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ABSTRACT

This teaching unit explores coal as an energy resource. Goals, student objectives, background information, and activity options are presented for each major section. The sections are: (1) an introduction to coal (which describes how and where coal was formed and explains the types of coal); (2) the mining of coal (including the methods and ways of transporting coal); (3) the use of coal (reviewing historical uses and current products); and (4) problems with using coal (assessing environmental and health related factors). Throughout the document several fact sheets are presented in a pictorial and graphic manner. References are given for films and publications that pertain to coal and/or energy-related issues. An appendix provides additional background information for teachers and activity possibilities for students. (ML)

ENERGY WORKSHOP

Dr. Arie Halachmi, Director

COAL AND ENERGY

by

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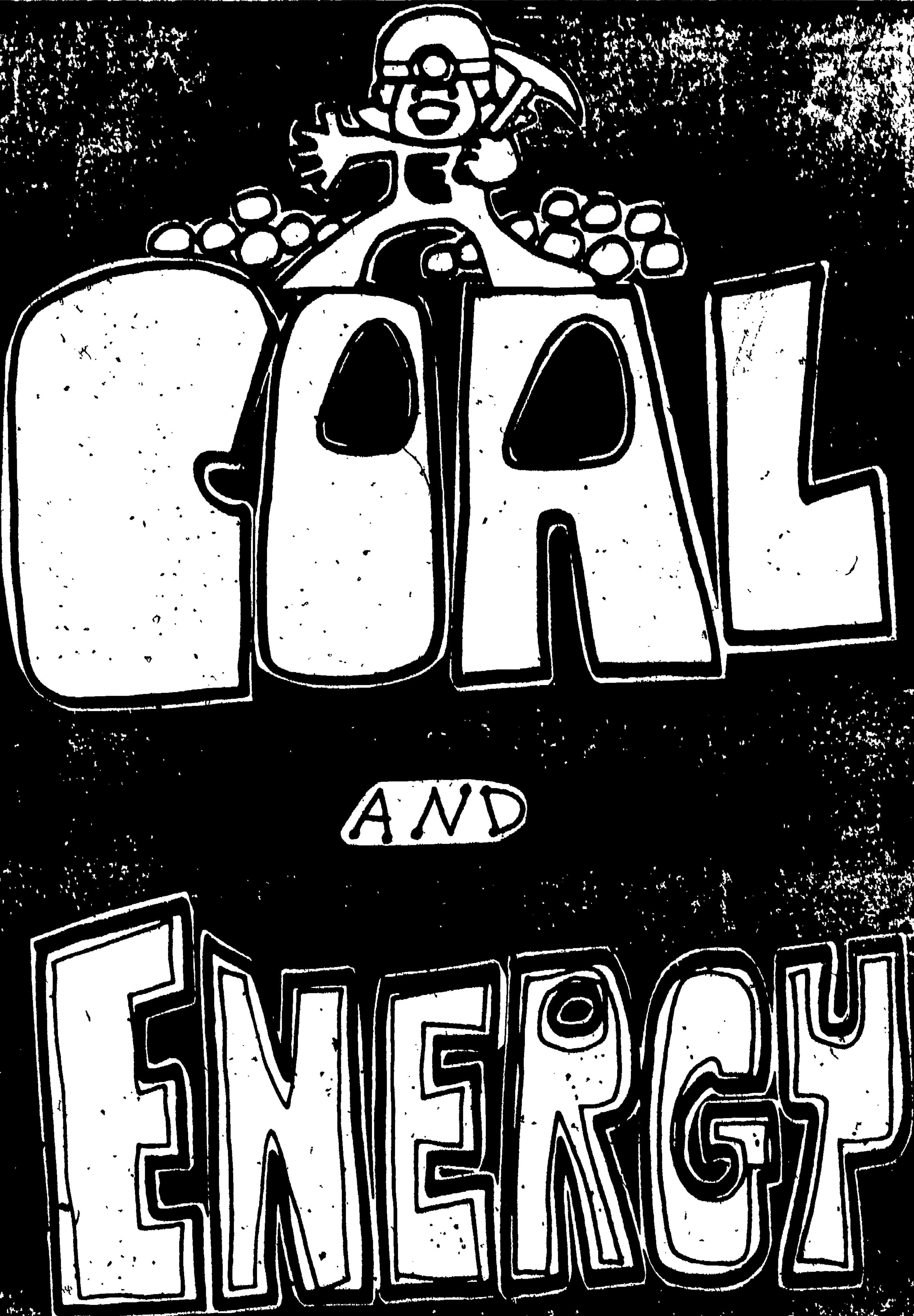

COAL
AND
ENERGY

COAL

I. Introduction

A. How coal was formed
B. Where coal was formed
C. Chief kinds of coal

II. Mining of Coal

A. How coal is mined
B. How coal is transported
C. Leading coal companies

III. Use of Coal

A. History of use
B. Products from coal
C. Used as a fuel

IV. Problems with Using Coal

A. Mine safety
B. Environmental factors
C. Health factors

COAL and ENERGY

Student Objective:
The student should be able to give a written definition of coal.

Coal definition:
Coal is a black or brownish-black solid combustible substance formed by the partial decomposition of vegetable matter without free access of air and under the influence of moisture and increased pressure and temperature.

Coal formation.
Some coal formed 400 million years ago but high ranking coal such as that in Eastern Tennessee was formed only 250 million years ago during the Paleozoic and Mississippian Periods. Coal forming periods are often called Early or Late Carboniferous Periods.
During the Late Paleozoic Era, 300,000,000 years ago, the earth's atmosphere was moisture laden and steamy. The earth's surface was covered with dense forests of mosses, ferns, and gymnosperm type plants. Bacteria, protozoan, fungi, and algae were quite common both on land masses and in the swamps and water environments. Among the plants lived giant insects and big lizards. As time passed, giant plants died and fell into the swamps. A spongy, brown vegetable matter called peat began to form. New plants grew on top of old. Then they too died and became part of the mass of peat. Stratification occurred with dirt and sand being deposited between layers of peat. Heat and pressure caused different types of coal to be formed. During millions of years these layers of vegetation were converted to carbon and hydrocarbons. Peat was converted to brown coals and lignite. With the addition of moisture, heat, and pressure, subbituminous and bituminous coals were formed. Anthracite coals were finally transformed by the chemical and physical interactions of moisture, heat and pressure, on the bituminous coals.

Student Objective:
The student should be able to outline the events in the formation of coal. Layers of vegetation ---> carbon and hydrocarbons ---> peat ---> brown coals and lignite (additional moisture, heat and pressure) ---> subbituminous and bituminous (chemical and physical interaction of moisture, heat and pressure) ---> anthracite coals.

Library study.
Using the World Book Encyclopedia or other resource materials, find out about the formation of coal and make a series of drawings for your notebook which shows how coal is formed and deposited. Lable your drawings.

Student Objective:
The student should be able to answer questions about the relative amounts of different ranks of coal and about the location of these coals in the United States and in Tennessee when given a map and information about coal deposits.

Map study activity. Appendix I-A

Show students samples of coal.

Coal deposits.
Most coal seams are 1-2 meters thick. In Lake De Smet, Johnson county, Wyoming, a coal seam has been identified as narrow as 30 meters and as thick as 70 meters. The thickest known seam recognized in the world today is located in Manchuria and is approximately 140 meters across.

Student Objective:
The student should be able to draw conclusions about the relationship between the rank of coal and the carbon and moisture content of the coal by reading tables.

Students should be able to list the ranks of coal from the highest rank to the lowest rank. (The 4 main classifications)

Reading tables activity. Appendix I-B

Differentiation of Coal by Rank

One classification of coal is by rank, that is, according to the degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite. In considering the ranking of coal, the volatile matter, fixed carbon, moisture content, and oxygen are identified with each sample. Older coals are often identified by percentages of fixed carbon and percentages of volatile matter. Younger coals are identified by the heating value in BTU/lb. The amount of heat which is released by burning coal can be determined by direct measurement in a calorimeter.

Student Objective:

The student should be able to list the elements present in coal and tell about the importance of each element. (Major elements)

Chemical Composition of Coal.

Two types of analysis are in common use for expressing the composition of coal. In the ultimate analysis the coal sample is dried and determination is made of each of the major chemical elements; carbon, hydrogen, sulfur, nitrogen and ash. The remainder is assumed to be oxygen. In proximate analysis four arbitrarily defined groups of constituents are determined. Moisture, volatile matter and ash are measured, and fixed carbon is that which is left. The sum of the fixed carbon and the volatile matter is termed the combustible.

Ash comes from two sources. The intrinsic ash is due to the mineral content of the vegetative matter in the original material. The extraneous ash is the result of mineral content of the mud deposits, shale and pyrites in the coal seams. Ash may include oxides of silicon, aluminum, titanium, iron, calcium, magnesium, sodium, and potassium. Sulfur may also be a constituent of the ash. Ash content varies over a wide range even within a single coal seam.

Library Study:

To find out about the elements present in coal and the importance of these elements to the fuel.

EVALUATION   Appendix I - C

Word list for definitions and spelling.

Quiz one

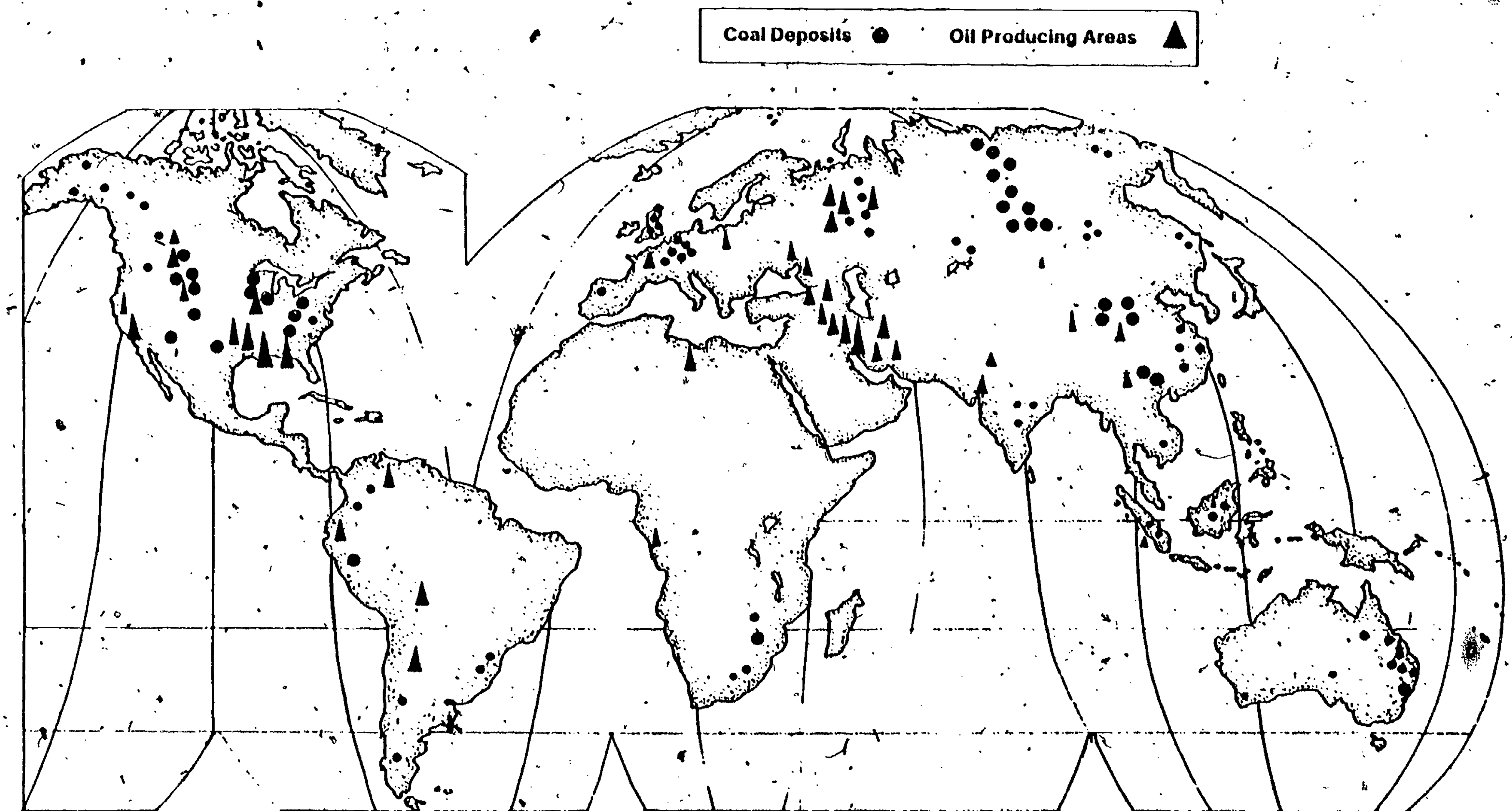
Supplemental Student Projects   Appendix I - D

Data for graphs

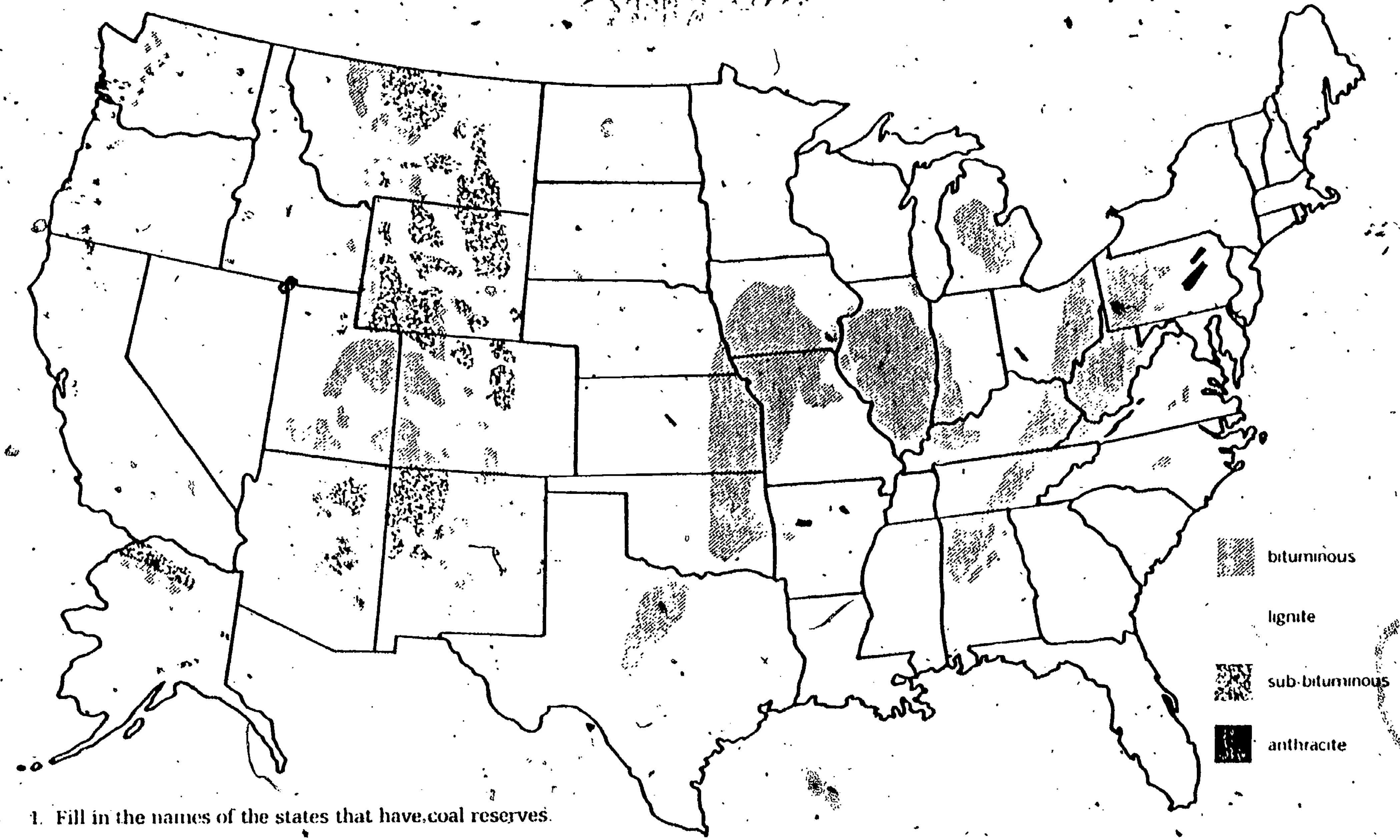
Editorial cartoons

APPENDIX I - A

The Earth's Coal and Oil



Map is based on Homolosine, Interrupted, equal area projection, to focus attention on the land masses of the Earth.



1. Fill in the names of the states that have coal reserves.

2. Can you tell from this map how many tons of coal we have in the United States? Why or why not?

3. Notice that there are large deposits shown in Michigan, yet coal is not mined there. Can you guess why not?

4. From looking at the map do you think that the area you live in has electricity produced from coal? Check with your local utility plant to find out whether or not you are right.

5. Where is the major deposit of anthracite coal found?

6. Where in the United States does one find deposits of lignite coal?
Name at least 8 states which have lignite deposits.

7. Name at least 5 states with subbituminous coal deposits.

8. Name four states which have both subbituminous as well as bituminous deposits of coal.

9. Approximately how many states have bituminous deposits of coal?

10. In what mountain area of East Tennessee are the deposits of bituminous coal found?

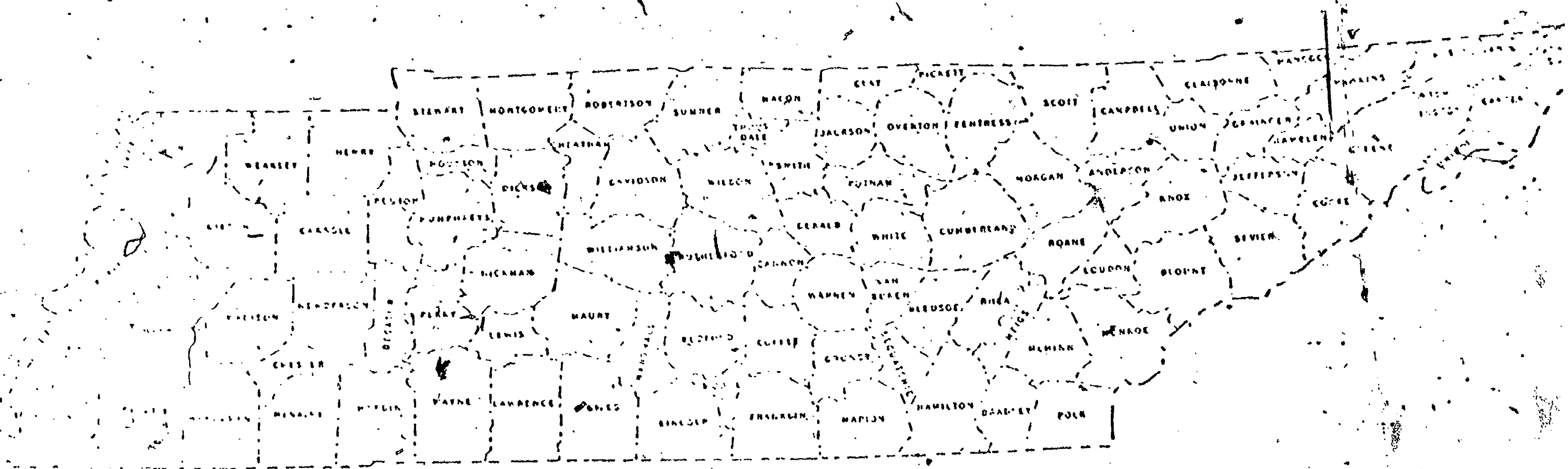
11. What is the name of the mountain chain which extends from Pennsylvania south and westward to the state of Alabama, in which deposits of bituminous coal are found?

12. Of the total coal reserves in the United States, what fraction of the area is found in the areas of the Great Plains, the Rocky Mountains and the Western states? (1/8 1/10 2/3 or 1/4) .

13. From your answer determined in question 9 above, why have these coal reserves not been used as widely as those deposits of coal found east of the Mississippi River? Discuss the reasons given for your answer in terms of location, transportation, and chemical composition of the coal itself.

COUNTIES OF THE

STATE OF TENNESSEE



Scale in Miles

0 25 50 75 100

With a color pencil shade in counties where coal averages a sulfur content greater than 3%. Use another color for sulfur content in the 2-3% range, a third color for the 1-2% range and a fourth color for a sulfur content less than 1%.

Typical Composition of Tennessee Coal

County	As Received				Moisture and Ash Free					
	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H_2	O_2	N_2	S	Heating Value Btu/lb
Anderson, Campbell	2-6	2-8	40.3	59.7	83.1	5.5	7.4	2.1	1.9	14880
Claiborne, Overton, Scott	2-6	2-11	40.5	59.5	83.5	5.6	6.8	2.0	2.4	14950
Fentress, Morgan, White	2-5	4-12	41.6	58.4	83.0	5.7	6.1	1.7	3.5	15090
Hamilton, Marion	3-5	3-11	31.1	68.9	87.3	5.4	4.2	1.6	1.5	15425
Grundy, Rhea, Roane	2-4	9-15	34.5	65.5	85.7	5.3	6.1	1.6	1.3	15160

NOTE: 1) Moisture refers to coal containing its natural inherent water content but not including visible water on the surface of the coal.

