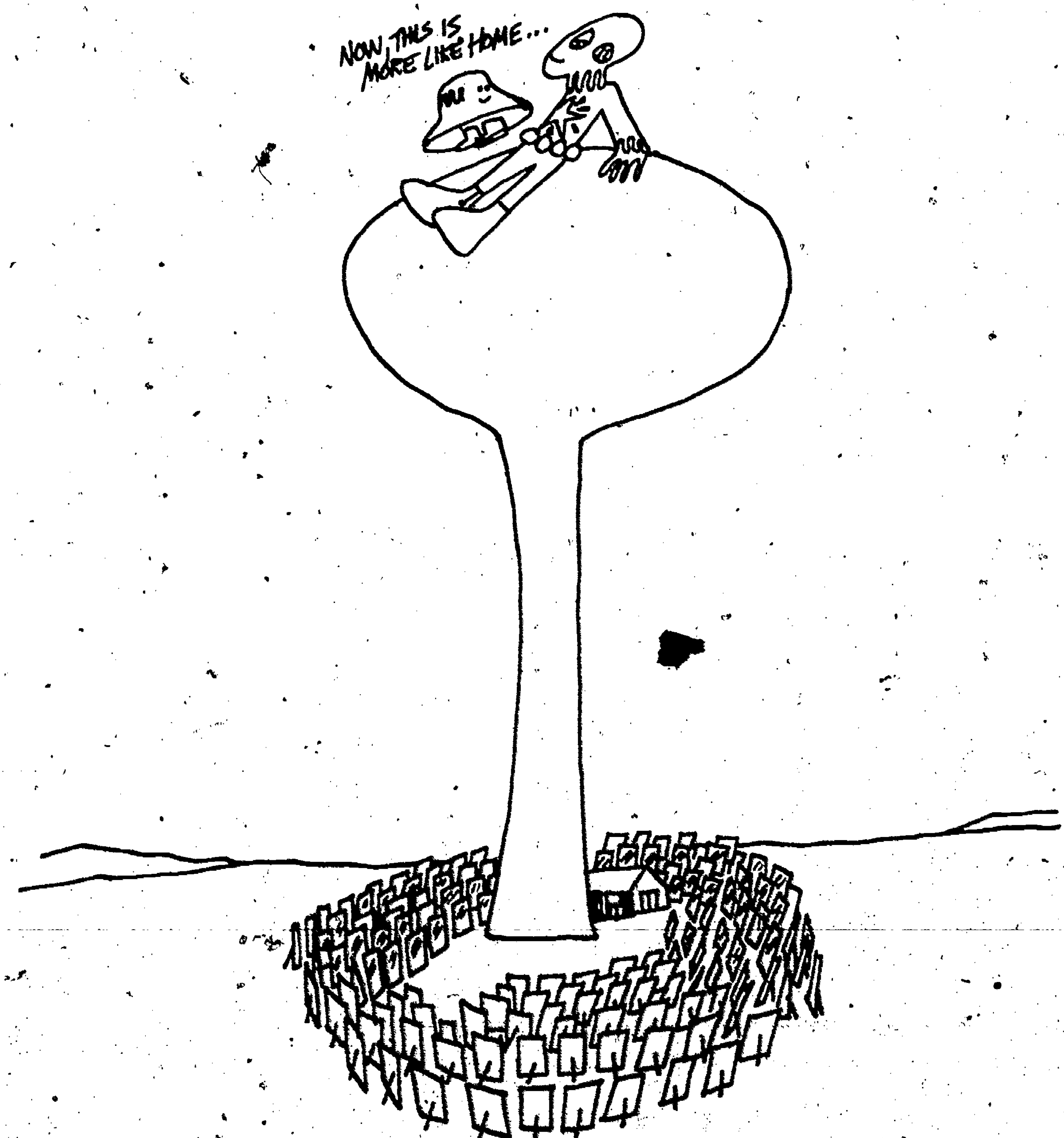
a) Optional: A solar cell may contain a substance, like silicon, known as a semiconductor. Semiconductors are so named because their ability to conduct an electric current is neither good like copper, nor poor like rubber. When two different kinds of semiconductors are joined together to make a solar cell, the common surface where they touch has a useful property. This property is the production of electricity when light, after passing through one of the semiconductors, strikes their common surface.