2) Volatile Matter and Fixed Carbon percentages must add up to 100, as well as the sum of C, H_2, O_2, N_2, and S.

Adapted from de Lorenzi, Otto, 1951, Combustion Engineering, Riverside Press, Cambridge, 2-13.

Appendix I - B

TABLE 1-4

Classification of coals by rank[a] (ASTM D 388)

Class	Group	Fixed Carbon Limits, % (Dry, Mineral-Matter-Free Basis): Equal or Greater Than	Fixed Carbon Limits, % (Dry, Mineral-Matter-Free Basis): Less Than	Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis): Greater Than	Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis): Equal or Less Than	Calorific Value Limits, Btu/lb (Moist,[b] Mineral-Matter-Free Basis): Equal or Greater Than	Calorific Value Limits, Btu/lb (Moist,[b] Mineral-Matter-Free Basis): Less Than	Agglomerating Character
I. Anthracitic	1. Meta-anthracite	98	—	—	2	—	—	Nonagglomerating
	2. Anthracite	92	98	2	8	—	—	
	3. Semianthracite[c]	86	92	8	14	—	—	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	—	—	Commonly agglomerating[e]
	2. Medium volatile bituminous coal	69	78	22	31	—	—	
	3. High volatile A bituminous coal	—	69	31	—	14,000[d]	—	
	4. High volatile B bituminous coal	—	—	—	—	13,000[d]	14,000	
	5. High volatile C bituminous coal	—	—	—	—	11,500	13,000	
						10,500[e]	11,500	Agglomerating
III. Subbituminous	1. Subbituminous A coal	—	—	—	—	10,500	11,500	Nonagglomerating
	2. Subbituminous B coal	—	—	—	—	9,500	10,500	
	3. Subbituminous C coal	—	—	—	—	8,300	9,500	
IV. Lignitic	1. Lignite A	—	—	—	—	6,300	8,300	
	2. Lignite B	—	—	—	—	—	6,300	

[a] This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48% dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free British thermal units per pound.

[b] Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[c] If agglomerating, classify in low-volatile group of the bituminous class.

[d] Coals having 69% or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[e] It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high volatile C bituminous group.

The Babcock and Wilcox Company, 1972, Steam - Its Generation and Use, New York, 5-11.

TABLE 1-1

Coal Analysis
On as-received basis
(Pittsburgh Seam Coal, West Virginia)

Proximate Analysis

Component	Weight, %
Moisture	2.5
Volatile matter	37.6
Fixed carbon	52.9
Ash	7.0
TOTAL	100.00
Heating value, Btu/lb	13,000

Ultimate Analysis

Component	Weight, %
Moisture	2.5
Carbon	75.0
Hydrogen	5.0
Sulfur	2.3
Nitrogen	1.5
Oxygen	6.7
Ash	7.0
TOTAL	100.0

From the Babcock & Wilcox Co., 1972, Steam-Its Generation and Use, New York, 5-9.

Using the table above and the table "The Typical Composition of Tennessee Coal" answer the following questions; (a) How does the fixed carbon in Tennessee Coal compare with the fixed carbon in Pittsburg coal? (b) What is the importance of the fixed carbon? (c) How does the fixed carbon relate to the coal rank? (d) How does moisture content relate to coal rank?

Using the table below, determine how the fixed carbon in the coal relates to the ignition temperature required to burn coal.

TABLE 1-3

Fuel	Ignition Temperature °C
Fixed carbon	
Bituminous coal	407
Semibituminous coal	466
Anthracite	449 - 602
Hydrogen	574 - 591
Sulfur	243
Kerosene	254 - 293
Gasoline	260 - 427

Adapted from: The Babcock & Wilcox Co., 1972, Steam - Its Generation and Use, New York, 6-6.

APPENDIX I - C

QUIZ #1

Using the words listed below, complete the following paragraphs

peat

compressed

Carboniferous Period

fossils

bituminous coal

anthracite

lignite

Coal was formed millions of years ago in the ____________________. We know what the plants looked like then because we find impressions of them in ____________________ today. Over the years the weight of the earth ____________________ the layers of dead plants.

Our most plentiful fuel source in the United States is ____________________.
____________________ is an excellent source of heat for homes, but there is not much of it.
____________________ is smoky when it burns and has a low heat content.
____________________, which is not really considered coal, is used for fuel in some countries of the world.

Word list for definitions and spelling.

1. Anthracite
2. Bituminous
3. Carboniferous
4. Coal seams
5. Coal reserve
6. Coal veins
7. Lignite
8. Metamorphism
9. Peat
10. Sedimentary rock
11. Stratification
12. Subbituminous
13. Volatile

APPENDIX I - D

Suggested Supplemental Student Projects

1. Students may collect materials on coal, coal mining, coal transportation, coal uses, etc. to make a bulletin board.

2. Students may draw cartoons or other editorial type drawings and label caption depicting theme of coal production or energy production using coal as it relates to environmental abuse.

3. Students may write a short poem or verse developing the story of coal.

4. Students may write a simple ballad to be sung with string or instrumental arrangements telling the story of coal.

5. Have students find samples of coal. Observe the characteristics of [illegible] to identify the rank (anthracite, bituminous, li[illegible], peat, etc.). Make other observations as students des[illegible] them. (Open ended)

6. Students could do research into the sulfur content of petroleum, natural gas and coal.

7. Make a line graph which will show the ranks of coal used to make electricity. (Data on next page)

8. Trace all of the energy changes that take place from the time coal begins to form until energy is produced in a light bulb in your home. (see list of examples of energy changes)

Use the data given in the following table to make a line graph. Plot time on the horizontal axis and fuel production on the vertical axis. The fuel production is reported in thousands of bituminous coal equivalent tons. Plot one line for each fuel. Study the energy production from the six sources of energy to determine the increase or decrease of the energy supplies.

Data:

U.S. PRODUCTION OF MINERAL FUELS AND ELECTRICITY FROM WATER AND NUCLEAR POWER, 1920-1970

Year	Bituminous Coal and Lignite	Anthracite Coal	Crude Petroleum	Natural Gas	Water Power	Nuclear Power
1920	568,667	86,870	98,053	33,702	28,168	-
1925	520,053	59,924	169,084	50,153	25,496	-
1930	467,526	67,252	198,778	81,985	28,702	-
1935	372,373	50,572	220,610	81,527	30,763	-
1940	460,772	49,924	299,580	113,702	33,588	-
1945	577,617	53,244	379,351	168,817	55,038	-
1950	516,311	42,748	436,984	261,107	60,038	-
1955	464,634	25,382	549,999	389,466	55,229	-
1960	415,512	18,245	570,069	527,586	65,755	208
1965	512,088	14,870	626,672	694,414	80,999	1,495
1970	602,932	9,928	794,695	970,820	105,707	9,204

Adapted from: National Coal Association, 1972, Bituminous Coal Facts 1972, Washington, D.C., 55.

Using the energy changes below as examples, trace all of the energy changes that take place from the time coal begins to form until the energy is produced as light in a light bulb in your home.

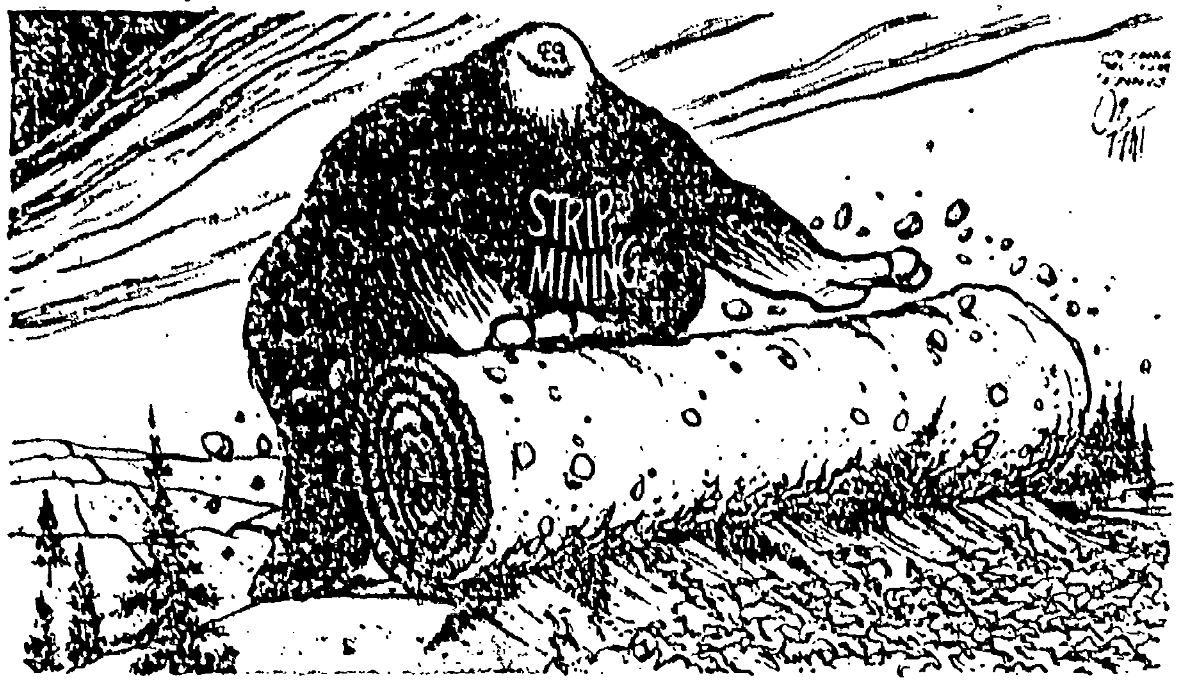
explosions	chemical	mechanical
dry cell	chemical	electrical
A bomb	nuclear	heat light mechanical
power plant	nuclear	electrical

incandescence	heat to	light
steam turbine	heat	mechanical
thermocouple	heat	electrical
photosynthesis	radiant	chemical
absorption	light	heat
radiometer	light	mechanical
solar battery	light	electrical
photography	light	chemical
friction	mechanical	heat
flint on steel	mechanical	light
hand magneto	mechanical	electrical
toaster or iron	electrical	heat
neon lamp	electrical	light
elect. motor	electrical	mechanical
electroplating	electrical	chemical
combustion	chemical	heat
combustion	chemical	light

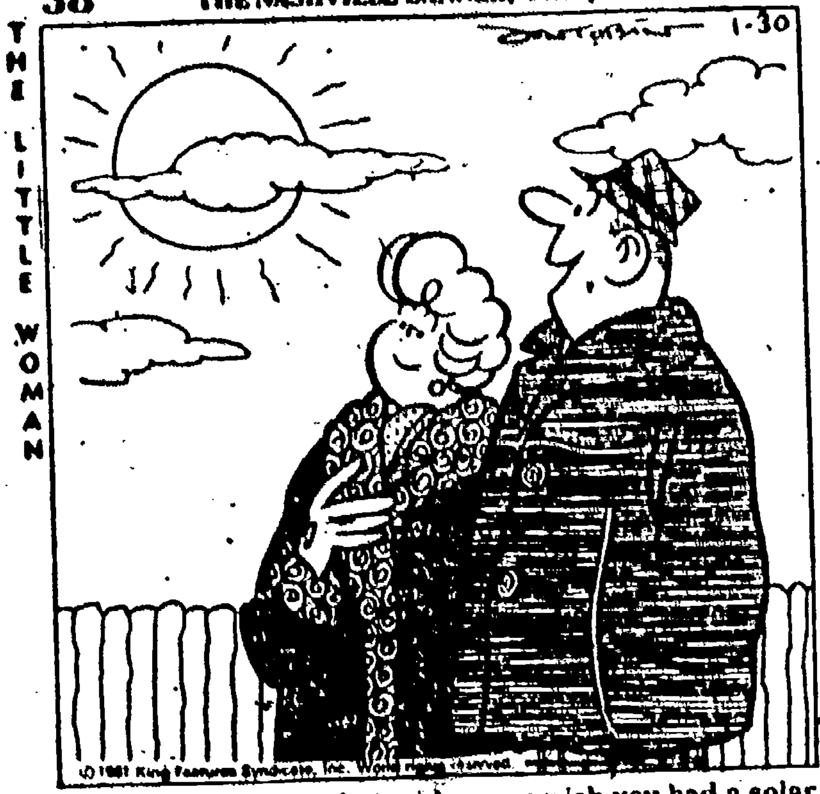
Changing Our Wasteful Ways Is Not So Easy

5.

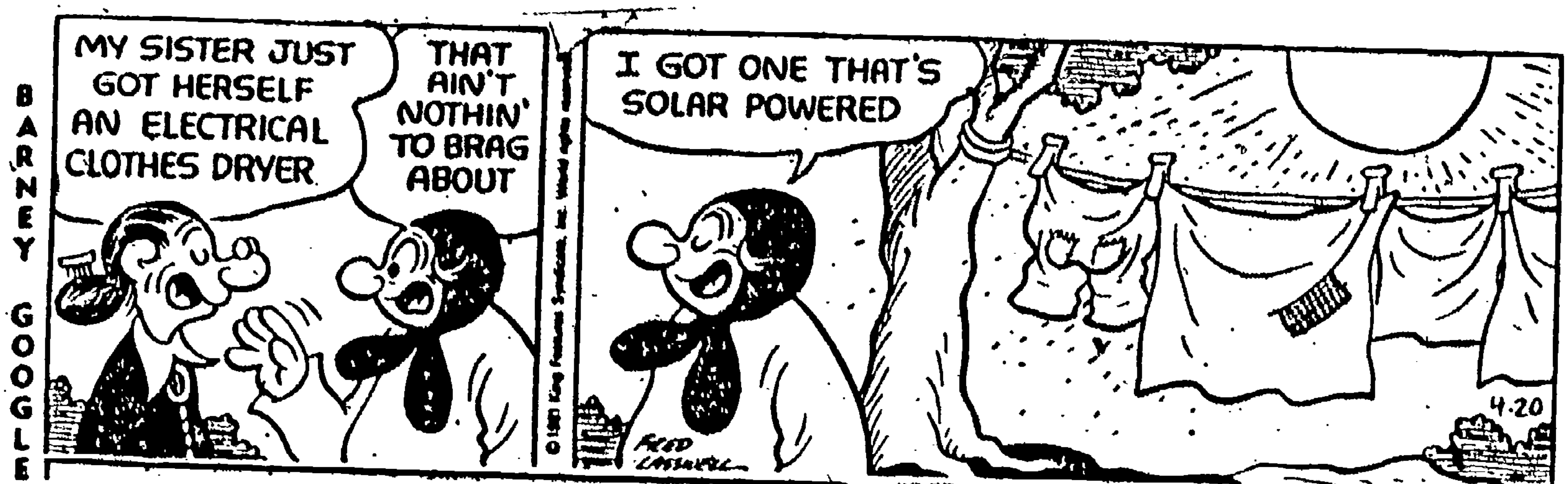
A Land Grab



38 THE NASHVILLE BANNER, Friday, Jan. 30, 1981

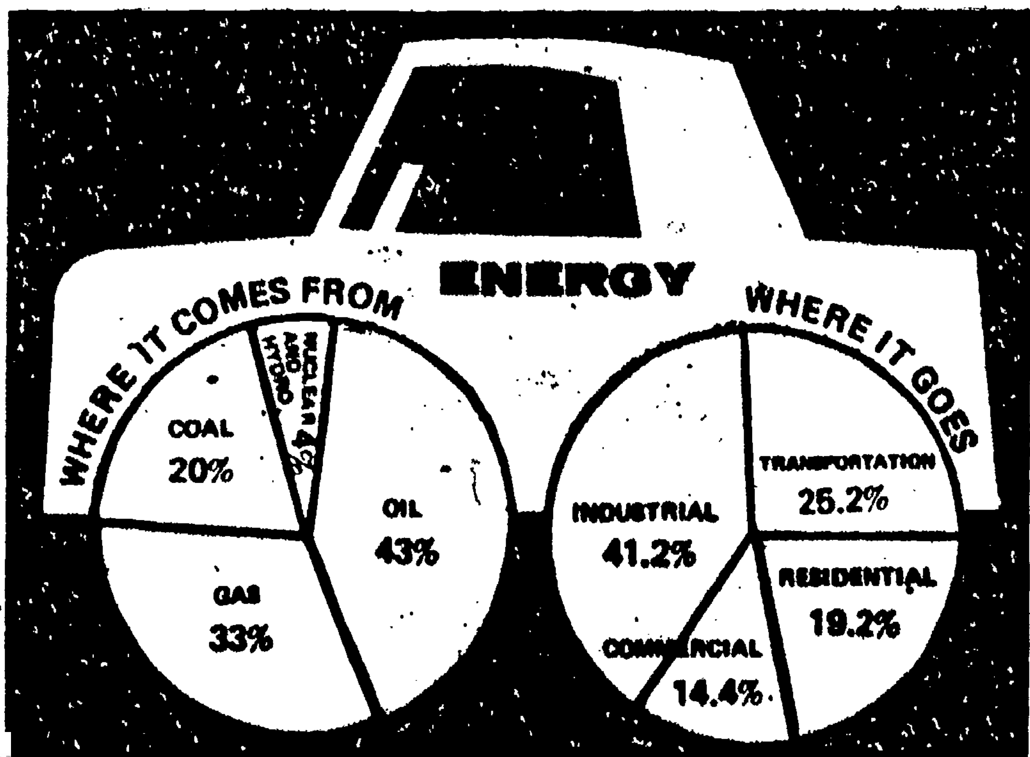


"It's the kind of day that makes you wish you had a solar heating system on the house."



ENERGY BULLETIN BOARD IDEAS

Snoopy's "SavEnergy" slogan is the new symbol for the Government's national energy conservation campaign. Use Snoopy or our mini car with its pie graph wheels depicting energy sources and energy uses on your bulletin board to start a Save Energy campaign among students.



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THE EARTH

Love it or love it.

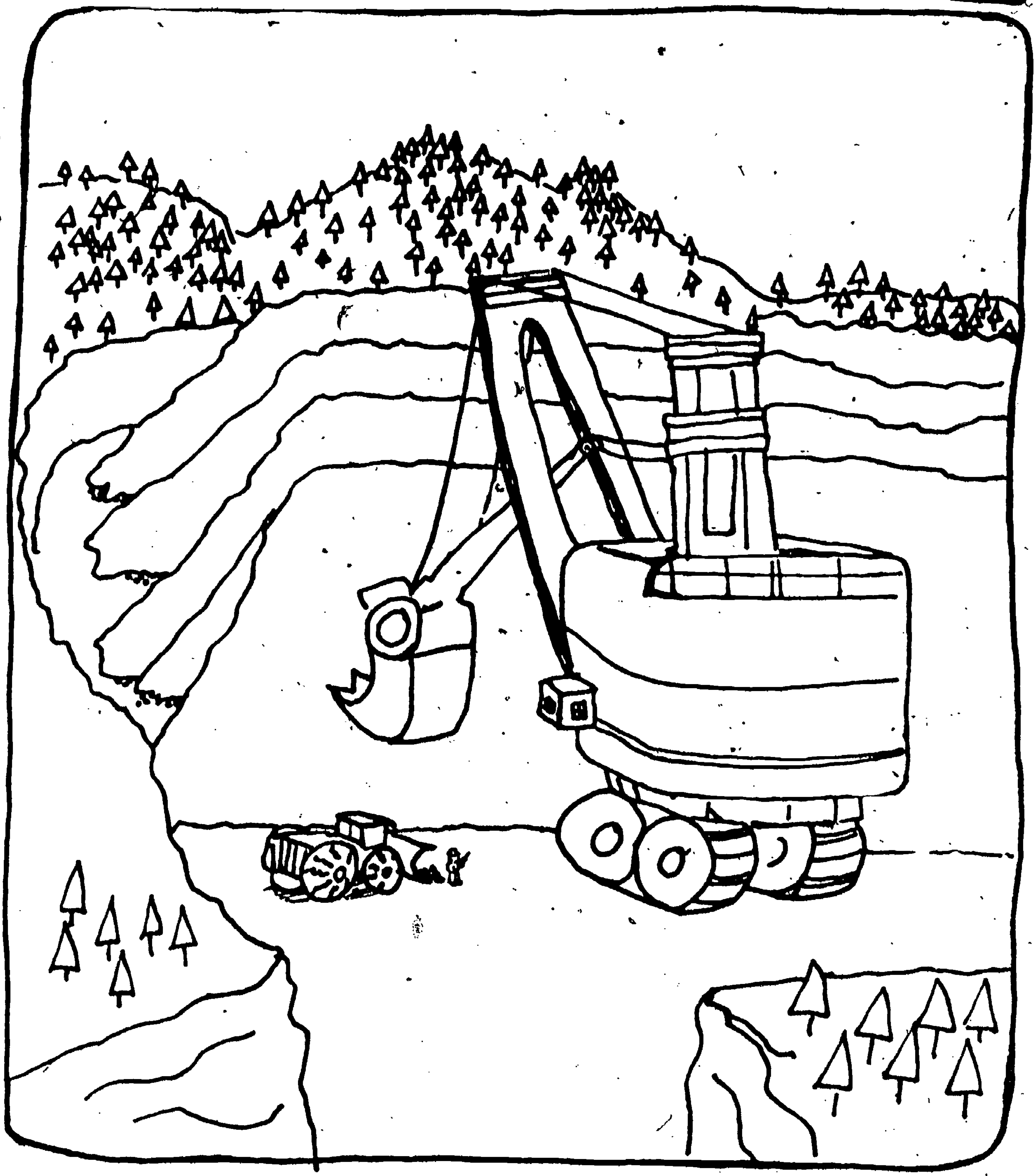
ANNOUNCING!

THE BATTLE OF THE CENTURY!

ENERGY NEEDS VS. ENVIRONMENT

Background and Play by Play:

COAL MINE



COAL: MINING, TRANSPORTATION, SAFETY

I. How is coal mined?

A. Surface mining
1. Area mining
2. Contour mining

B. Underground mining
1. Types
a. Shaft mines
b. Slope mines
c. Drift mines

2. Systems of underground mining
a. Room-and-Pillow System
b. The Longwall System

C. Breaking down the coal

1. Undercutting
2. Cracking the coal wall
3. Continuous coal mining machines
4. Push-button mining

D. Processing the coal

1. Hauling the coal out of the mine
2. Sizing the coal
3. Cleaning and grading the coal

II. How is coal transported?

A. Shipping
1. Railroad
2. Barge
3. Trucks

B. Storing

III. Mine safety measures

A. The Miner's Clothing

B. Protection against gases, coal dust explosions, and other hazards

C. Draining the mine

D. Safety education

E. Government regulation

Goal:

Students will gain an understanding of how coal is mined, transported, and regulated by the government.

Objectives:

Upon completion of the reading and activities and when asked to diagram, demonstrate, or respond either orally or on a written test, students will:

1. name and distinguish between the two general methods used to mine coal.
2. describe the two methods used by strip miners in removing coal from the earth.
3. explain how strip miners reclaim the land.
4. name and describe or sketch the three groups of mines used in underground mining.
5. describe the two main systems of underground mining.
6. tell what type of machinery is used in removing coal from the earth.
7. describe the type of clothing worn by miners.
8. explain how the coal is processed after it is removed from the earth.
9. tell how the coal is transported from the mine.
10. tell what countries and states produce and mine coal.
11. point out some of the problems involved in coal mining.

COMPREHENSION QUESTIONS

1. What are the chief types of coal mines, and how do they differ?
2. On what bases are strip mines classified?
3. On what bases are underground mines divided into three main groups?
4. Describe the two main systems of underground mining.
5. Name and give the function of the types of underground mining equipment.
6. Explain how impurities are removed from coal.
7. What is the principal means of transporting coal in the United States?
8. What are the chief safety precautions which must be taken in coal mines?
9. Explain how strip-mined land is reclaimed.
10. List and explain the most important state and federal laws governing the mining industry.
11. What are the four largest coal mining countries of the world?
12. What are the ten leading coal producing states in the United States?
13. How much coal is mined each year in the United States?
14. How long may the coal resources of the United States be expected to last?
15. What are some of the research developments of the coal industry?

INVESTIGATIONS

1. Conduct a field trip to a strip mine or deep mine.

2. Have students research such topics as:

   Coal Products
   Black Lung Disease
   Coal Minning Methods
   How Coal Helps to Make Electricity
   Different Kinds of Coal
   How Coal is Used
   How Coal Pollutes
   Conservation of Coal

3. Have students prepare a bulletin board containing pictures and information about coal.

4. Have students collect newspaper clippings on current developments about coal.

5. Invite resource people

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BACKGROUND INFORMATION

and

ACTIVITIES

HOW COAL IS MINED

There are basically two types of coal mines, strip or surface mines and underground or deep mines. The type of mine depends primarily upon the relationship of the coal bed to the surface. Strip mining can be carried on to a depth of 100 to 200 feet. When the coal seams lie deeper than 200 feet beneath the surface or when they run deep into the earth from an outcrop on a hillside, underground mining is conducted.

Most strip mines follow the same basic steps to produce coal. Miners operating giant power shovels strip away the earth and rock, or overburden, that lies above the coal. Then blasters, using special explosives may break the coal seam into small pieces. Finally, smaller shovels scoop up the coal and load it onto trucks which haul it away from the mine.

Although most strip mines follow the same basic steps, strip-mining methods vary according to whether the land is flat or hilly. Strip mining can thus be classed as either area mining or contour mining. Area mining is practiced where the land is relatively level. Contour mining is practiced in hilly or mountainous country. It involves mining on the contour--that is, around slopes.

Once the coal has been removed from the ground, the land is reclaimed. Sometimes old strip mines become farms, recreation areas, pastures, residential areas, or shopping centers.

Underground Mining: Depending upon the way in which the coal seam is approached, underground mines are either drift, slope, or

shaft mines. Each type of mine is best suited to removing the coal from a particular type of coal bed. In a shaft mine, the entrance and exit passages are vertical. In a slope mine, they are dug on a slant. In a drift mine, the passages are dug into the side of a coal bed exposed on a slope.

Two main systems of underground mining are used: the room-and-pillow system and the longwall system. Each system has its own set of mining techniques. Either system may be used in a shaft, slope, or drift mine. The room-and-pillar system is more common in the United States because the coal seams, especially bituminous seams, are of unusual thickness. The longwall method is used in European mines.

In the room-and-pillow system, pillars of coal are left standing to provide support to the roof or overburden of the rooms from which the coal has been removed. After the mine face has been advanced as far as planned, the miners work backward, or retreat, withdrawing the standing sections, which are called pillars, and allowing the roof to collapse behind them.

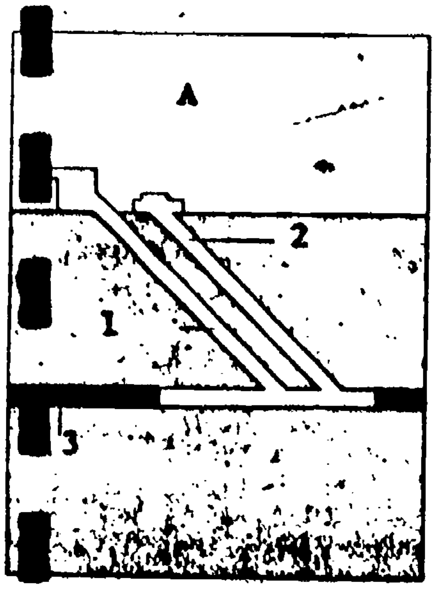
In the longwall system, almost all of the coal is removed from the working surface or face, and the area that has been mined is filled in mechanically with rock or sand.

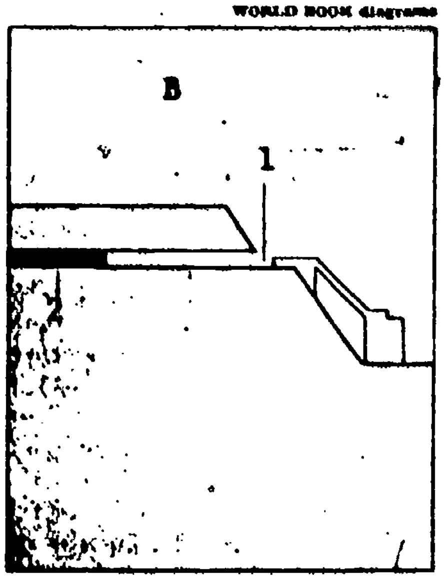
ACTIVITY

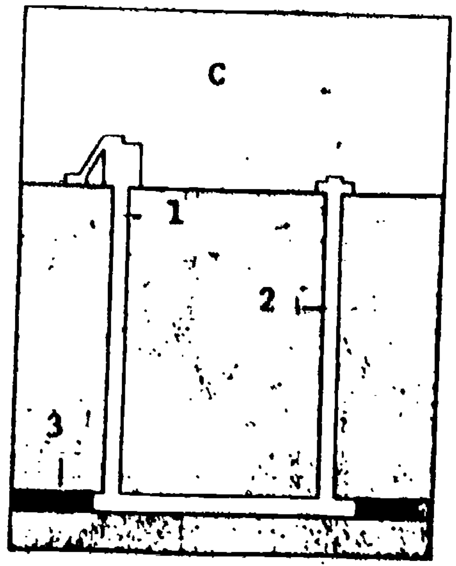
Label the following kinds of mines as drift, shaft, or slope.

Label the indicated part of each mine.

WORLD BOOK diagrams







Kinds of Underground Mines:

Mine A. ______________

Parts:

1. ______________
2. ______________
3. ______________

Mine B. ______________

Parts:

1. ______________
2. ______________

Mine C. ______________

Parts:

1. ______________
2. ______________
3. ______________

Breaking Down the Coal. There are many methods of breaking coal from the mine face in lumps suitable for hauling to the surface of the mine. A few are listed below.

1. Undercutting- The process of cutting out the mine face at the bottom of the coal bed so the coal can be shattered more easily by explosives.

2. Cracking the Coal Wall- the process of drilling shot holes at intervals along the face of the coal bed. Explosives are inserted in these holes and when set off, cracks the coal wall into pieces.

3. Continuous Coal-Mining Machines- A machine that can cut the coal loose and load it in one operation.

4. Push-button miner- A miner with electronic remote controls can send a boring-type mining machine 1,000 feet under the ground while he (the operator) stays on the surface.

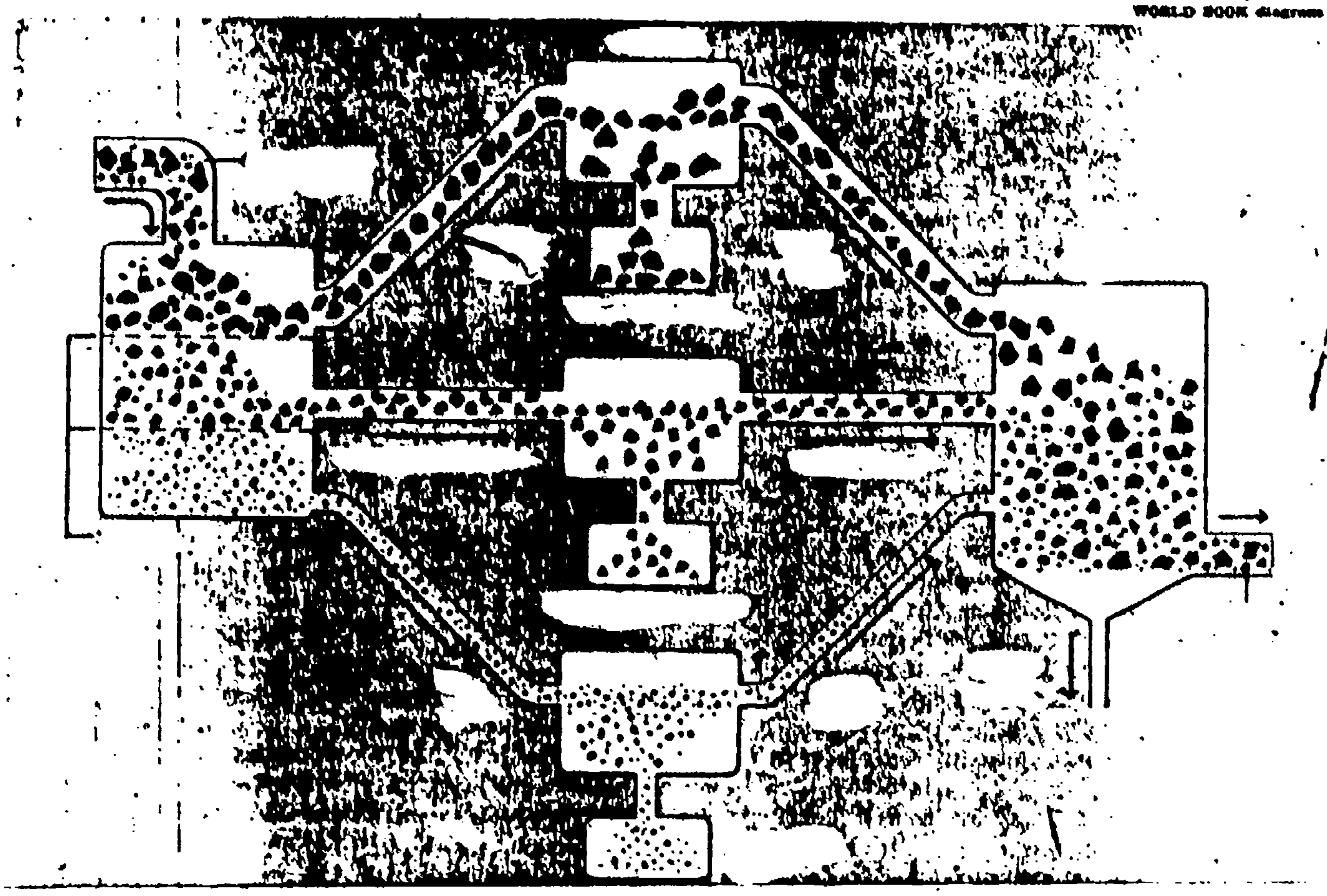
Processing the Coal. As the coal is mined, tracks are laid in the main haulageway. Cars loaded with coal are pulled over these tracks by small but very powerful electric locomotives. An increasing number of mines use conveyor belts or shuttle cars to carry the coal to the surface to be cleaned before it is shipped to buyers.

Mining companies clean coal in specially designed preparation plants. The plants use a variety of machines and other equipment to remove the impurities from coal.

The raw coal is sorted initially in the plant by a tilted vibrating screen that has sections with different sized holes through which the coal falls. More sorting according to size and grade occurs during subsequent cleaning and separating operations. Each batch of sorted coal is piped into a separate washing device, where it is mixed with water. The devices separate the impurities by means of specific gravity. The heaviest pieces, those containing the largest amounts of

ACTIVITY

Name the steps in the processing of coal by labeling the diagram.



Explain what is happening in each of the major compartments as the coal passes through.

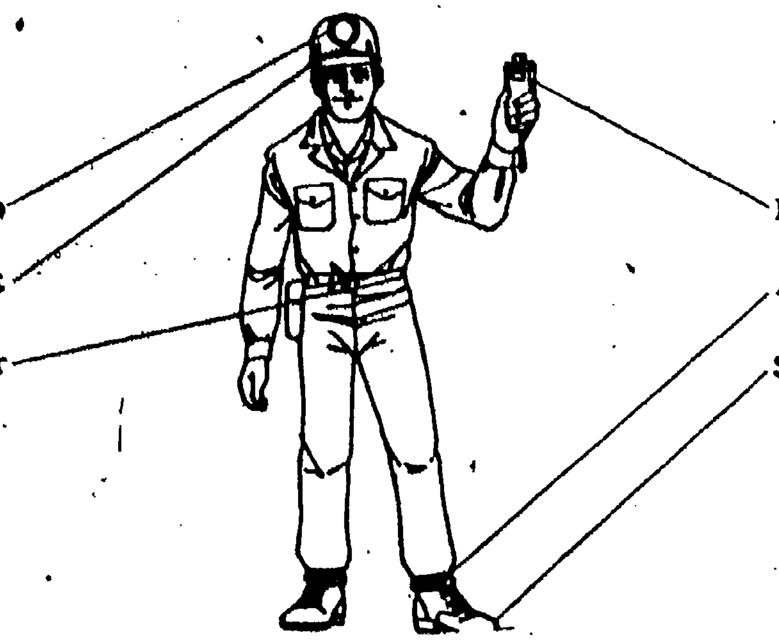
impurities, drop into a refuse bin. Washing removes much of the ash from the coal, but the organic sulfur is so closely bound to the carbon that only small amounts can be removed.

The washing leaves the coal dripping wet. If this excess moisture is not removed, the heating value of the coal will be greatly reduced. Preparation plants use various devices, such as a vibrator or hot-air blower, to dry coal after it is washed.

In its natural state, coal is classified by rank, which depends on its carbon and ash content, the amount of volatile, or gassy, matter and moisture it contains and its heat value. As sold in the market, coal is classified by grade, which depends on its rank and such other characteristics as the size of the lumps and on special treatment which the coal has received. The grade of coal is important to customers, for it means that the coal will meet certain standards.

MINE SAFETY MEASURES

MINER"S CLOTHING:



For their safety, miners must wear special clothing. Heavy-duty overalls, heavy steel-tipped shoes and hard hats make up the bulk of their gear. To keep the pant legs from getting caught in any machinery, straps are worn around the legs of the overalls. A battery-powered lamp is worn on the hat. The battery is attached to the belt and a cord runs from the battery to the lamp. A self-rescuer is also strapped to the belt. It provides air for a miner in case of air contamination or loss.

Precautions must be taken in mines to detect and control methane gas, which is highly explosive. Mines are required to test the methane level with an electrical methane-detecting device. Methane can be cleared out of mines with huge ventilating systems. These systems are used to eliminate other gases also.

ACTIVITY

Draw an arrow to show where each piece of the miner's equipment is located.

steel tipped boots

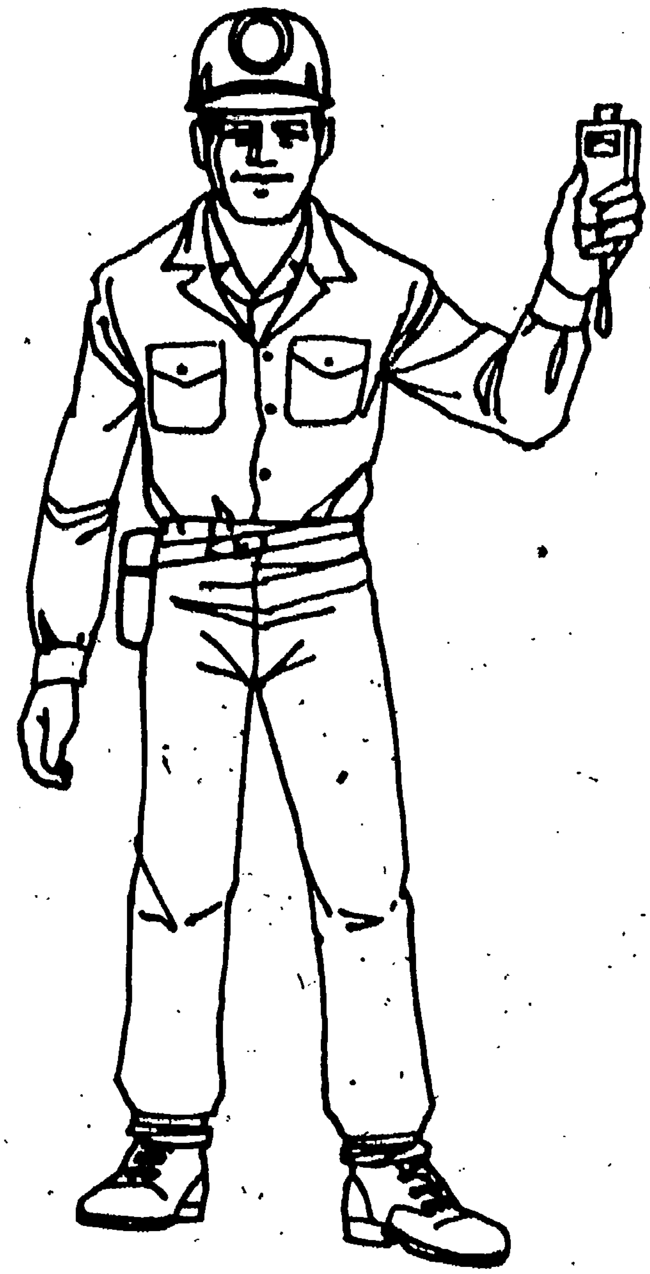
self-rescuer

methane monitor

ankle straps

hard hat

lamp



Match the words on the left with the proper explanation on the right.

lamp	checks air quality in the mine
self-rescuer	allows miner to see better underground.
steel tipped boots	protects miner from dropped hand tools
methane monitor	prevents clothing from being caught in machines
hard hat	provides fresh air in case of an emergency
ankle straps	protects miner from falling rocks

HOW COAL IS TRANSPORTED

Most coal shipments within a country are carried by rail, barge, or truck. In many cases, a particular shipment must travel by two or all three of these means to reach the buyer.

Special trains called unit trains take coal directly from the mine to users, with no stops in between. Unit trains help speed long-distance shipments.

Barges provide the cheapest way of shipping coal within a country, but they can operate only between river or coastal ports. Trucks are the least costly means of moving small shipments of coal short distances by land.

An underground pipeline is used in some cases to carry coal from a mine to a power plant. The coal is crushed and mixed with water to form a slurry (soupy substance) that can be pumped through the pipeline. In some cases, however, pipelines are more costly and less efficient than the traditional methods of shipping coal.

Storing. Most large consumers of coal try to keep a supply of coal on hand which will last several months beyond their immediate requirements. Sometimes coal is stored in the open, and sometimes in bins. Anthracite and bituminous coal may be kept for long periods of time without losing their heating or power values. Subbituminous coal must be stored or piled carefully to protect it from weather, and lignite cannot be stored long because it dries out.

Proper ventilation removes much of the coal dust from the air in the mine. This dust can cause a disease of the lungs or an explosion. To further prevent or control dust, federal law requires that underground mines be reckdusted. In this process, the miners spray powered limestone on all exposed surfaces in the mine entries. The limestone dilutes the coal dust and so lessens the chance of an explosion. Mines use water sprays to hold down the dust along a face that is being mined.

Mines that are located below surface or under subterranean streams are flooded with large quantities of water which must be pumped out constantly. When this water is pumped from the mine, it may pollute nearby streams and water supplies. The United States Bureau of Mines conducts a research program to solve this problem.

Coal mining today is safer than ever before. Some of the improvements have resulted from the development of improved safety devices, but safety education has also played an important part. Safety directors meet regularly with employee groups, posters are placed at various locations about the mine to warn the workers, and associations aid in safety work and instruction of miners.