An electric wire must be connected to each of the semiconductors, and by properly hooking up the wires from many solar cells, larger amounts of electric power can be obtained. The electricity produced using solar cells is still about 20 times as expensive as electricity from fossil fuel power plants.

b) Optional: The following is a proposal for an Earth Satellite Solar Power Plant. An earth satellite would be placed in a synchronous orbit, which means it would remain above a particular spot on the earth's surface. This would put it about 35,000 kilometers (or 22,000 miles) high and it would always be in the sunlight. Moreover, this sunlight would be stronger since it would not have passed through the earth's atmosphere. The satellite would consist of two huge panels of solar cells about 4 kilometers (2.5 miles) on an edge, connected to a central transmitting station, Figure 23. The electric energy from solar cells would be converted into microwaves (as in microwave ovens) which pass through air rather easily. The microwaves would be beamed to a microwave receiver on the surface of the earth and their energy changed back into electricity. What possible problems are there with this proposal?

Building something this size in space would be difficult and expensive. There could be problems with the microwave beam it if missed the location of the receiver or if birds or airplanes flew into it.

Figure 22
Solar Power Tower



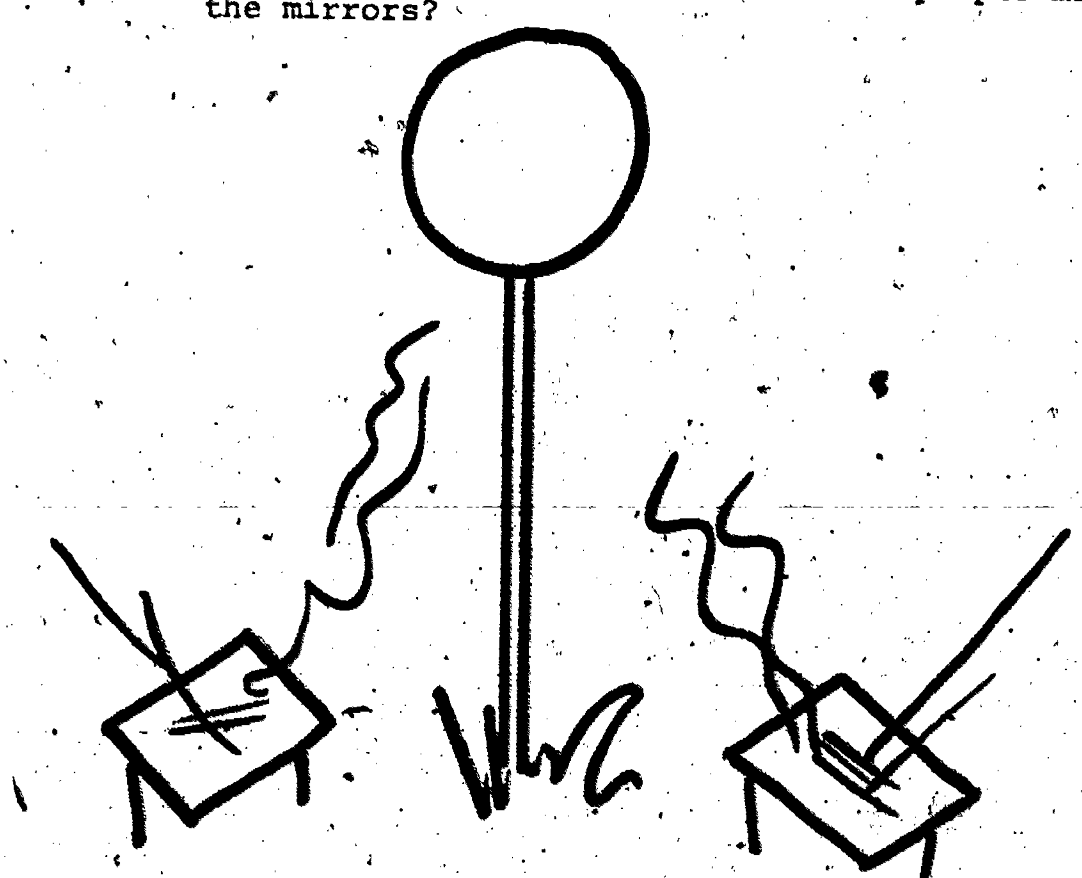
Activity 20

Materials

Dowel, 50 cm long
Ball (foam)
20 mirrors, 10 cm x 15 cm
Large mural paper
Popsicle sticks (20)
Tape

1. Push dowel into foam ball.
2. Tape popsicle stick on each mirror.
3. Place mural paper on level ground outside school.
4. Push dowel with ball into paper and ground (about center of paper).
5. Place mirrors in ground similar manner and at such an angle so as to reflect sunlight on the foam ball.
6. Push mirrors in ground.
7. Mirror checks: Every half hour check mirrors and move them if necessary in order to keep the sunlight reflecting onto the ball.
8. Hang mural paper in classroom after all mirror checks.