The United States Bureau of Mines founded in 1910 and the Federal Coal Mine Health and Safety Act of 1969, regulate the safety standards of mines.

STUDY QUESTIONS OR QUIZ

A. VOCABULARY: Define, then write a sentence in which you use correctly each of the following words or terms.

strip mining	drift mine
underground mining	slope mine
overburden	slurry
spoils	reclaim
shaft mine	run-of-mine

B. TRUE or FALSE: Determine whether each of the following sentences is true or false.

1. Anthracite, bituminous, and lignite may be kept for long periods of time without losing their heating or power values.
2. Underground mining require more miners than does surface mining.
3. Mine work requires little or no education.
4. The United States is the world's leading coal exporter.
5. Strip mines produce about 60 per cent of the coal mined in the United States.
6. All industries are likely to be seriously affected if anything interrupts the steady flow of coal from the mines.
7. Both strip and underground mining are done with the same tools.
8. For every ton of coal dug, about 10 tons of water are pumped out of a mine.
9. Coal is shipped in pipelines in a soupy mixture called slurry.
10. West Virginia, Kentucky, and Pennsylvania supply about 60 per cent of the bituminous coal in the country.

C. MULTIPLE CHOICE: Choose one word or phrase that correctly completes each of the following sentences.

1. Miners usually use (shaft, strip, underground) mining when the coal beds lie close to the surface of the earth.

2. The law requires mine owners in the United States to (reclaim, save, ignite) all the land they use for strip mining.

3. As of 1976, the leading coal mining country was (the United States, Russia, China).

4. In (shaft, slope, drift) mines, the entrance and exist passages are vertical.

5. In its natural state (mines, coal, safety equipment) is classified by rank.

6. Underground coal mines contain coal deposits (100, 200, 300) feet within the earth's surface.

7. The layer of earth and rock that covers the coal seam is called (a shaft, a slope, the overburden).

8. Coal is generally shipped long distances by (train, trucks, barge).

9. (Shaft, Strip, Slope) mining is fast and efficient.

10. The (longwall, room-and-pillar, shaft) system is used in most of the underground mines of the United States.

D. HOW and WHY:

1. What are the chief safety precautions which must be taken in mining coal?

2. Explain how impurities are removed from coal.

3. What are some of the major problems of the coal industry?

4. What are some of the job opportunities available in the mining industry?

5. What are some of the research developments of the coal industry?

ADDITIONAL ACTIVITIES

COAL FACTS: COSTS AND BENEFITS

Overview

Coal could be one of the major sources of short term increases in the supply of energy. Even under the most conservative estimates, the U.S. has enough economically recoverable coal to last well into the twenty-first century. However, the environmental, economic and social costs of coal production are high. The students examine the costs and benefits involved in various policies concerning the changes in the present production of coal.

Concepts

Costs & Benefits
Policy

Major Understanding

The supply of energy can be increased in the short run in the United States by developing and increasing the use of coal, but this will involve investment and tradeoffs.

Student Objectives

The students should be able to:

1. Evaluate some of the costs and benefits of increased coal production.
2. Develop and evaluate a policy position on the development of coal reserves.

Time Allotment

One-two class periods

Materials

"The Coal Facts"

"Coal: The Costs and Benefits"

"The President's Cabinet"

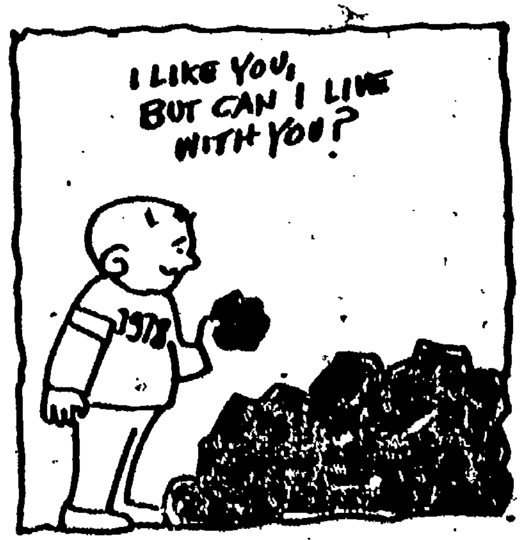
Procedures	Commentary
ACTIVITY 1	
Introduce the students to the idea of costs and benefits.	
Remind the students of the shortage exercise in Lesson 1. Oil could not be delivered. Assume that the community decides to close down the schools.	

Top Ten Owners of Coal Reserves in U.S. (1975)

1. Continental Oil
2. Burlington Northern
3. Union Pacific
4. Peabody Coal
5. Exxon (Carter Oil)
6. AMAX (20.6% Standard Oil of California)
7. North American Coal
8. Occidental Petroleum
9. U.S. Steel
10. Kerr McGee

The U.S. has over 390 billion tons of coal recoverable at today's prices. This coal may contain more than 5 times the energy in Middle Eastern Oil Reserves.

Developing coal takes both time and money. Opening a surface mine takes 3 to 5 years. Underground mines may take 5-7 years to develop. It costs 20-30 million dollars to open a new surface mine; 40-60 million dollars for a new deep mine.



Top Ten Coal Companies in U.S. (1974)	
1.	Peabody Coal Co.
2.	Consolidated Coal Co.
3.	Island Creek Coal Co.
4.	Amax Coal Co.
5.	The Pittston Co.
6.	The U.S. Steel Corp.
7.	Arch Mineral Corp.
8.	Bethlehem Mines Corp.
9.	N. American Coal Corp.
10.	Peter Kewit Sons Mining Division

Miners make between $14,000 and $20,000 a year.

Number of Mine Workers in the United States (1976)	
Underground Miners	123,000
Strip Miners	44,000
Related jobs in the mines	17,000
TOTAL	184,000

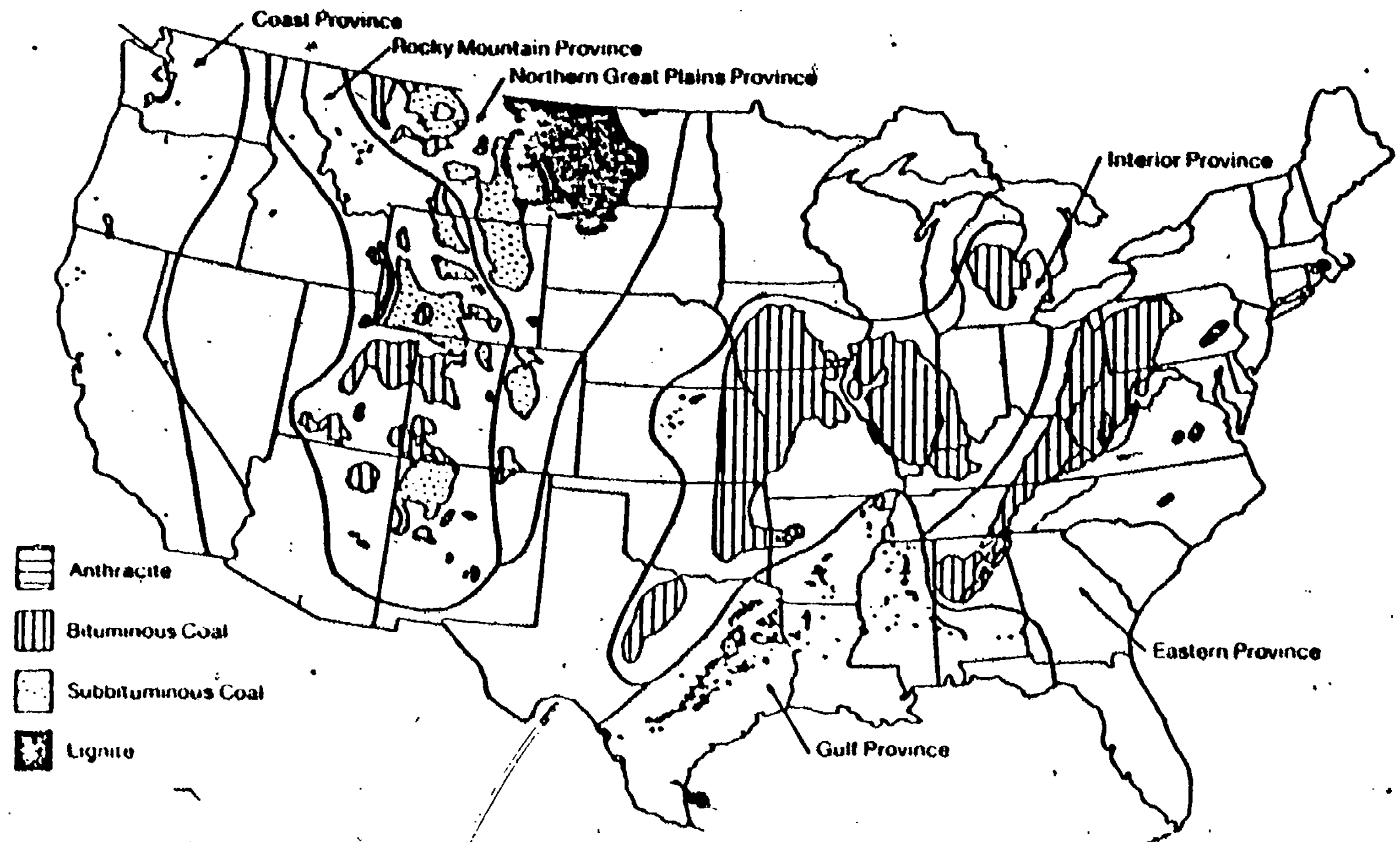
Jobs Needed to Produce Coal

miners	*power shovel operators*
drill operators	*roof bolter operators*
cutting machine operators	*tipple machinery operators*
locomotive operators	*carpenters*
loading machine operators	*construction workers*
electricians	*explosives handlers*
lubricating specialists	*machine-tool operators*
masons	*mechanics*
pipefitters	*plumbers*
repairmen	*truck & tractor mechanics*

Heat and pressure applied in the right way can convert a 4 pound piece of coal into about 1 quart of synthetic crude oil or about 32 cubic feet of synthetic gas. These are very expensive products.

47% of the electricity used in the U.S. comes from coal.

Distribution of United States Coal Resources



Source Bureau of Land Management Draft Environmental Impact Statement Proposed Federal Coal Leasing Program (1974)

The burning of coal can produce sulfur and nitrogen oxides, soot, and ash. Depending on the type of coal that is burned, these pollutants can produce mild or severe damage to the environment and to people.

Surface Mining can hurt the natural environment. As the coal is stripped away, so is much of the topsoil. Laws requiring reclamation of land do help. This is not always possible. Large amounts of water are needed and water is often in short supply. Reclamation adds to the cost of coal production.

Underground mining is a dirty and sometimes dangerous job. There are more job related accidents in coal mining than any other industry in the U.S.

The use of strip mining as a means of getting at coal is increasing. In 1960, 25% of the coal was strip mined. By 1970, about half of the coal was strip mined.

Number of Mine Workers in the United States (1976)	
Underground Miners	123,000
Strip Miners	44,000
Related jobs in the mines	17,000
TOTAL	184,000

The following products come from coal:

steel	*nylon*	*plastic*
perfume	*aluminum*	*paint*
dye	*aspirin*	*detergent*
insecticide		*motor fuel*
drugs	*rubber*	*food preservatives*

Heat and pressure applied in the right way can convert a 4 pound piece of coal into about 1 quart of synthetic crude oil or about 32 cubic feet of synthetic gas. These are very expensive products.

Jobs Needed to Produce Coal

miners
drill operators
cutting machine operators
locomotive operators
loading machine operators
electricians
lubricating specialists
masons
pipefitters
repairmen
power shovel operators
roof bolter operators
tipple machinery operators
carpenters
construction workers
explosives handlers
machine-tool operators
mechanics
plumbers
truck & tractor mechanics

47% of the electricity used in the U.S. comes from coal.

LEADING COAL-MINING STATES

Tons of Coal Mined in 1969

West Virginia
141,000,000 tons

Kentucky
109,100,000 tons

Pennsylvania
89,100,000 tons

Illinois
64,700,000 tons

Ohio
51,200,. 000 tons

Virginia
35,6000,000 tons

Indiana
20,100,000 tons

Alabama
17,500,000 tons

Tennessee
8,100,000 tons

Colorado
5,500,000 tons

LEADING COAL-MINING COUNTRIES

Tons of coal mined in 1969

Russia
670,204,000 tons

United States
570,978,000 tons

China
364,000,000 tons

Germany (East)
274,476,000 tons

Germany (West)
242,307,000 tons

Poland
181,971,000 tons

Great Britain
168,621,000 tons

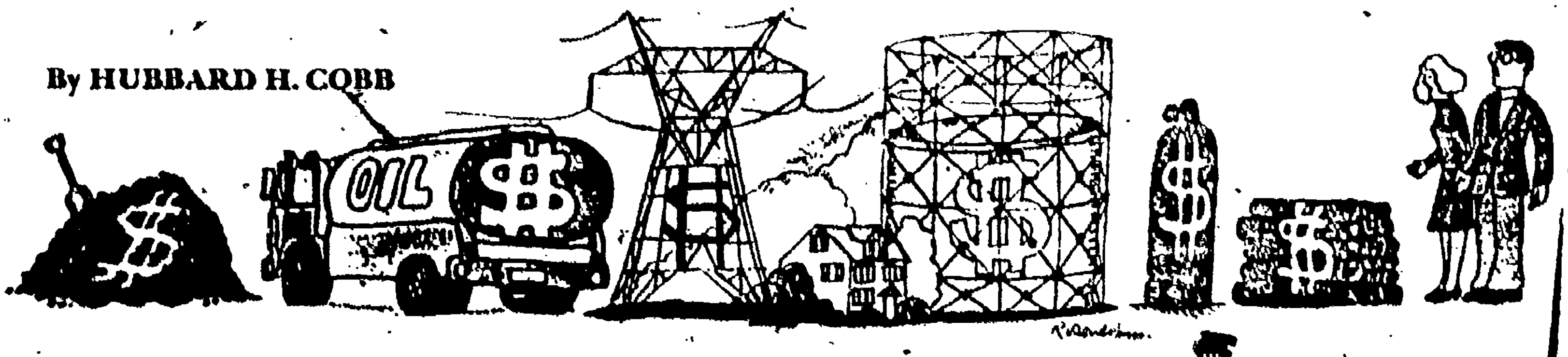
Czechoslovakia
117,442,000 tons

India
85,247,000 tons

Australia
76,453,000 tons

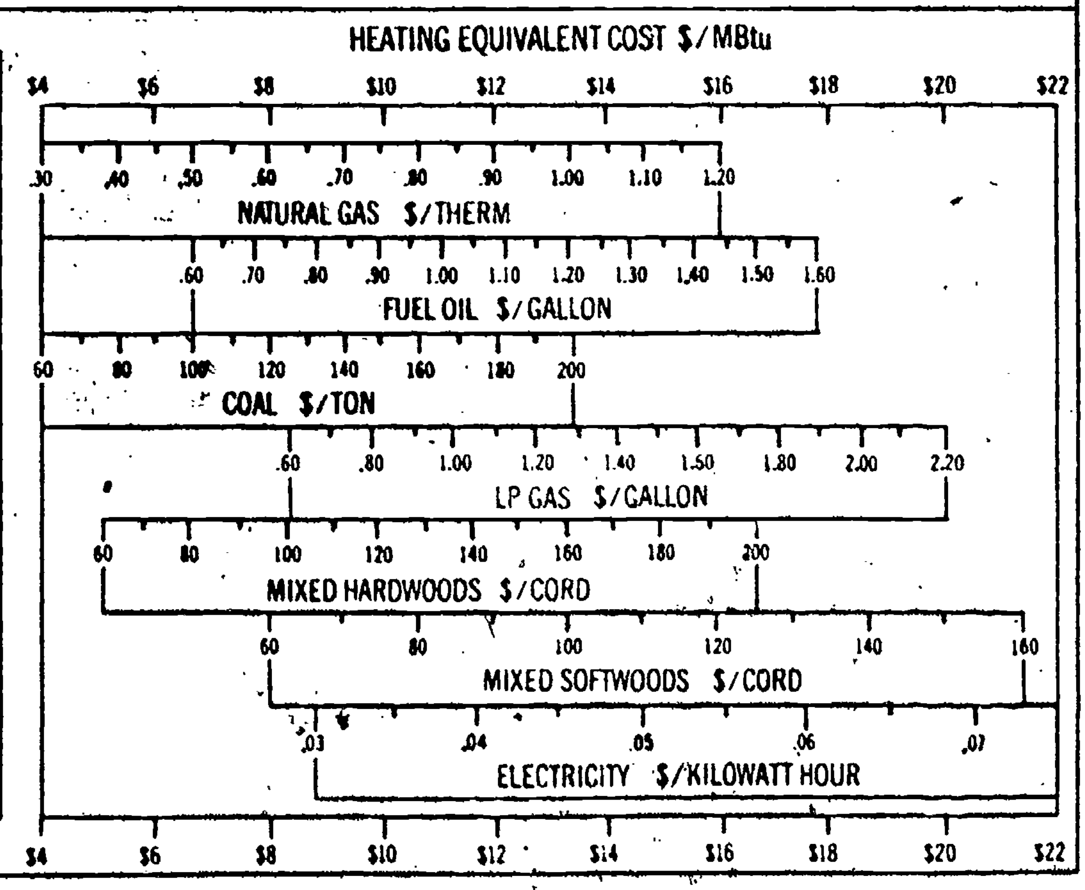
(From the World Book Encyclopedia)

By HUBBARD H. COBB



The Cheapest Way to Heat Your House

FUEL COST COMPARISON



ASSUMPTIONS:

Natural Gas – Therm = 100,000 Btu = 100 cu ft
75% Efficiency
\$/MBtu = 13.33 x \$/therm

Fuel Oil – 138,000 Btu/gallon
65% Efficiency
\$/MBtu = 11.15 x \$/gallon

LP Gas – 93,000 Btu/gallon
75% Efficiency
\$/Btu = 14.34 x \$/gallon

Electricity – 3,412 Btu/kwh
(Resistance) 100% Efficiency
\$/MBtu = 293 x \$/kwh

Mixed Hardwoods – 24 Btu/cord
50% Efficiency
\$/MBtu = \$/cord ÷ 12

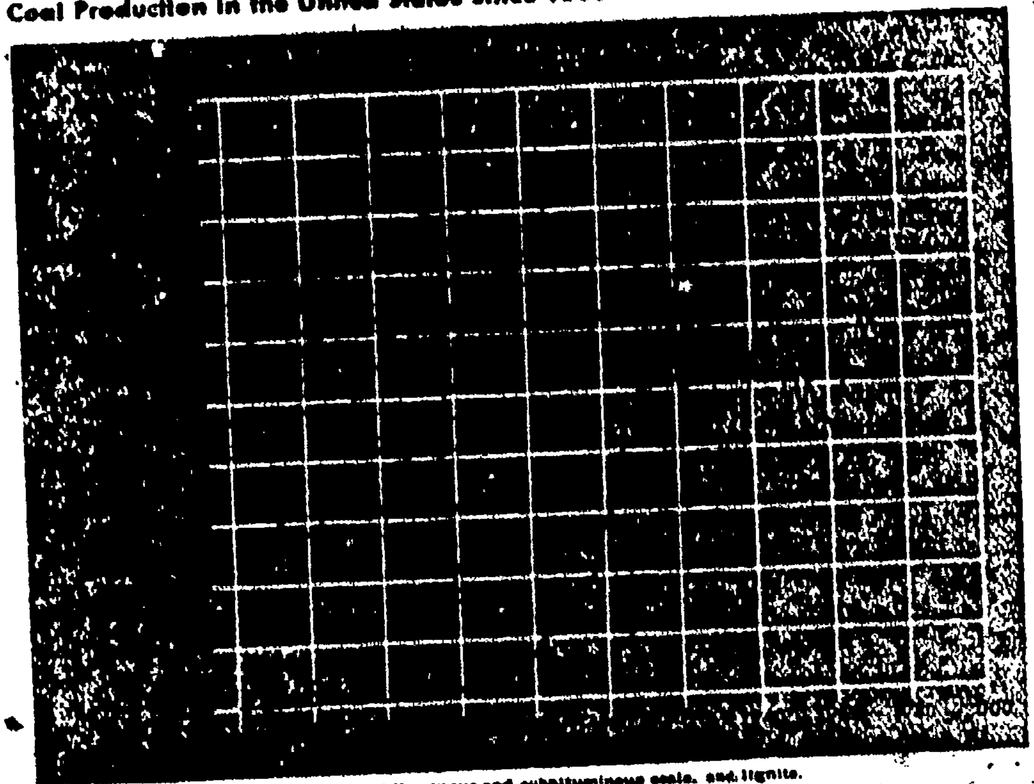
Mixed Softwoods – 15 MBtu/cord
50% Efficiency
\$/MBtu = \$/cord ÷ 7.5

Coal – 12,500 Btu/lb
60% Efficiency
\$/MBtu = \$/ton ÷ 15

WOMAN'S DAY 10/14/80

COAL FACTS

Coal Production in the United States Since 1800*



Year	Short tons	Metric tons
1800	108,000	97,980
1810	178,000	161,500
1820	334,000	303,000
1830	881,000	799,200
1840	2,474,000	2,244,400
1850	8,356,000	7,580,400
1860	20,041,000	18,180,900
1870	40,429,000	36,676,600
1880	79,407,000	72,036,800
1890	157,771,000	143,127,400
1900	269,684,000	244,653,200
1910	501,596,000	455,040,200
1920	658,265,000	597,167,900
1930	536,911,000	487,077,400
1940	512,256,000	464,710,800
1950	560,388,000	508,375,400
1960	434,330,000	394,017,500
1970	612,661,000	555,796,700
1976	684,913,000	621,342,600

*Includes all types of coal—anthracite, bituminous and subbituminous coals, and lignite.
Source: U.S. Department of Energy.

COAL: THE COSTS AND BENEFITS

The United States must make some major decisions about energy for the near future. Many experts point out that the demand for energy is growing faster than the supply of energy. This scarcity of energy will create serious problems.

Assume that you are an advisor to the President. The President wants to know if the nation should increase its production of coal.

To make a good decision, the President must know what are some of the benefits and some of the costs of increased coal production.

Examine the data on the Coal Facts sheet.

List five costs and five benefits of coal production. Remember that costs and benefits include not only money but also changes in the number of jobs, foreign relations, working and living conditions.

<u>Benefits of increased coal production</u>

1.

2.

3.

4.

5.

<u>Costs of increased coal production</u>

1.

2.

3.

4.

5.

Look back at the costs and benfits that you have listed.

Put a star before the most serious cost and the most important benefit.

On what basis did you make that decision?

— Coal and Natural Gas Supply Lifetimes

Students apply the graph methods of analysis employed in determining the lifetime of United States supplies of oil to determine the lifetimes of two other fossil fuels: natural gas and coal.

1. Relate oil to other fossil fuels.

Begin with a discussion of why oil is called a fossil fuel.

"Are there other fossil fuels, those materials formed thousands of years ago by the decay of plants and animals and the pressure of subsequent layers of rock and earth, which release their stored energy when burned?"

Identify natural gas and coal as the other fossil fuels.

2. Organize student investigation of lifetimes of other fossil fuels.

"Are the United States supplies of natural gas and coal also running out? Will we have enough of these fuels to meet future demand? Let's find out."

- Divide the class into three groups. Assign two groups the task of determining estimates of the lifetime of our supplies of natural gas and one group the task for coal. One of the two groups for natural gas will examine future supplies with a future consumption rate equal to the rate for 1970-1974, the other will study the supply lifetime with a more realistic consumption rate.

  Note: The lifetime estimates for coal greatly exceed those for oil and natural gas. The demand for coal has not increased in the past 30 years due to the increased use of the oil and natural gas alternatives. Thus, an increasing consumption situation has not been presented, since projections so far into the future might be misleading.

  Distribute copies of the task sheets and graphs (enclosed) to each student in these respective groups. Answer sheets are also enclosed.

  Allow approximately one period for students to complete the tasks specified on the sheets. Circulate through the classroom to determine if students are able to proceed through the tasks by examining their responses to tasks 1-3. These tasks cover the more elementary graph interpretation skills. An answer sheet is enclosed.

  The long lifetimes for coal may require students to attach additional sheets to their graphs, if the same graph procedures are employed. An alternative arithmetic method is suggested on the task sheet for the constant consumption projection.

— Fossil Fuel Lifetimes

The objectives of this day's activities are to summarize the results of the students' investigations of the lifetimes of natural gas, coal, and oil and draw conclusions concerning the finite nature of our fossil fuel resources as well as the likelihood of future shortages.

1. Record summary statement of fossil fuel lifetimes on a chart. Construct on the blackboard a table similar to the following:

United States Oil Supplies

Future Consumption	1. Low Estimate (reserves) 52 billion barrels	2. High Estimate (ultimately recoverable) 602 billion barrels
A. Constant (does not increase)		
B. Increases (as in past 30 years)		

United States Natural Gas Supplies

Future Consumption	1. Low Estimate (reserves) 290 trillion cubic feet	2. High Estimate (ultimately recoverable) 2,390 trillion cubic feet
A. Constant (does not increase)		
B. Increases (as in past 30 years)		

United States Coal Supplies

Future Consumption	1. Low Estimate (reserves) 150 billion tons	2. High Estimate (ultimately recoverable) 1,500 billion tons
Same as in past 25 years		

Ask students to fill in the lifetime determined for each situation and the span of years in which the supply will be totally consumed.

The answers are:

	1.	2.
Oil A	5-10 years, 1980-1984	90 years, 2060-2064
Oil B	5-10 years, 1980-1984	40 years, 2010-2014
Gas A	10-15 years, 1985-1989	110 years, 2080-2085
Gas B	10-15 years, 1985-1989	65-70 years, 2040-2045
Coal	375-400 years, 2350-2374	4,000 years, 5950-5975

(Technical Note: The estimates of fossil fuel supplies were obtained, with one exception, from the U.S. Geological Survey — see NSTA *Energy-Environment Source Book*, Chapter 2, Volume 2. The estimate of coal reserves, 150 billion tons, was obtained from the "U.S. Energy Outlook, A Summary Report of the National Petroleum Council," December 1972. A higher estimate, 390 billion tons, is given by the U.S. Geological Survey. The lower number was chosen to facilitate the students' graph analysis.)

2. Discuss with students the implications of this summary:
   - ☐ Note that although it is realistic to assume that the demand for fossil fuels is likely to increase, the lifetimes for oil and natural gas are still short even *when it is assumed that demand will not increase*.
   - ☐ Compare the lifetimes of the fossil fuels with the lifetimes of the students. Are the expected lifetimes of the fuels longer or shorter than the students? If demand will exceed future supplies, what is the likelihood of future shortages of the fossil fuels?
   - ☐ You might also discuss the implications of the differences in the lifetimes estimated for *reserves* versus those for *ultimately recoverable* supplies. Ask students to recall the differences between these two types of estimates. If new, more costly methods of mining and recovery need to be developed to extract oil and gas from new types of wells, will the price of these fuels increase? Is more exploration required?

   (One aspect of the future supply-and-demand situation for fossil fuels that has been purposefully overlooked in this mini-unit is the effect of imports. Our domestic supplies for oil, even in the past 30 years, have not met domestic demand, since our production capability, i.e., drilling and refining activity, falls short of demand. Thus, today we import close to 50 percent of the crude oil that we consume. Our imports are expected to increase in the future as it becomes more costly to extract our domestic supplies. These facts may be brought into a more general discussion outlined below.)

3. As a concluding discussion, explore with the students the possible consequences of oil and gas shortages.

   "Are there other alternatives to fossil fuels? Can coal be employed to replace oil and gas? How will shortages of gas and oil affect consumption of coal? Do other nations have enough supplies of oil and gas for themselves as well as for us?" (It is often noted that the United States has 6 percent of the world's population but consumes 25 percent of the world's energy.)

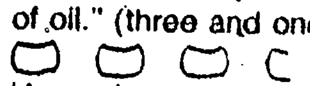
   Several of these points are examined in other mini-units.

Evaluation Suggestions

1. To evaluate student understanding of the concepts of supply, demand, and shortage and their ability to apply them, employ questions of the following type:

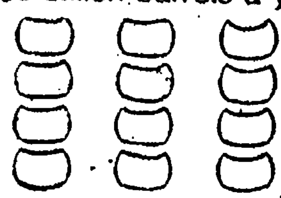
   "A soda machine at a beach contains 100 cans of soda. On a hot day, each person consumes an average of two cans at 25 cents each. If there are 60 people at the beach on a hot day, will there be a *shortage* of soda? If so, how much? Explain." (Answer: Yes, 60 × 2 = 120 cans = Demand. Supply = 100 cans. Shortage = 20 cans.)

2. Present, via overhead projector and/or duplicated copies, the mini-unit pictograph that shows United States consumption of oil (or natural gas or coal). Ask students to interpret the pictograph as follows:
   A. "How many barrels of oil (cubic feet of natural gas or tons of coal) were consumed from 1960-1964?" (18 billion barrels.)
   B. "How many barrels of oil were consumed from 1945-1964?" (56.5 billion barrels.)
   C. "Indicate the number of barrel symbols to be shaded to show a consumption of 35 billion barrels of oil." (three and one-half symbols or

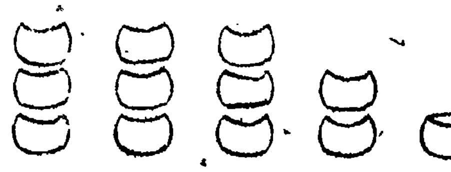
   D. (Assuming students have a copy of the pictograph) Shade barrels in the pictograph to show the number of years necessary to exhaust a reserve of 120 billion barrels, starting in 1975 with consumption a *constant* 30 billion barrels a year.

   Answer: 1975-1979
   1980-1984
   1985-1989
   1990-1994

   E. Shade barrels in the pictograph to show the number of years necessary to exhaust a reserve of 120 billion barrels, starting in 1975 with consumption at 30 billion barrels for 1975-1979, increasing to 40 billion barrels in 1980-1984, to 50 billion barrels in 1985-1989, and to 60 billion barrels in 1990-1994, etc.

   Answer:
   1975-1979
   1980-1984
   1985-1989

   F. Ask students if they would predict a *shortage* of oil in the future and, if so, why. (Yes, supply becomes exhausted but demand continues.)
   G. "How can a shortage be prevented?" (Increase supply and/or decrease demand, or find alternatives.)

Natural Gas Consumption— Past and Future

Constant Future Demand

GROUP A TASKS

Are there sufficient United States supplies of natural gas to meet future demand? What are the lifetimes of United States supplies of natural gas? Complete the following tasks to find out.

1. Examine the accompanying graph.

   A. What are the units of the scale at the top?

   ____

   B. How much natural gas does each symbol represent?

   ______

   C. Draw the number of symbols which would represent:

   20 trillion cubic feet ______________

   13 trillion cubic feet ______________

   5 trillion cubic feet ______________

   The abbreviation for trillion cubic feet is TCF.

2. Construct a table with the following headings:

Years	Amount of Natural Gas Consumed (in trillion cubic feet)
1945-1949	
1950-1954	
1955-1959	
1960-1964	
1965-1969	
1970-1974	

   A. Read the graph and enter into the table the amount of natural gas consumed in *each* five-year period from 1945 to 1974.

   B. Did demand increase or decrease? How many times greater was the amount consumed in 1970-1974 than the amount consumed in 1950-1954?

   C. How many times greater was the United States population in 1970 than in 1950? (Refer to work on oil or see 1973 Almanac.) Is your answer to 2B, the increase in the consumption of natural gas, greater than, equal to, or less than the increase in the United States population?

   ____

3. Estimates of the supply of natural gas in the United States are:

	Reserves	*Ultimately Recoverable*
Natural Gas (in trillion cubic feet)	290	2,390

   A. Calculate from your table or graph the total amount of natural gas consumed in the past 30 years (1945-1974).

   ____

   B. Is this amount greater than, equal to, or less than the reserves of natural gas?

   ____

   C. Is it greater than, equal to, or less than the amount ultimately recoverable?

   ____

   D. If in the next 30 years we attempt to consume the same amount used in the past 30 years, will we run out of reserves? ______ Out of ultimately recoverable resources of natural gas? ______ Explain your answers.

4. A. How many symbols would be required to represent the amount of natural gas *reserves*?

   ____

   B. How many symbols would be required to represent the amount of *ultimately recoverable* natural gas?

   ____

5. A. How much natural gas was consumed in 1970-1974?

   ____

   How many symbols are used to represent this quantity?

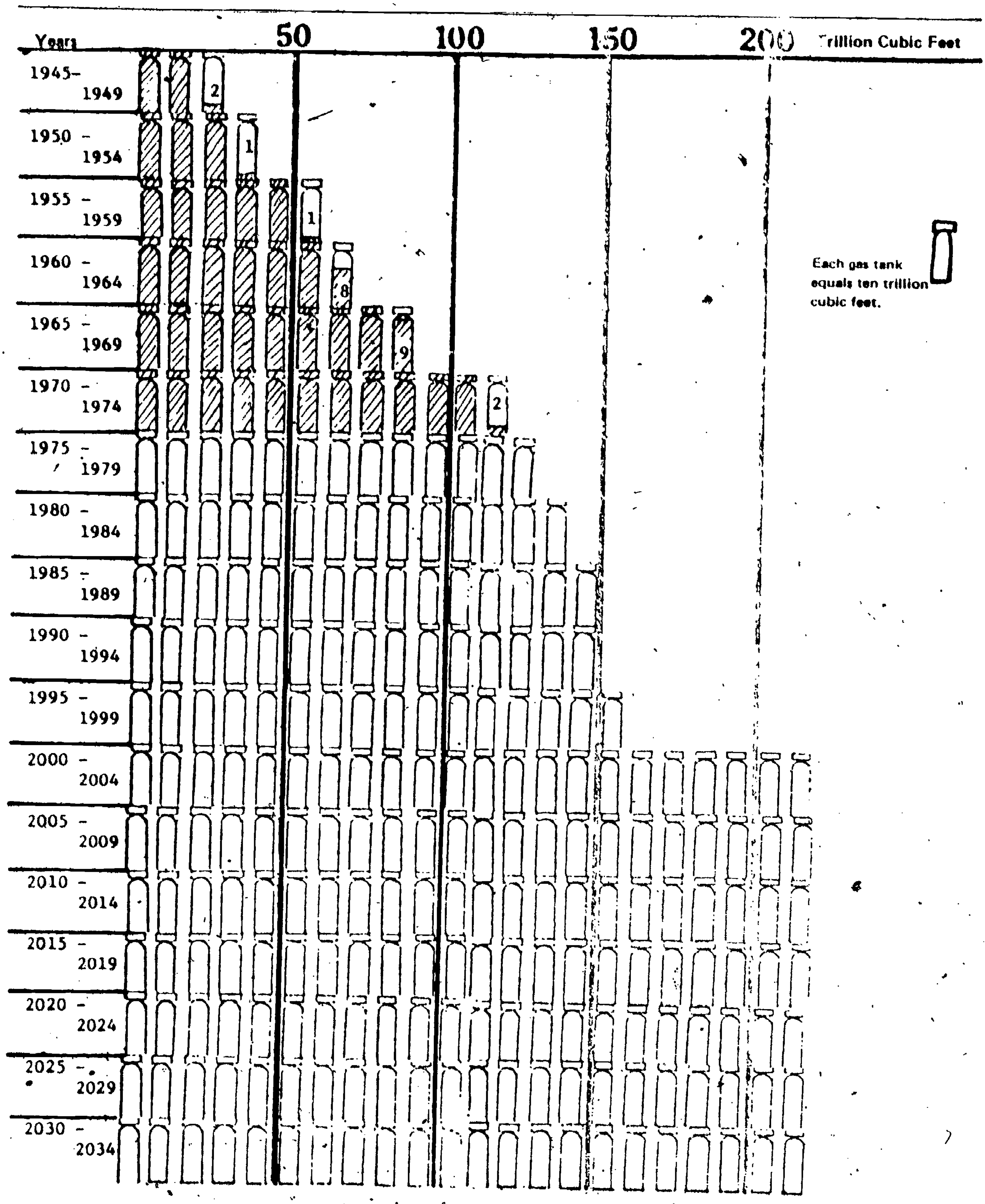
   ____

   B. Color this many symbols in each row after 1970-1974 until the total number of symbols equals the *reserves* of natural gas. In what five-year period would the *reserves* be totally consumed? ____________ What is the lifetime of the United States reserves of natural gas at a constant consumption rate? ____________

   C. Similarly, color the number of symbols in your answer to 5A in each row until the *ultimately recoverable* resources of natural gas are totally consumed. In what five-year period does this occur? ____________ What is the lifetime of the *ultimately recoverable* United States supplies of natural gas at a constant consumption rate?

   ____

U.S. Consumption of Natural Gas



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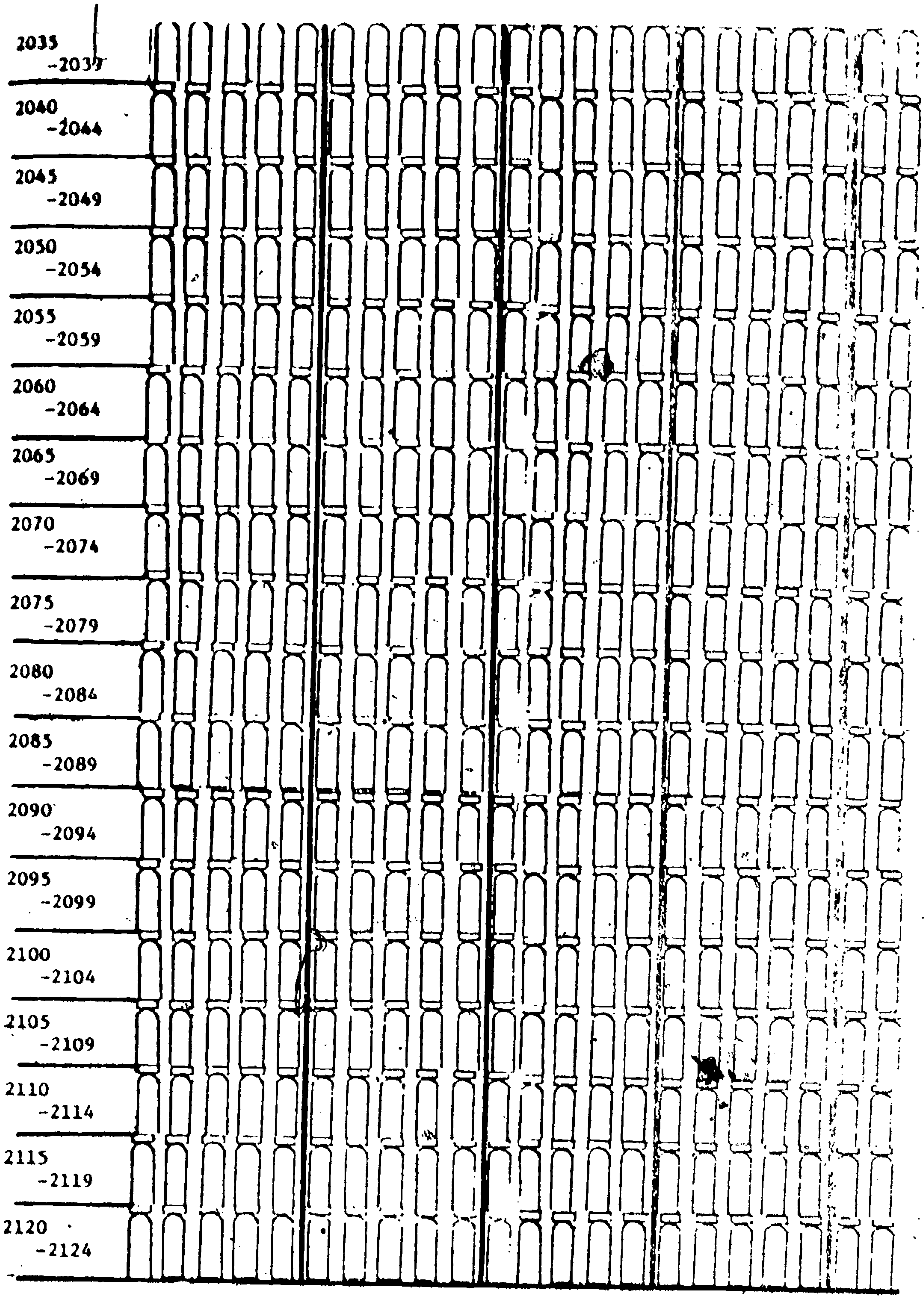

2035 -2039
2040 -2044
2045 -2049
2050 -2054
2055 -2059
2060 -2064
2065 -2069
2070 -2074
2075 -2079
2080 -2084
2085 -2089
2090 -2094
2095 -2099
2100 -2104
2105 -2109
2110 -2114
2115 -2119
2120 -2124

Natural Gas Consumption—Past and Future

Increasing Future Demand

GROUP B TASKS

Are there sufficient United States supplies of natural gas to meet future demand? What are the lifetimes of United States supplies of natural gas? Complete the following tasks to find out.

1. Examine the accompanying graph.

   A. What are the units of the scale at the top?

   ____

   B. How much natural gas does each symbol represent?

   ________ ________

   C. Draw the number of symbols which would represent:

   20 trillion cubic feet ______________________

   13 trillion cubic feet ______________________

   8 trillion cubic feet ______________________

   The abbreviation for trillion cubic feet is TCF.

2. Construct a table with the following headings:

Years	Amount of Natural Gas Consumed (in trillion cubic feet)
1945-1949	
1950-1954	
1955-1959	
1960-1964	
1965-1969	
1970-1974	

   A. Read the graph and enter into the table the amount of natural gas consumed in *each* five-year period from 1945 to 1974.

   B. Did demand increase or decrease? How many times greater was the amount consumed in 1970-1974 than the amount consumed in 1950-1954?

   C. How many times greater was the United States population in 1970 than in 1950? (Refer to work on oil or see 1973 Almanac.) Is your answer to 2B, the increase in the consumption of natural gas, greater than, equal to, or less than the increase in the United States population?

   ____

3. Estimates of the supply of natural gas in the United States are:

	Reserves	*Ultimately recoverable*
Natural Gas (in trillion cubic feet)	290	2,390

   A. Calculate from your table or graph the total amount of natural gas consumed in the past 30 years (1945-1974).

   ____

   B. Is this amount greater than, equal to, or less than the reserves of natural gas?

   ____

   C. Is it greater than, equal to, or less than the amount ultimately recoverable?

   ____

   D. If in the next 30 years we attempt to consume the same amount used in the past 30 years, will we run out of reserves? ______ Out of ultimately recoverable resources of natural gas? ______ Explain your answers.