Discuss: How many mirror moves were required? How could these moves be accomplished without people moving the mirrors?



Activity 21
Solar Cell Powered Motor

Suitable apparatus for this demonstration, if not on hand, may be borrowed from a physics teacher, a student who has an electricity experiment kit, or purchased from electronic supply stores, or scientific supply companies.

Materials

Solar cell (Bell Telephone Co., Radio Shack, Edwards Scientific)
Motor with spinner disc
Lamp with 100 watt bulb

1. Aim the solar cell at the sun.

2. Turn the solar cell slightly away from the sun. Explain any changes in how fast the motor goes. A 100 watt incandescent light bulb can be substituted for the sun.

3. Move the solar cell different distances from the light bulb. Explain any changes in how fast the motor goes.

4. Discuss: Would you expect any differences in how fast the motor goes when the solar cell is pointed directly at the sun early in the morning, at noon, and late in the afternoon? Try it! Explain any differences.

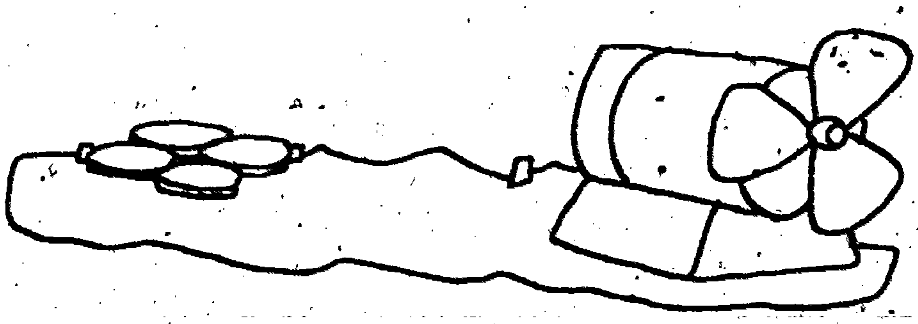
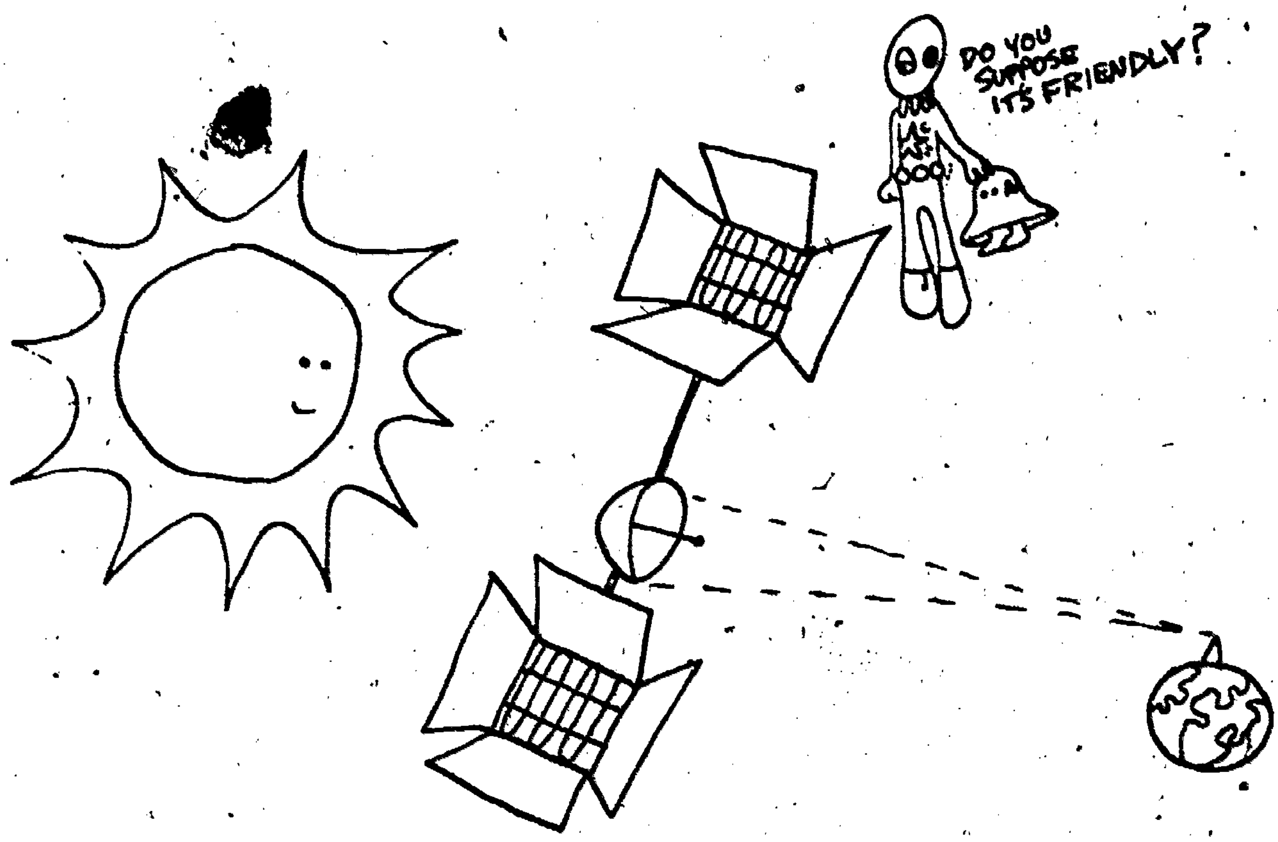