4. A. How many sumbols would be required to represent the amount of natural gas *reserves*?

   ____

   B. How many symbols would be required to represent the amount of *ultimately recoverable* natural gas?

   ____

5. A realistic projection of future consumption of natural gas is given by the following set of numbers:

Year	Demand (in trillion cubic feet)	Year	Demand (in trillion cubic feet)	Year	Demand (in trillion cubic feet)
1975-1979	126	2000-2004	168	2025-2029	221
1980-1984	134	2005-2009	177	2030-2034	234
1985-1989	141	2010-2014	188	2035-2039	247
1990-1994	150	2015-2019	199	2040-2044	261
1995-1999	158	2020-2024	210	2045-20[illegible]	276

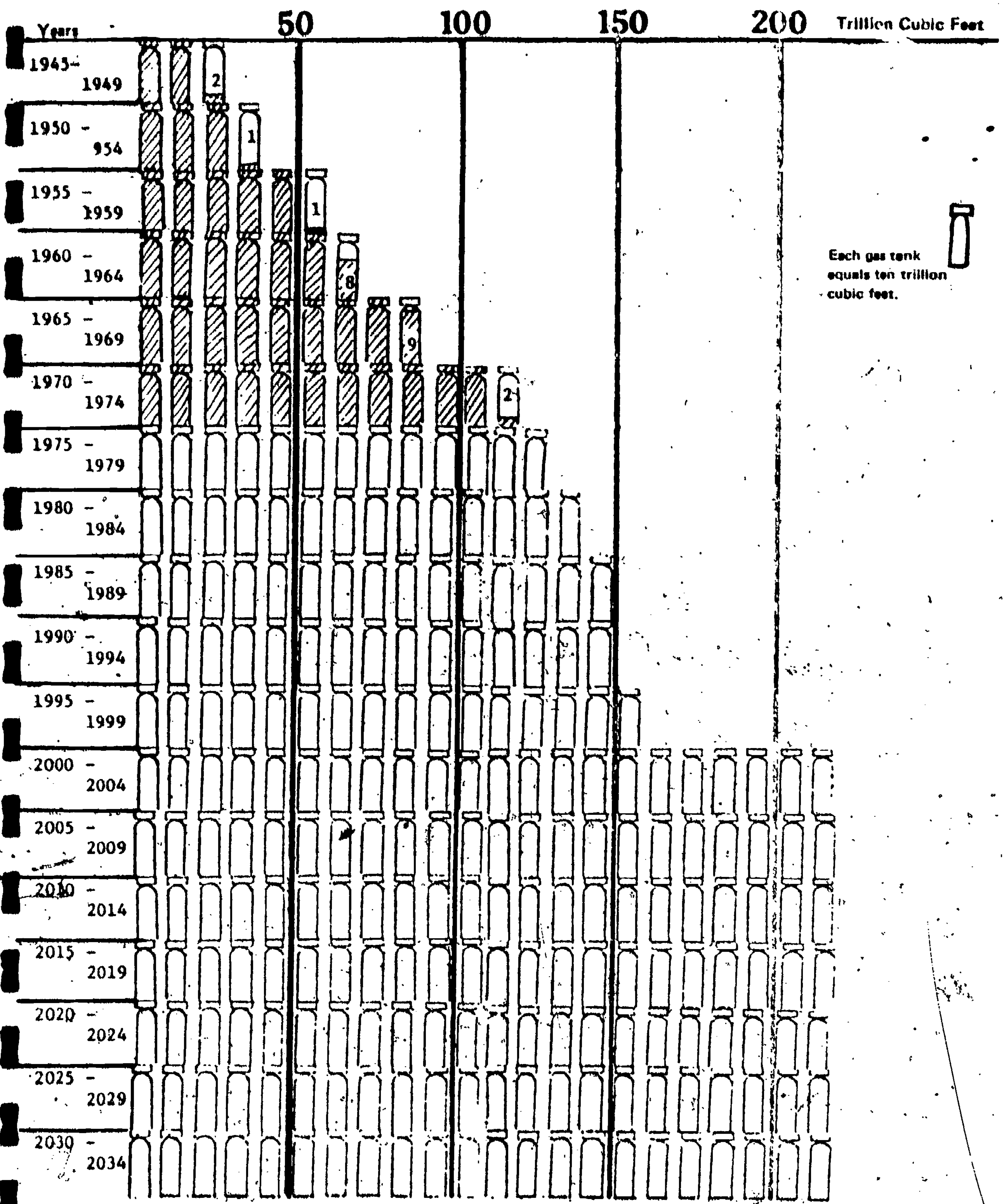
   A. How many symbols are required for each of these numbers? 126 TCF ________, 134 TCF ________, 141 TCF ________, 150 TCF ________, 158 TCF ________

   B. Color the symbols in each row up to these respective maximum amounts until the *reserves* of natural gas are totally consumed. In which five-year period does this occur? ____________ What is the lifetime of the United States *reserves* of natural gas at an increasing consumption rate?

   ____

   C. Similarly, color in each row up to the maximum amounts until the *ultimately recoverable* natural gas resources are totally consumed. In which five-year period does this occur? ____________ What is the lifetime of the *ultimately recoverable United States supply of natural gas?* ________

U.S. Consumption of Natural Gas



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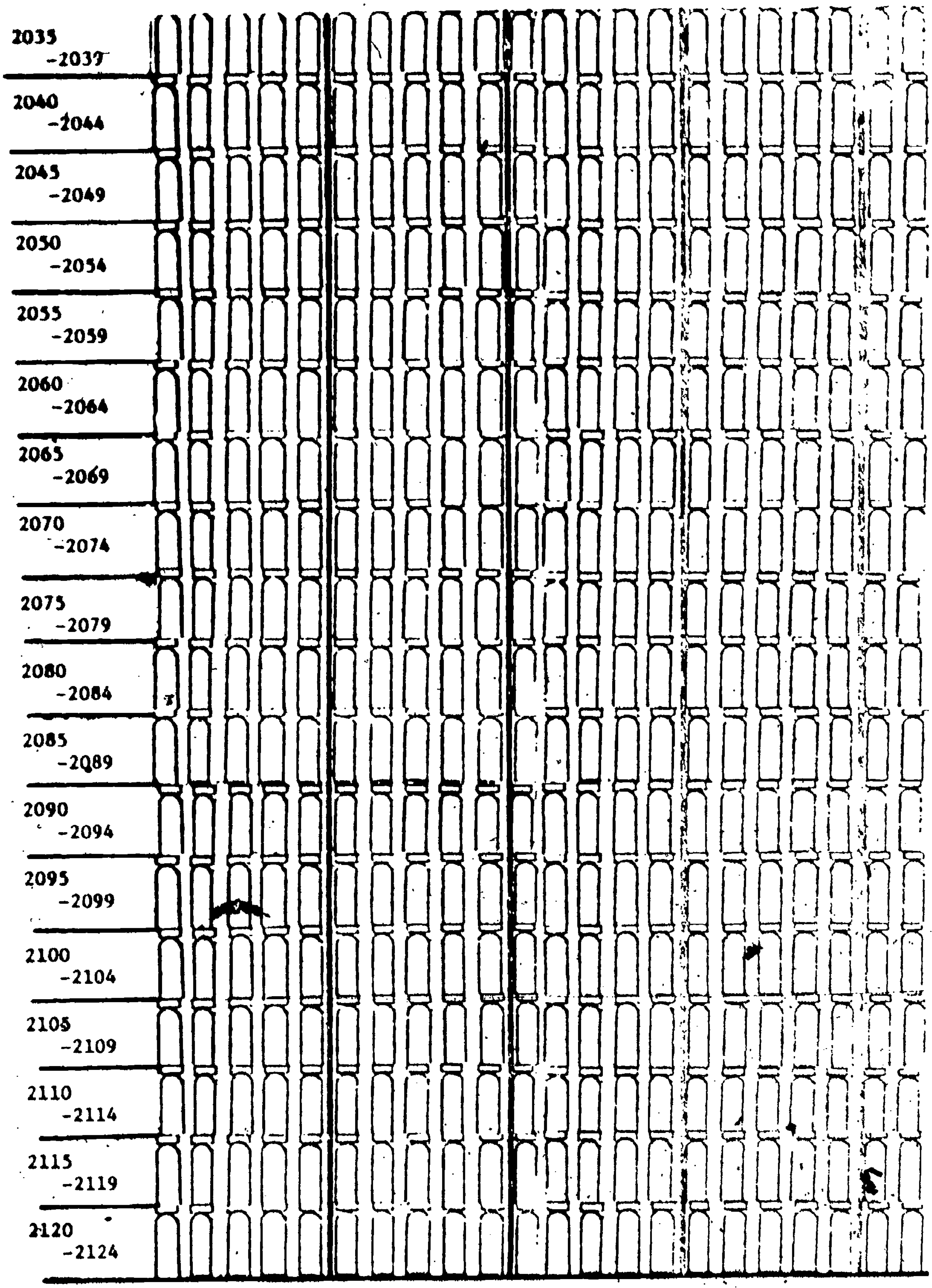

2035 -2039
2040 -2044
2045 -2049
2050 -2054
2055 -2059
2060 -2064
2065 -2069
2070 -2074
2075 -2079
2080 -2084
2085 -2089
2090 -2094
2095 -2099
2100 -2104
2105 -2109
2110 -2114
2115 -2119
2120 -2124

Coal Consumption— Past and Future Constant Future Demand

GROUP C TASKS

Are there sufficient United States supplies of coal to meet future demand? What is the lifetime of United States supplies of coal? Complete the following tasks to find out.

1. Examine Graph 1.
   A. What are the units of the scale at the top?

   ____

   B. How much coal does each pile of coal, or symbol, in the figure represent?

   ____

   C. Draw the number of symbols which would represent:

   2 billion tons of coal ______________

   1 1/3 billion tons of coal ______________

   2 1/10 billion tons of coal ______________

   The abbreviation for a billion tons of coal is B tons.

2. Construct a table with the following headings:

Years	Coal Consumed
1945-1949	
1950-1954	
1955-1959	
1960-1964	
1965-1969	
1970-1974	

   A. Read the graph and enter into the table the amount of coal consumed in each five-year period from 1945 through 1974.
   B. Did the demand increase, decrease, or remain the same in the last 20 years? ______________ How many times greater was the amount consumed in 1970-1974 than in 1950-1954? ______________
   C. How much did the United States population increase from 1950 to 1970? (Refer to your work on oil or see 1973 World Almanac.) ______________ Is your answer to 2B, the change in consumption of coal, greater than, equal to, or less than the increase in United States population?

   ____

3. Estimates of the supply of coal in the United States are:

	Reserves	Ultimately recoverable
Coal (in billion tons)	150	1,500

   A. Calculate from your table or Graph 1 the total amount of coal consumed in the past 30 years (1945-1974).

   ____

   B. Is this amount greater than, equal to, or less than the United States *reserves* of coal? ______________ Is it greater than, equal to, or less than the amount *ultimately recoverable*?

   ____

   C. If in the next 30 years we attempt to consume the same amount used in the past 30 years, will we run out of reserves? ______________ Will we run out of ultimately recoverable resources of United States coal? ______________ Explain your answers.

4. A. How many symbols would be required to represent the amount of United States coal *reserves*?

   ____

   B. How many symbols would be required to represent the amount of *ultimately recoverable* United States resources of coal?

   ____

   C. How many symbols would represent the total amount of coal consumed in the 25-year period *1950-1974*?

   ____

   Enter this number of symbols on the first row of Graph 2 and in every succeeding row until the United States reserves of coal are totally consumed.
   During what 25-year period will the United States reserves be totally consumed? ______________
   What is the lifetime of coal *reserves*?

   ____

5. A. How many future 25-year periods are there; i.e., how many rows did it take to totally consume all of the coal reserves?

   ____

   B. Is this approximately the same number you would obtain by dividing the amount of the reserves (150 billion tons) by the consumption in the 25-year period 1950-1974 (see your answer to 4C)?

   ____

   C. If you took your answer to 5A, the number of 25-year periods, and multiplied it by 25 years, do you obtain the same answer as in 4C for the reserve lifetime?

   ____

   Explain ______________

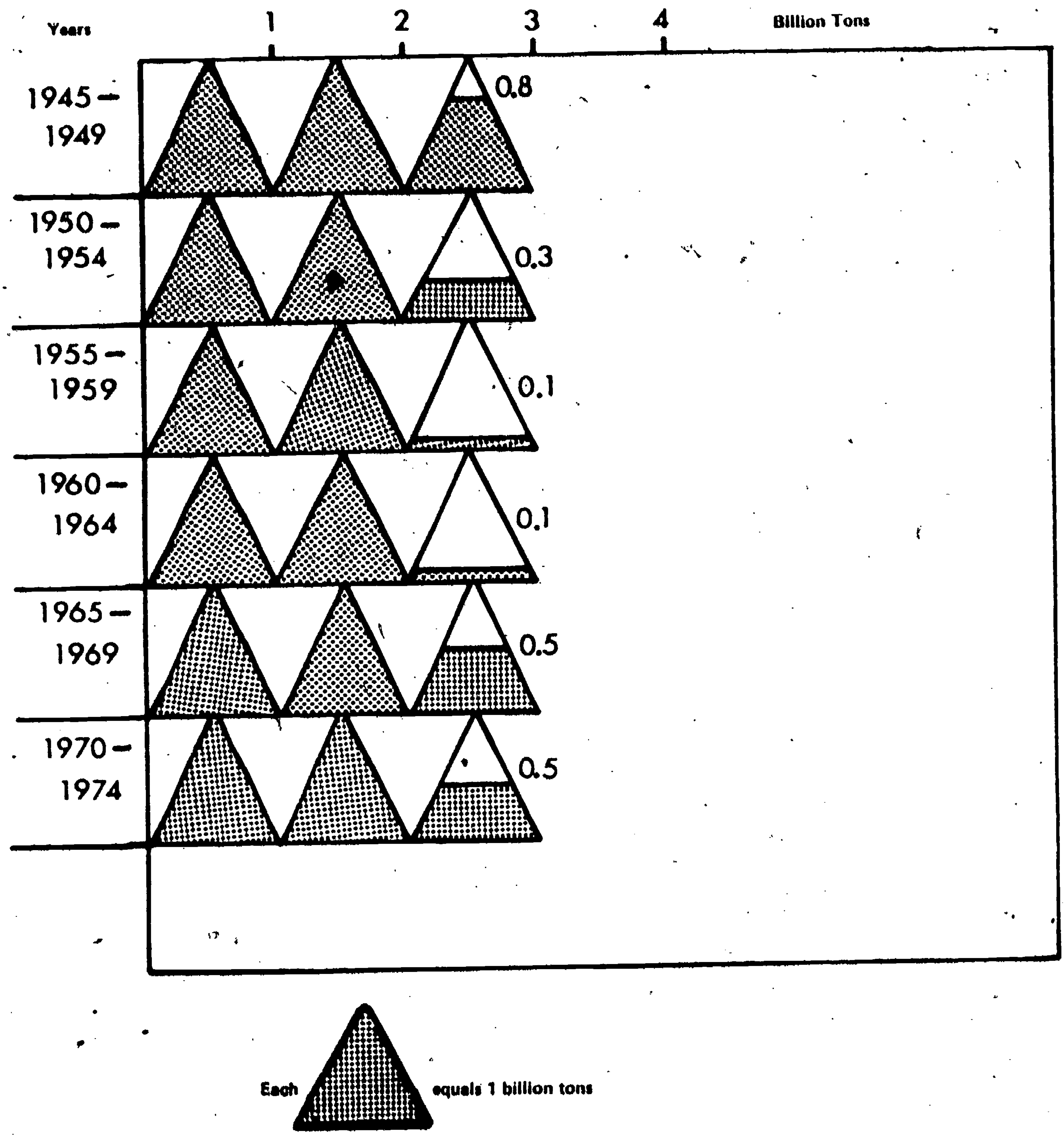
6. Your answers to 5B and C suggest an alternative method for calculating resource lifetime when the consumption remains *constant*.
   Using the estimate of 1,500 billion tons for ultimately recoverable supply of United States coal, calculate, using this alternative method, the lifetime of this supply.

   ____

   During what period would this supply be totally consumed?

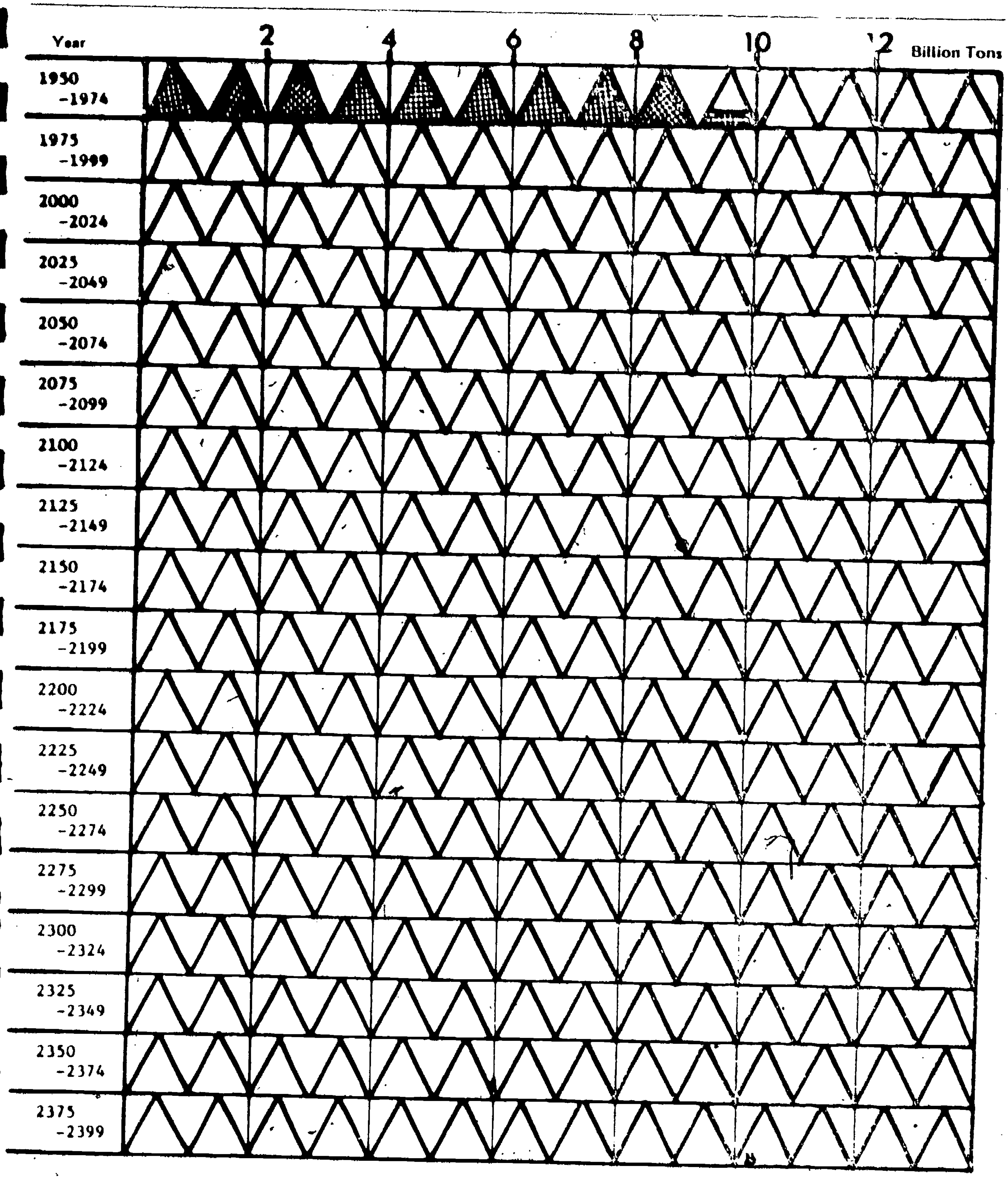
   ____

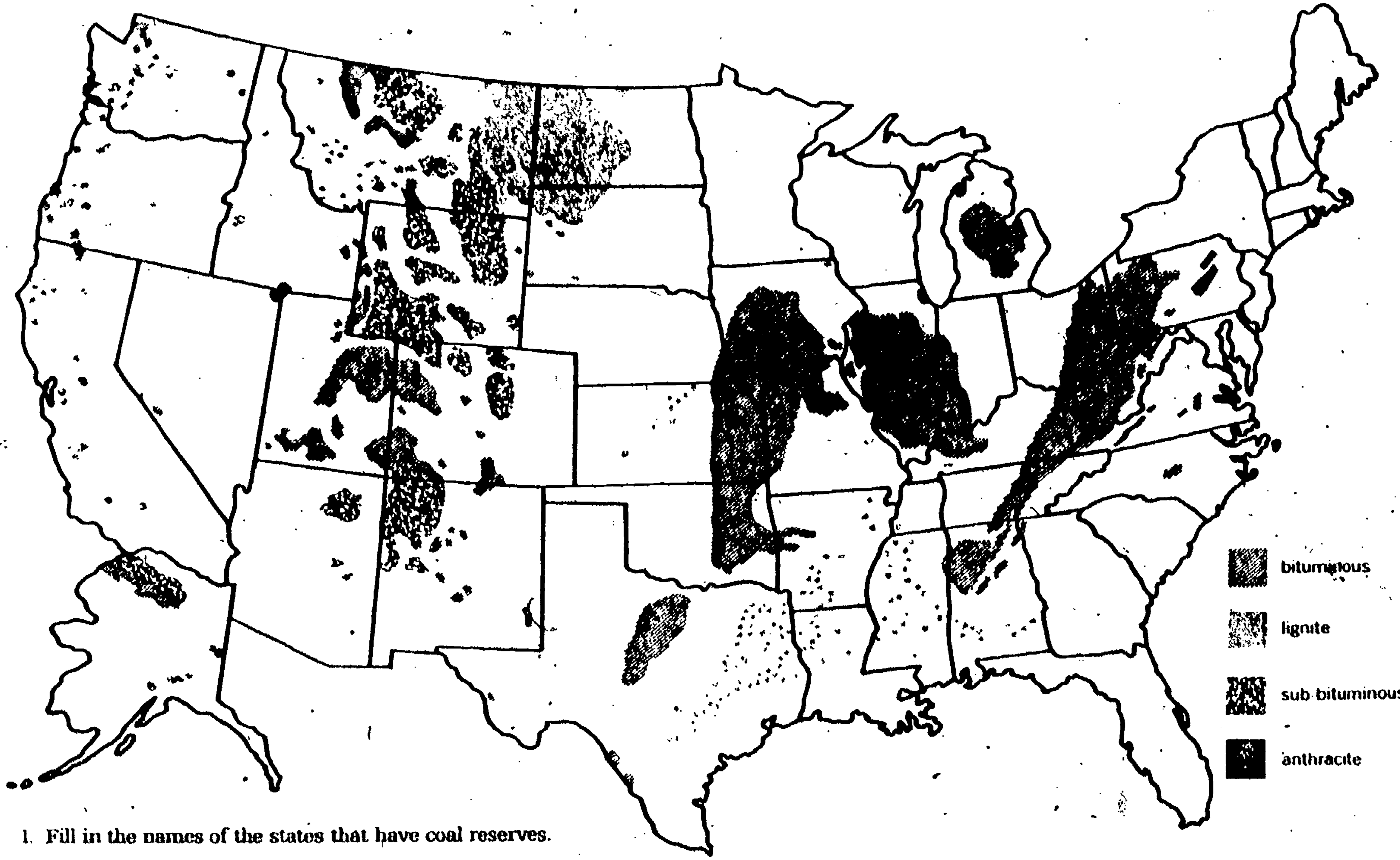
GRAPH 1
U.S. Consumption of Coal, 1945-1974



GRAPH 2

U.S. Consumption of Coal





1. Fill in the names of the states that have coal reserves.

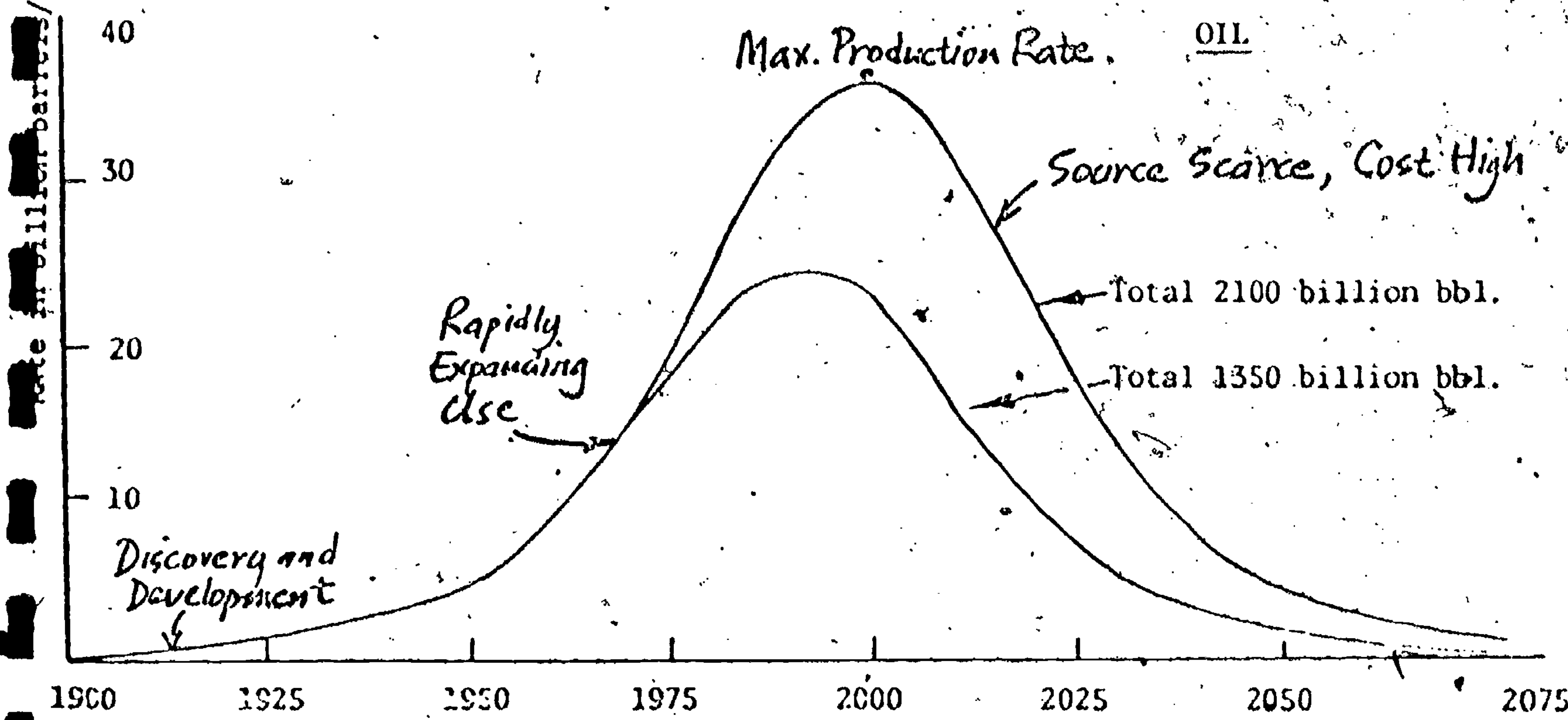
2. Can you tell from this map how many tons of coal we have in the United States? Why or why not?

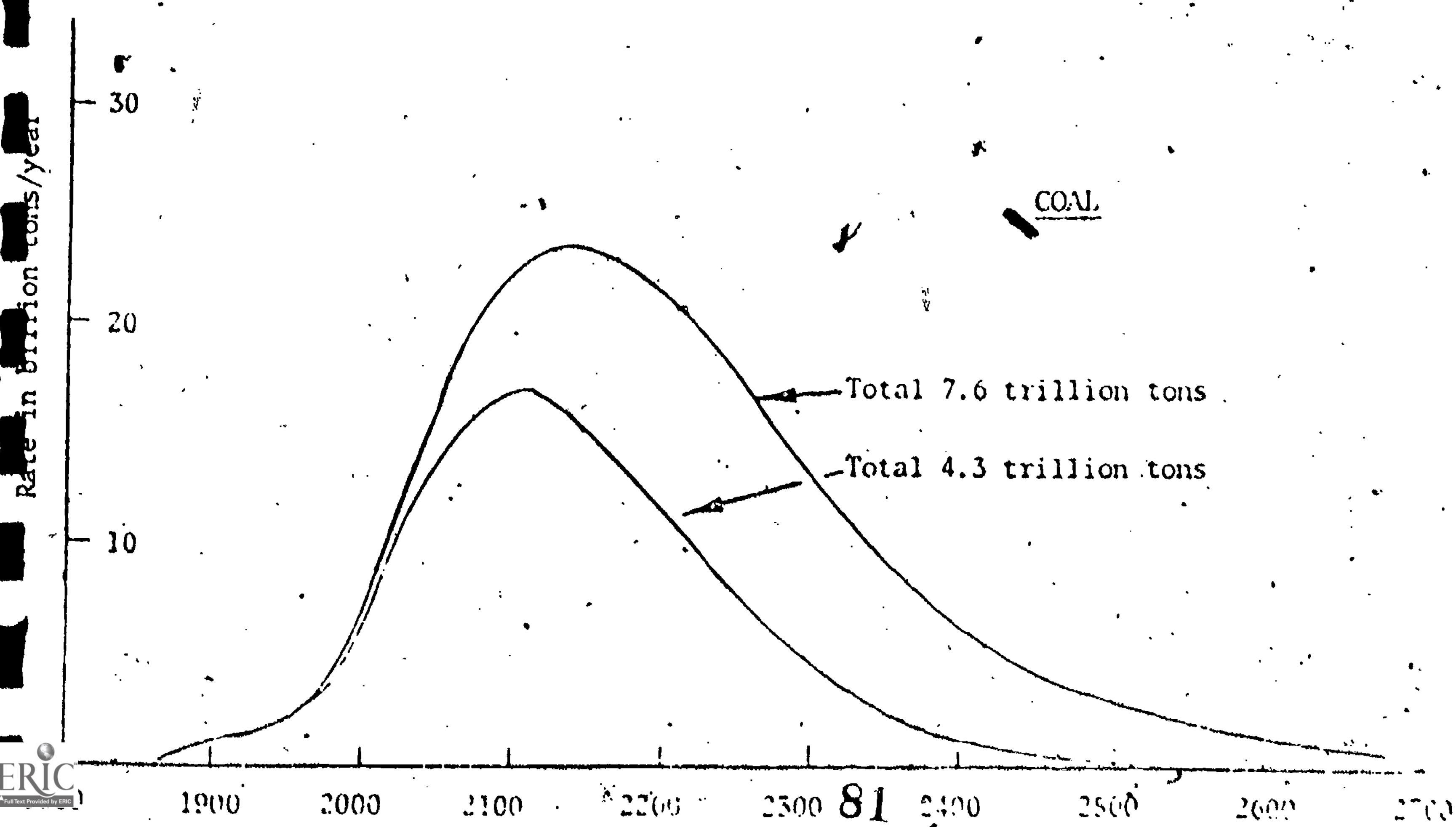
3. Notice that there are large deposits shown in Michigan, yet coal is not mined there. Can you guess why not?

4. From looking at the map do you think that the area you live in has electricity produced from coal? Check with your local utility plant to find out whether or not you are right.

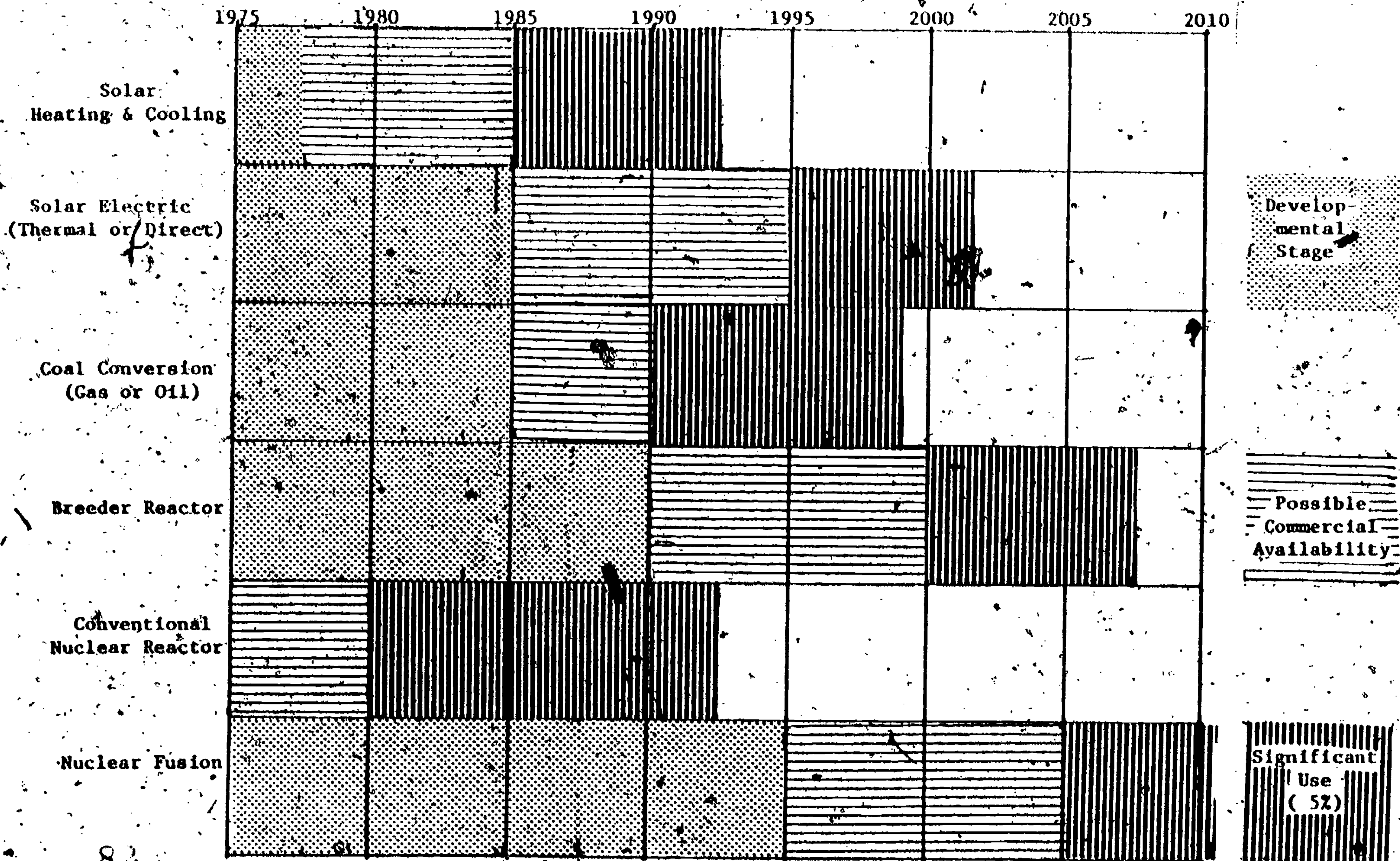
LIFE SPAN OF WORLD'S PETROLEUM AND COAL RESOURCES

Area under the curve represents the total amount of the resource available at the outset, including proved reserves and best estimates of unproved reserves. The high and low values reflect the uncertainty of estimating the amount of unproved reserves.





NEW SOURCES OF ENERGY FOR ELECTRICITY



SCHOOLS CLOSE
for 2 weeks

INDUSTRY CUTS BACK ELECTRICITY USE 50%

Detroit Lays Off 1,000 Workers

LIGHTS OUT - CRIME INCREASE FEARED

President Orders Coal Miners Back to Work

These headlines show some of the effects of the long coal strike of 1978. Which of these effects do you think are most serious? Which are least serious? Why?

Why might schools be ordered closed during a shortage of coal?

Why might you close industries?

What other alternatives are available for dealing with the shortage?

NEWSPAPER CLIPPING

Oil firms are leasing Texas land for lignite

By Allen K. Short
Associated Press

FAIRFIELD, Texas — In a region better known for oil wells than strip mines, some of the nation's biggest oil and energy companies are quietly acquiring leases on millions of acres of farm and ranchlands.

The heavy investment in six Gulf Coast states comes as companies such as Phillips Coal Co., a subsidiary of Phillips Petroleum, Exxon and 10 other energy concerns anticipate a coal boom that could forever change power use patterns in this oil-rich region.

Lignite — soft brown coal somewhat denser and richer in carbon than the peat burned in some countries — underlies a vast section of the region.

With the long-term availability of natural gas in question and prices for domestic and imported gas rising, the area's estimated 35 billion tons of lignite figure prominently in several proposals for developing synthetic fuels, state and industry officials say.

In eastern Texas, where salt water is seeping into the famous oil fields, some of the state's 23.4 million tons of lignite are already being dug from three strip mines operated by a consortium of Texas electric utilities. Eight generating plants located right at the mouths of the consortium's mines last year produced enough electricity to meet the needs of a city of 2 million.

Phillips Coal, founded in Dallas six years ago, now holds leases on more than a million acres, while a dozen other major oil and coal companies own lignite rights on an additional 3.4 million acres in Texas, Louisiana, Arkansas, Tennessee, Mississippi and Alabama.

A recent study by the the Texas Bureau of Economic Geology estimates the region's lignite reserves have the energy content of more than double its proven oil and natural gas reserves combined.

As a result, lignite mining along the burgeoning Gulf Coast is projected to soar from 30 million tons last year to as much as 138 million tons by 1990. Barely a decade ago, only 2 million tons a year were being mined in the six-state region, the bureau said.

James Van Reenan, vice president for marketing of Phillips Coal, said lignite is fast becoming the fuel of choice for the region's utility companies and heavy in-

As a fuel, Gulf Coast lignite is only slightly less efficient than Western coal and transportation costs are almost non-existent because the plants are near the mines, Van Reenan said. And it's easier to reclaim strip-mined land along the flat, verdant Gulf Coast than in the arid coal fields of Wyoming and North Dakota, he added.

The soft, chunky lignite resembles topsoil in appearance and texture, and owes its existence to the same geological process that produced the Texas oilfields. The process began 70 million years ago when silt covered a thick layer of plant matter along the Gulf Coast.

The fossilized remains of the vegetation are lignite, which lies 10 to 200 feet below the surface in a giant black blanket spread from the Texas-Mexico border to Alabama and Kentucky. Older deposits of organic materials became pockets of oil and natural gas.

Exxon is designing a proposed $4 billion synthetic fuels plant to

process Texas lignite into a synthetic crude petroleum which, in turn, could be used to produce synthetic gas.

If the company goes ahead with the plant, lignite mining would begin near Troup, Texas, in 1986. About 600 million tons of lignite would be mined during the life of the plant.

Phillips, which also is thinking about building a synfuels plant along the Gulf Coast, has already signed contracts to supply several mine-mouth power plants in Louisiana with lignite.

Beginning in 1984, Phillips will charge Cajun Electric Power Cooperative $[illegible] a ton for lignite delivered to Cajun's proposed power plants 40 miles south of Shreveport. In comparison, lignite delivered to Houston from North Dakota costs about $32 a ton, which includes rail costs of more than $20 a ton, Van Reenan said.

Although the Gulf Coast deposit is the second largest in the United States — North Dakota's is the largest at 550 billion tons — only one of the region's six states, Texas, is now burning lignite to light homes and factories.

Texas Utilities Generating Co. operates eight electrical generating units at three lignite mines. Together, the plants produce 5,300 megawatts of power — enough to serve a community larger than Houston or Dallas. Six other utilities say they plan to operate lignite-fired plants in Texas by 1989.

Lignite development isn't new to Texas, says state geologist William Kaiser. In 1929, 60 percent of all electricity produced in Texas came from coal-fired plants. But as oil and natural gas deposits were discovered, lignite fell into disfavor because of mining costs and lower energy efficiency.

In 1980, the three utilities that make up Texas Utilities Generating Co. satisfied one-sixth of Texas' total energy demands by burning lignite.

"You might say Texas has entered its second phase in lignite mining, the modern era brought on by the price and availability of natural gas," said Kaiser.

Associated Press

A dragline operator at a strip mine in Fairfield, Texas, scoops up a giant shovel of dirt exposing a seam of Texas lignite coal.

SOME COAL USES

USES OF COAL

I. Chemical content and classification

II. Coal as a fuel
   A. Past and present use
   B. Future predictions
   C. Coal as a fraction of total energy sources
   D. Production of electricity

III. Coal as a raw material
   A. Coke production
   B. Coal products
   C. Gasification and hydrogenation

IV. History of coal use

Objectives--Students will be able to list the four types of coals, their heating values, and discuss their uses.

The Uses of Coal

The chemical composition and moisture content are the two things that determine how coal is used. Coal is not a true mineral. It does not have a fixed chemical formula. All coal consists of certain solids and moisture. The solids are composed chiefly of the elements carbon, hydrogen, nitrogen, oxygen and sulfur. But coal varies widely in the amount of each element it has as well as in its moisture content. Thus, no two deposits of coal are exactly alike in their make-up.

Coal is usually classified according to how much carbon it contains. There are four main groups of coal. The carbon content decreases from 1 to 4.

1. anthracites
2. bituminous
3. subbituminous
4. lignites (brown coal)

The anthracites have the greatest carbon content. The highest ranking anthracites contain about 98 % carbon. The lowest ranking lignites have a carbon content of only about 30 %. Thus anthracites and bituminous coals have a higher heating value than do subbituminous and lignite coals. The moisture content increases as you go down the rank. Heating value refers to the amount of heat a given amount of coal will produce when burned.

Bituminous coals are by far the most plentiful and widely in use of the major ranks. They are the only ones suited to make coke. Anthracites are hard to ignite and burn slowly. Thus they are unsuited to today's standard method of producing electricity from coal. Anthracites are also the least plentiful of the four ranks. Less than 1 % of the coal found in the United States is anthracite.

Questions

1. What two things mainly determine the way in which coal is used?

2. Why is coal not a true mineral?

3. What are the 5 chief elements found in coal?

4. Rank the four main classes of coal from the lowest heating value to the highest.

5. How does the moisture content of coal affect the heating value of coal?

6. Which type of coal is most widely used in the U.S.?

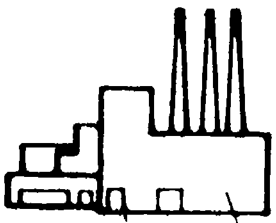
7. Which type of coal is the least plentiful?