Figure 23
Earth Satellite Solar Power Plant



Unit IV, Lesson 3: The Energy Future

Overview

The lesson begins with discussions of alternative energy sources. In this lesson each student should be able to tie together all that has been previously presented. Projections concerning the energy scene for his/her lifetime are made.

Background Information

While this lesson has a modicum of the more objective, factual, summative material, its focus is on getting students to accept the idea that we do have an energy problem. There is some controversy as to the nature and details of the energy problem(s) and the appropriate solutions. For background a teacher needs to carefully examine the different points of view and be alert to the special interests represented in much of the material put out for public consumption. The Energy-Environment Source Book, by John M. Fowler, National Science Teachers Association, Washington, D.C., 1975, is informative without serving one side or another, especially pp. 85-102.

Objectives

Students should be able to:
1. List additional alternative energy sources.
2. Identify certain aspects of energy supply and demand which s/he believes will effect his/her life.

Materials

1. New Energy Resources (Figure 24)
2. Ranking New Energy Resources (Activity 22)
3. Non-Fossil Fuel Flowchart (Activity 23)
4. Projections of Types of Non-Fossil Fuel Energy Use (Figure 25)

Teaching Suggestions

1. This lesson can begin with a consideration of New Energy Resources, Figure 24.

Use Figure 24 and Activity 22. Follow with Activity 23.

2. Ask students if they would be interested in knowing where they will spend the rest of their lives.

The Solardroids have been thinking about their future and one of them has a final statement to make to the class. Have students attempt to convince the Solardroids to stay/leave earth in debate fashion.

Commentary

1. Student committee reports may be an appropriate way to explore energy alternatives with students.

Activity 22 offers a way for students to rank alternative energy resources.

Activity 23 allows the student to use a mixture of energy alternatives.

2. They will spend their lives in the future.

Solardroid: The other extraterrestrials have supposedly asked you to make this last class presentation for them. Your assignment is to express some concern for the future and attempt to get your classmates, also, to give some serious thought to their energy future.

"Since...our...flying...saucer...crash... landed...here...on...earth...we...have... learned...a...great...deal...about...this... planet...and...the...United...States. We...

now...must...make...a...decision...which... may...be...the...most...important...one...in ...our...lives. We...have...repaired...our... flying...saucer...as...best...we...can. It... may...not...be...good...enough...to...get... us...back...home...safely...to...planet...X. But...if...we...decide...to...stay...here... on...planet...Earth,...we...see...problems... in...connection...with...energy...supplies. Our...questions...about...the...future...need ...answers...before...we...Solardroids...can ...make...our...decision...to...stay...or... leave. We...would...like...our...Earthling... friends...in...this...class...to...tell...us ...the...energy...future...they...see...for... their...lifetimes...please."

3. Nobody knows for sure what will happen in the future, but most everyone makes some guesses.

Earthlings: Offer responses to the Solardroids' plea.

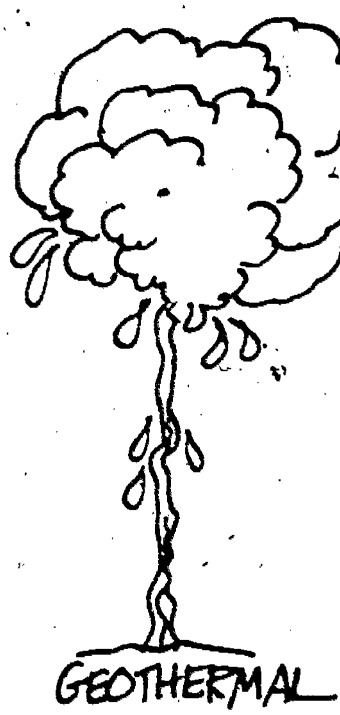
The guesses are less certain the further they go into the future. After studying this material on energy students should have a better basis for predicting certain aspects of their future. Ask what they see in their future in regard to energy.

Go over instructions on how to use Figure 25. Suggest that on the back of Figure 25 students write any comments or explanations they have regarding their predictions. The students could work in small groups.

What the students put down on paper is much less important than the fact that they are thinking about their energy future.

4. Optional: If not done previously, go over the results which were obtained from the Energy Attitude Survey. The responses may be put on the overhead projector or distributed to each student.

Figure 24
New Energy Resources



GEOTHERMAL

--The earth's center is a molten mass.

--At places the hot mass is close to the surface.

--Evidence of the closeness are volcanos, geysers, hot springs.

--This heat can be tapped.

--It can be used to generate electricity.

--There are few environmental problems with it.

--This energy can now only be tapped where it is near the surface.

--The search is on for other areas where this geothermal energy can be reached.

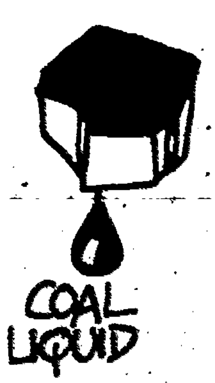
COAL GASIFICATION

--Using high temperature and pressure, coal can be converted into a gas.

--Conversion plants need to be near coal fields.

--Coal gas burns cleanly.

--Pollution problems occur in the coal mining process, as they always have.



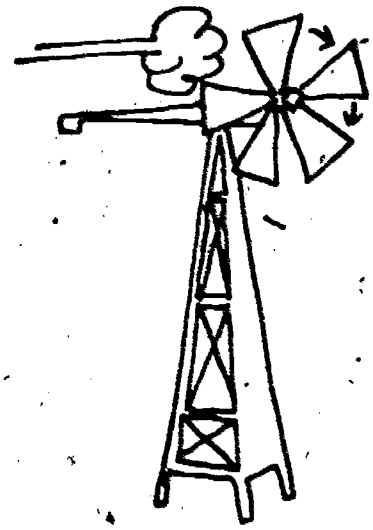
COAL LIQUEFACTION

--Coal can be converted to an oil-like liquid.

--The technology is not completely developed.

--The advantage over coal gas is it can make all the usual oil products, including a kind of gasoline to run our cars.

Figure 24 con't.



WIND

--Wind is a form of solar energy.

--It is caused by variations in the temperature of the air heated by the sun.

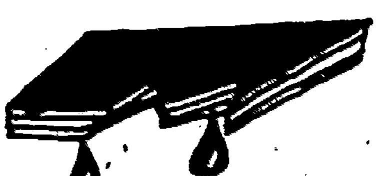
--This temperature change causes air to move.

--Wind doesn't blow all the time.

--Practical storage systems are still being developed.

--Sailors and farmers have used wind for ages.

--Will large windmills someday be able to provide electricity for entire towns?



OIL SHALE

--Oil shale is a rock that yields oil when crushed and heated.

--One ton of rock may produce as much as 25 gallons of oil.

--Oil shale deposits are located in the West.

--The rock must be mined.

--To extract the oil large amounts of water are needed.

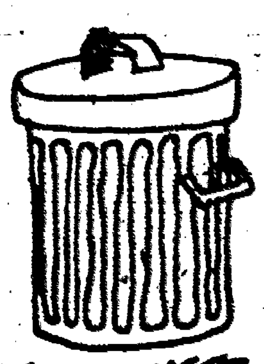
--How to dispose of the spent rock after the oil is extracted is a problem.

--Vegetation will not grow on the used shale.

--Without vegetation, some animals may lose their homes and food.

--Pollutants will possibly be carried to larger bodies of water.

--Oil shale processing contributes to air pollution.



PYROLYSIS OF SOLID WASTE

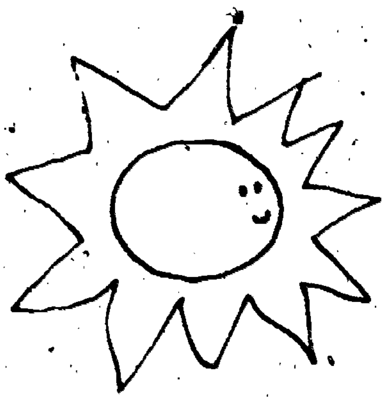
--Waste can be heated to produce oil and gaseous products.

--This same waste is an environmental problem.

Figure 24 con't.

--This material tends to be scattered in small amounts.

--The cost of collecting it is a problem.

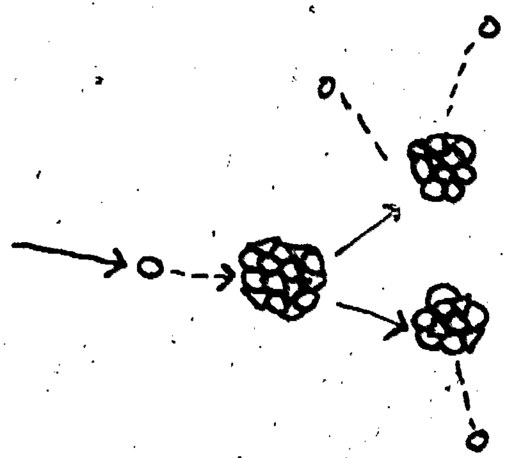


SOLAR

--At present this is very expensive.

--Prices will probably get lower.

--There are many problems to be solved (e.g., improving collectors, installing, storage).

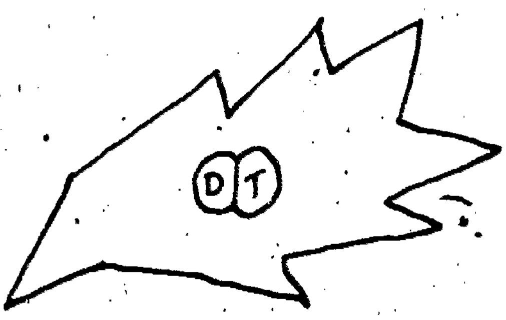


FISSION (Breeder Reactor)

--Uses uranium which will probably last 100 years.

--Questionable as far as safety (for example, local safety, bomb making).

--The original cost of a breeder is very large.



FUSION

--Uses "fuels" which probably will not ever "run out".

--Appears to be environmentally safe.

--There is no appropriate way to contain it yet.

--It probably won't be available until after 2000.

Activity 22

Some energy resources are better to use than others. Some are easier to get at. Some exist in greater quantities than others. Each has its positive and negative points.

Consider each of the following: (a) geothermal; (b) coal gasification; (c) coal liquefaction; (d) wind; (e) oil shale; (f) pyrolysis of solid waste; (g) solar; (h) fission; (i) fusion. Determine the plus and minus points involving the use of each according to the following factors:

A. Technological feasibility
B. Quantity
C. Availability
D. Impact on environment
E. Obvious problems

Ranking New Energy Resources

	A	B	C	D	E	Total (-)	Total (+)
Geothermal							
Coal Gasification							
Coal Liquefaction							
Wind							
Oil Shale							
Pyrolysis of Solid Waste							
Solar							
Fission							
Fusion							

Place either (+) or (-) in each box.

Rank Order

MOST ACCEPTABLE LEAST ACCEPTABLE

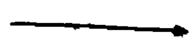
1. ______ 2. ______ 3. ______ 4. ______ 5. ______

Should a decision be made to only use one of the above energy resources? Why? What other options are there?

Activity 23

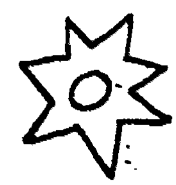
Draw a flowchart using a mix of new energy resources to provide heat, electricity, etc. for this house.

Use these symbols:



direction of flow

explanation of



sun

Provide your own symbols as needed.

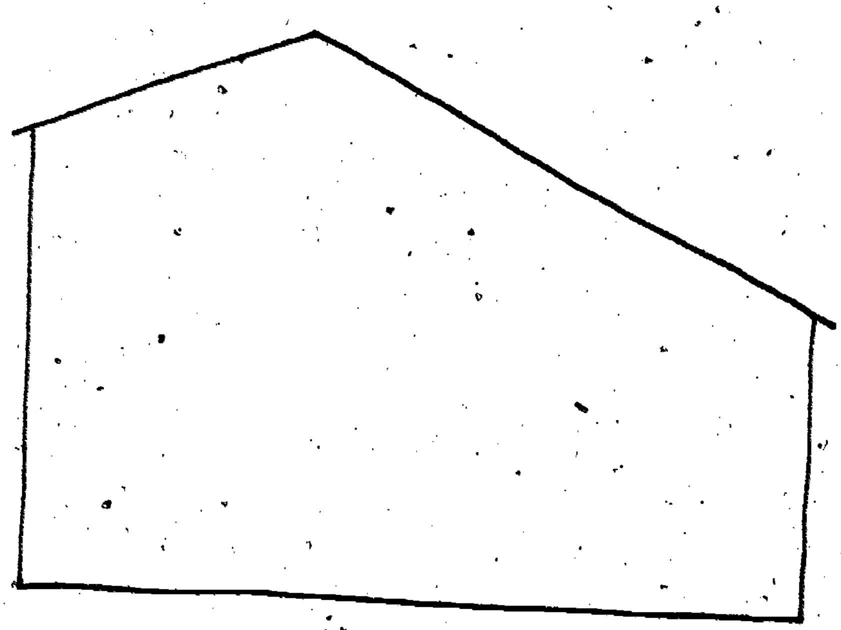


Figure 25
Projections of Types of Non-Fossil Fuel Energy Use

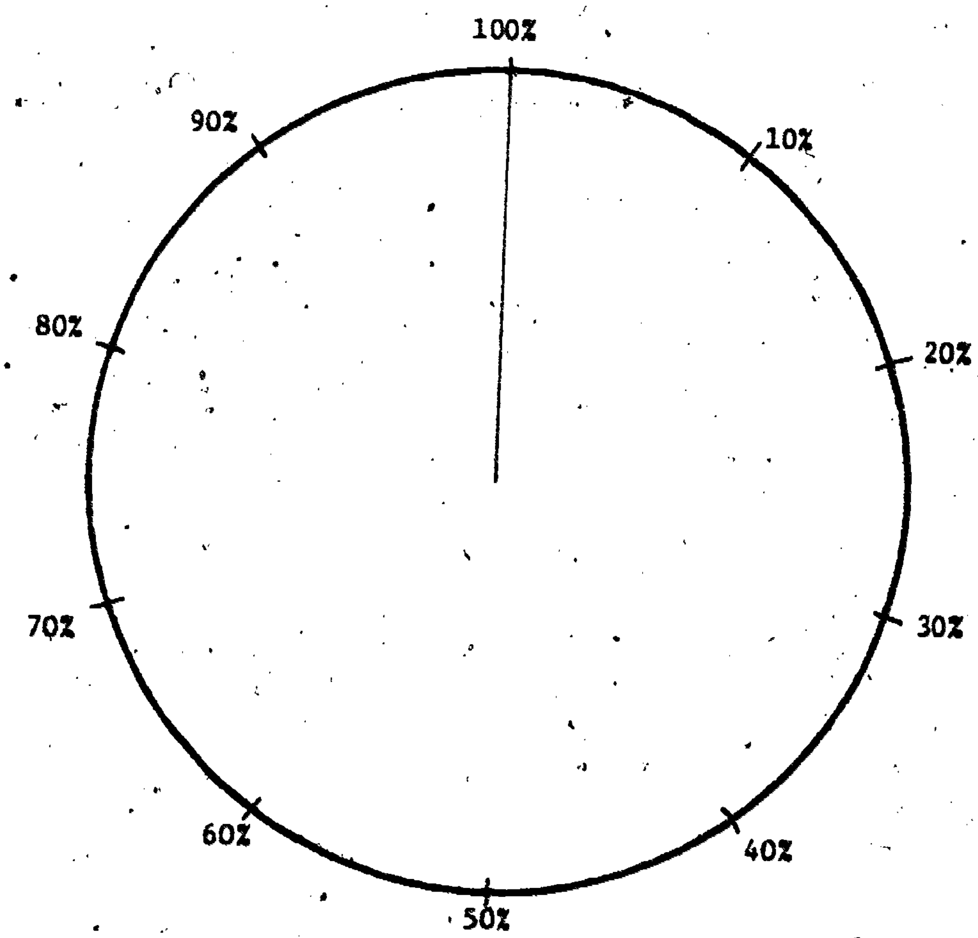
The first circle represents the total amount of energy from non-fossil fuels used in the year 1975. Complete the graph for the year 2050. You may want to jot down your percentages on the table below to make sure they total 100% before marking the graphs.

When marking the graphs, start with the given line and go clockwise, giving in order the particular sources indicated below and labeling each source's slice of the pie with its letter key. Omit any source you know nothing about or are predicting will be less than 1%.

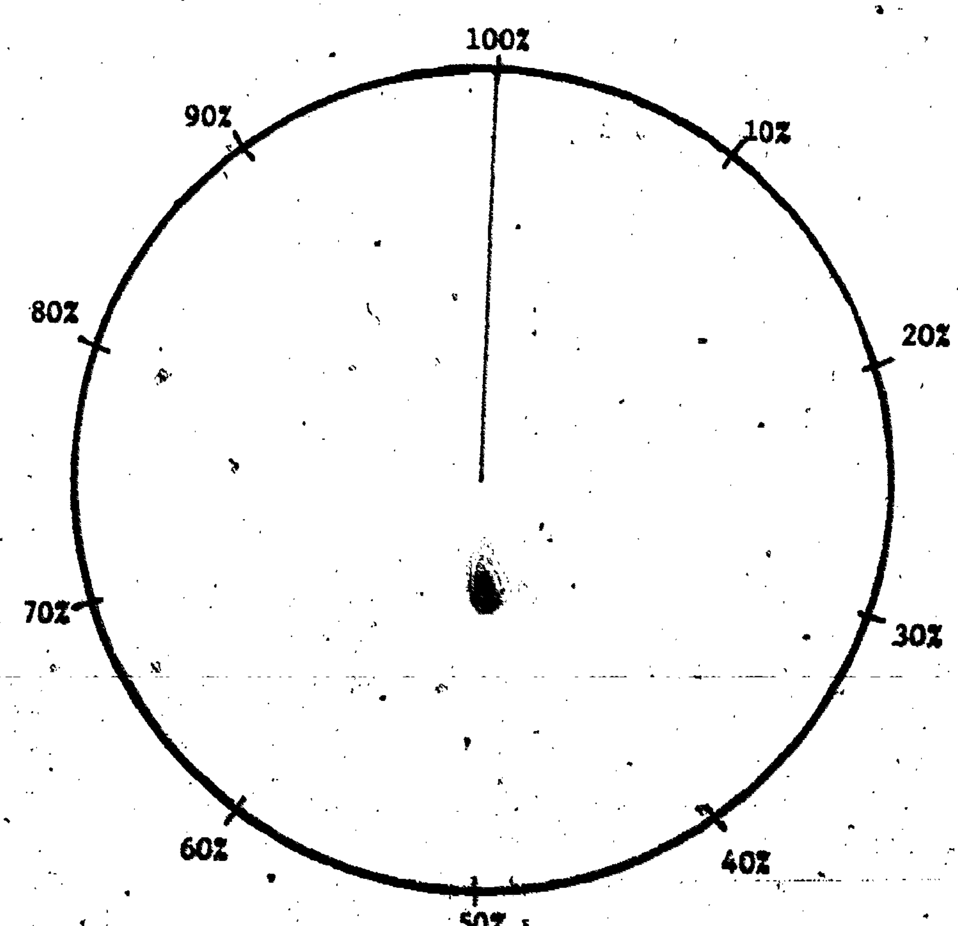
		1975*	2050
A.	Geothermal		
B.	Hydro	4%	
C.	Fuels from municipal wastes		
D.	Nuclear, conventional fission	1%	
E.	Nuclear, breeder		
F.	Nuclear, fusion		
G.	Ocean (waves, tides, thermal)		
H.	Solar heating and cooling		
I.	Solar electric		
J.	Wind		
K.	Wood and other fuels from non-fossil plants		
L.	Sources not listed above	95%	
	TOTAL	100%	100%

*In 1975 all uses of non-fossil fuel except hydroelectric and conventional and breeder nuclear energy were less than 1%. All other energy used came from fossil fuels.

1975



2050



* U. S. GOVERNMENT PRINTING OFFICE : 1980 311-112/19