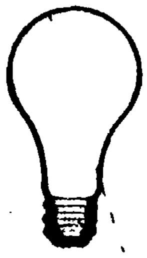
8. Why are anthracites unsuited to today's standard method of producing electricity from coal?

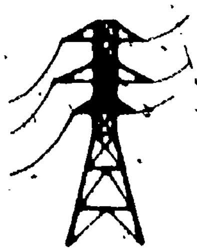
Activity Master 6

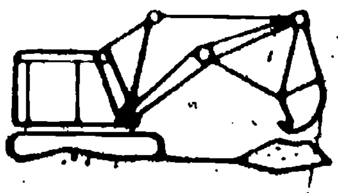
How Coal is Used

This activity follows coal from the mine to your electric light.









1.

2.

3.

4.

5.

1. Coal is mined either by surface or underground mining. Before it leaves the mine, it is often cleaned, crushed, and sorted.

2. About 2/3 of our coal is transported by rail, much of it in special cars. One coal train can carry as much as 10,000 tons per trip.

3. 46 percent of U.S. electrical generators are powered by coal. Power plants burn coal to turn water into steam. The steam turns a turbine, a series of wheels with vanes like a windmill. The turbine rotates coils of wire in a generator through a magnetic field to produce electricity.

4. Electricity is transported on wires at very high voltages. Electricity is usually not shipped more than 600 miles by wire because of expense and loss of energy. Only 26 percent of the original energy remains when the electricity is used.

5. Electricity lights the lamps in your home. How many other uses of electricity in your home can you name? Write them on the back of this paper. Then place a star before those you think you could do without.

Some Facts About Coal

Decide whether each of the following facts is a problem (P) or an opportunity (O). Put a P or an O — or both — in each blank. On the back of this sheet, write down ways some of the problems could be overcome. Compare ideas with your classmates.

_______ 1. 90 percent of U.S. fossil fuel reserves (coal, oil, natural gas) are coal.

_______ 2. Some deep mines are dangerous.

_______ 3. 50 percent of our mineable coal is in the western United States.

_______ 4. We have enough coal to last for 350 years, at current level of use.

_______ 5. Mining coal can cause damage to the environment.

_______ 6. In the future, we will rely more on coal as a source for synthetic oil and gas.

Objective- Student will unscramble coal vocabulary using clues given by each word.

WORD SCRAMBLE- COAL

______	1.	DIOSLS	All caol consists of moisture and ______.
______	2.	SETTCARHTNA	Coal with the greatest carbon content
______	3.	MUITIBSOUN	Most widely used coal type
______	4.	SLEITGIN	Brown coals
______	5.	THINGEA ULAVE	Amount of heat a given amount of coal will produce
______	6.	ABRNOC	Element found in coal
______	7.	LFUUSR	Impurity found in coal
______	8.	LCTEEIRCYIT	Coal is the fuel used chiefly in the production of ______.
______	9.	FLUSUR IODIDXE	Poisonous gas that comes from burning coal
______	10.	TIBSUMINOU	50% of this coal type in the U.S. has medium or high sulfur content

Objective- Student will be able to graph the usage of coal in the U.S.

USES OF COAL IN THE UNITED STATES

According to the 1976 U.S. Dept. of Energy figures, 663,228,000 short tons of coal were consumed or exported. Using the information below, complete the graph below.

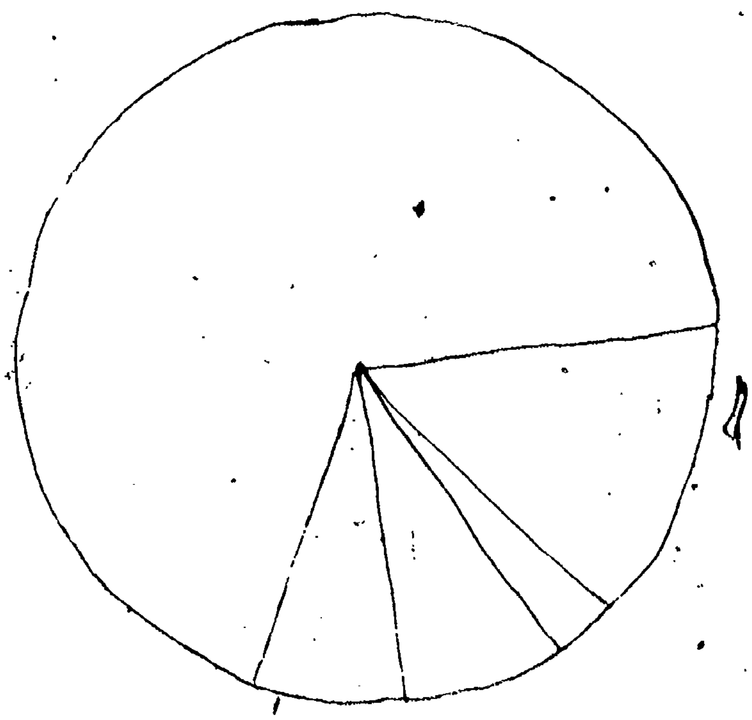
1 % - heating

9 % - exports

9 % - general industries

13 % - coking coal

[illegible] % - electric power



Objective- Students will be able to graph present and future energy sources for the United States, and then specifically determine the role of coal as a fuel source.

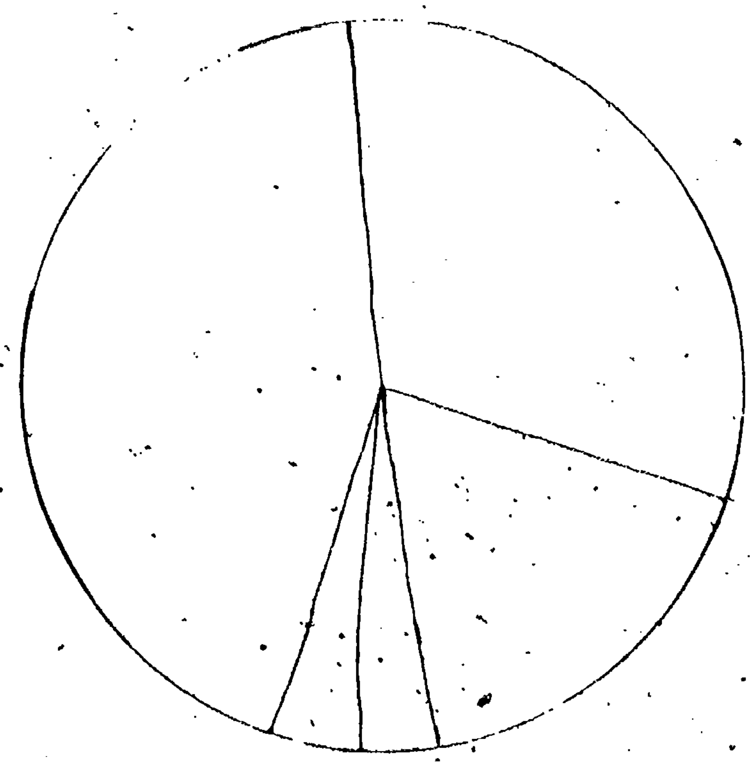
Energy Use Now and Future Predictions

Int he U.S., we use oil, gas and coal to provide most of our energy. Oil or petroleum accounts for about 44 % of all the energy we use, natural gas accounts for about 31 percent, and coal provides about 18 %. Uranium provides only about 4 % and water power provides 3 %.

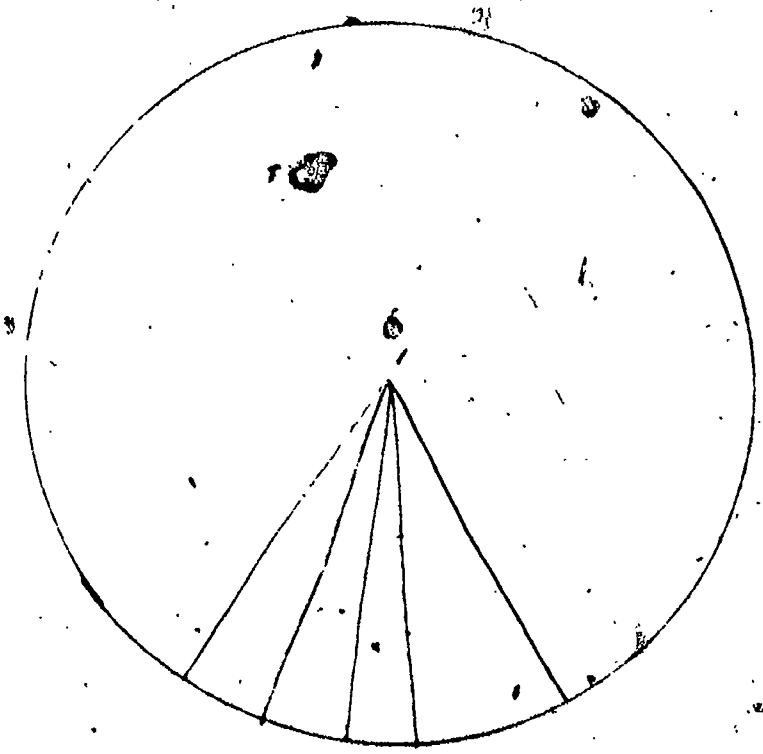
Oil and gas are cleaner fuels to burn than coal, but our supplies of them are very small compared to the amount of coal that we have. Looking into the future, we see that oil left in the ground makes up only about 3 % of the total fuels we have left. Shale oil makes up 7 %. Gas makes up 4 % and uranium also provides 4 %. But if we look at how much coal we have in the gound, we see that it makes up more than 80 % of the fuel we have left in the United States. We have more than 430 billion toms of coal in the gound that we can mine in ways that are largely used today. That is enough coal to last 200-300 years or more.

Using this information, fill in the graphs that follow.

WHERE U.S. ENERGY COMES FROM TODAY



U.S. FUELS FOR THE FUTURE



* Complete these graphs bu using information found in the preceding activity. Give percent and name of fuel.

Objective- Students will be able to answer and discuss questions concerning the use of coal as a fuel.

COAL AS A FUEL

Coal is a useful fuel because it is abundant and has a relatively high heating value. But coal has certain impurities that limit its usefulness as a fuel. These impurities include sulfur and various minerals. As coal is burned, most of the sulfur combines with oxygen and forms a poisonous gas called sulfur dioxide (SO_2). Most of the minerals turn into ash.

Low-sulfur coals or coals with a sulfur content of less than 1 per cent, can be burned without adding harmful amounts of SO_2 to the air. But medium and high-sulfur coals (coals with more than 1% sulfur) can cause serious air pollution if they are burned in large quantities without proper safeguards. The high cost of these safeguards has greatly restricted ths use of coal as a fuel.

Coal is chiefly used to produce electricity. Electric power plants use more than two-thirds of the coal mined in the United States.

1. What main impurities are found in coal?

2. What poisonous gas is formed when sulfur combines with oxygen?

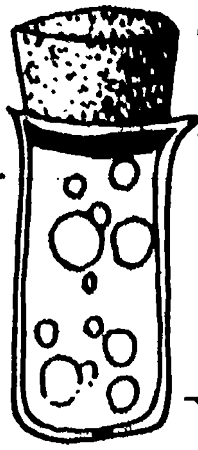
3. What type of coal can be burned safely without taking extra safeguards?

4. What is coal chiefly used for?

5. What per cent of the coal mined in the U.S. is used to produce electricity?

HOW MUCH METHANE CAN YOU COLLECT IN 2 DAYS FROM 1/2 CUP OF COAL?

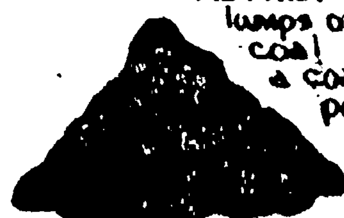
natural gas!



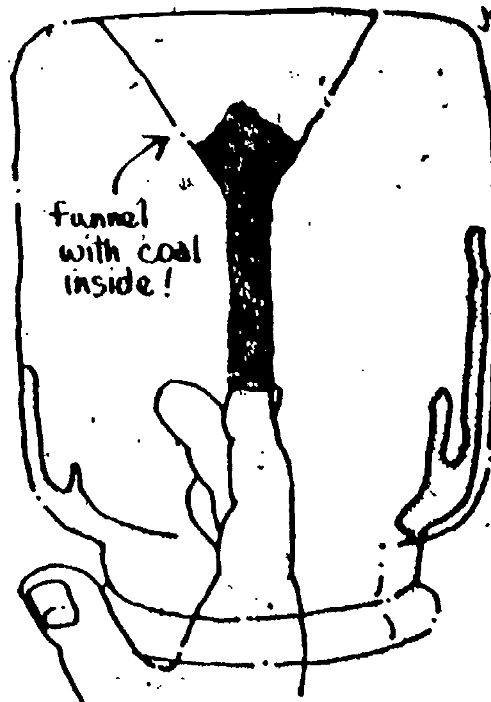
9

MATERIALS:
Soft or bituminous coal
Funnel, quart jar, water
Test tube, rubber band

Do this first:



Put the coal in the funnel and place the funnel inside the jar.

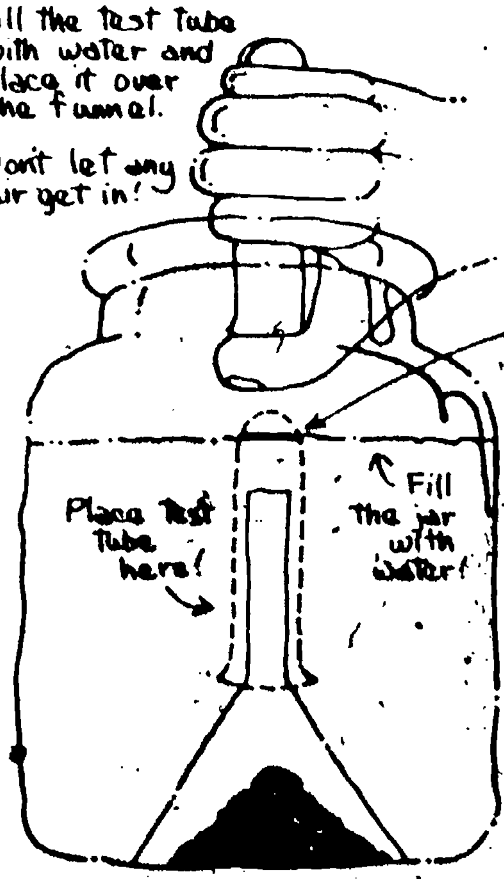


Then, do this.

Fill the jar with water first.

Fill the test tube with water and place it over the funnel.

Don't let any air get in!



Mark the test tube at the water line with a rubber band or china marker.

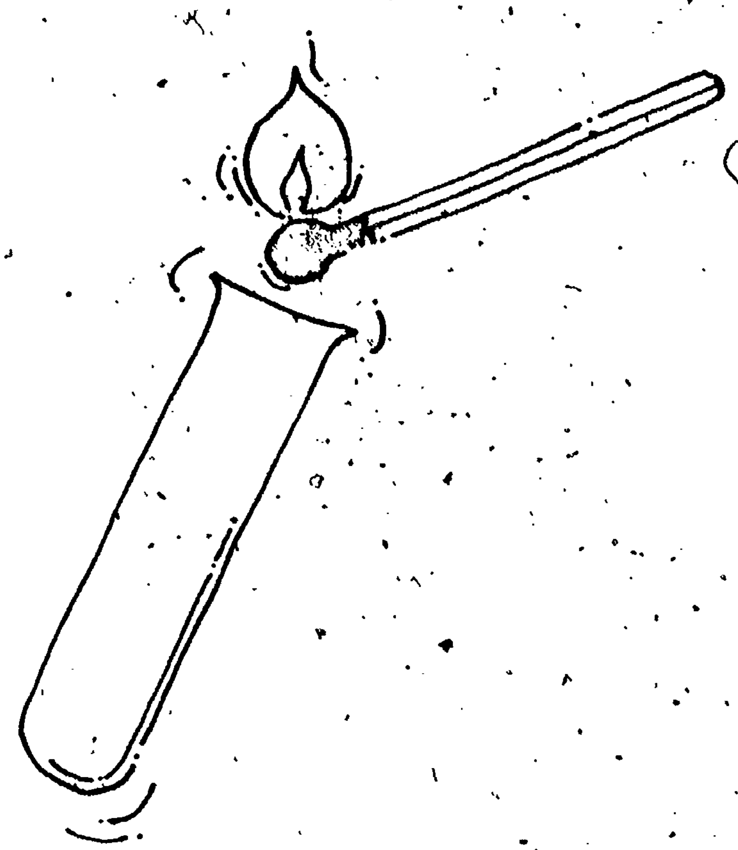
Methane will begin to collect in the test tube!

this should take about 2 days!

After the tube seems to be filled, will the coal still give off methane gas? How can you find out?

OTHER IDEAS TO EXPLORE:

Will the methane you collected burn?



Remove the test tube and put your thumb over the top.

Light a match and turn test tube upright. Let the gas out. What happens?

Why is mining a dangerous occupation?

Objective- Students will graph U.S. coal consumption since 1900.

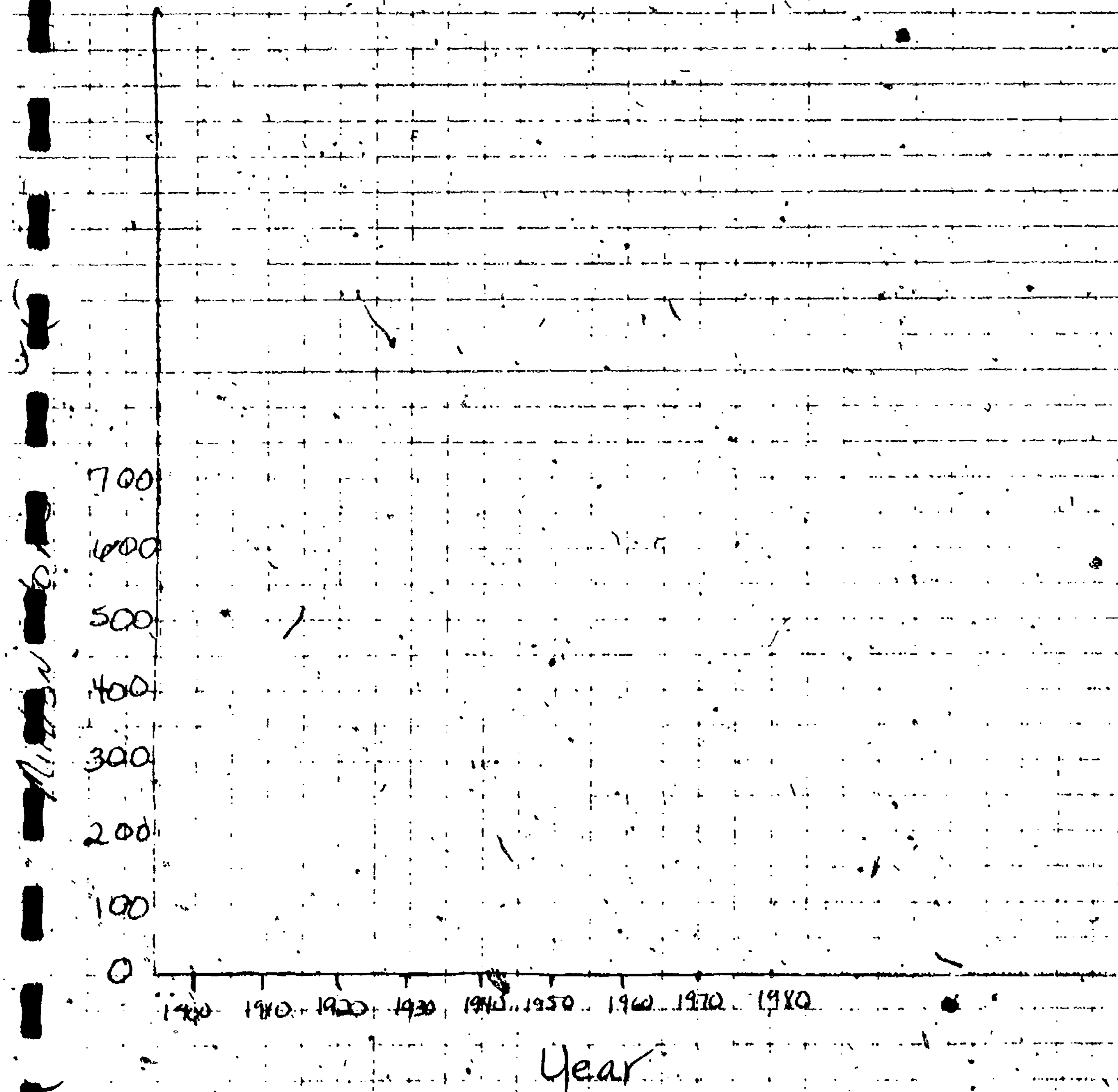
U.S. Dept. Of Energy Data

Fill in the graph that follows using the following data.

Year	Millions of tons used (approximate figures)
1900	275
1910	450
1920	550
1930	475
1940	485
1950	500
1960	400
1970	525
1979	650

U.S. Coal Consumption 1900-1979

Use the data on the preceding page to complete this graph.



Objective- Students will graph the percent of coal use vs. total energy consumption in the U.S. since 1900.

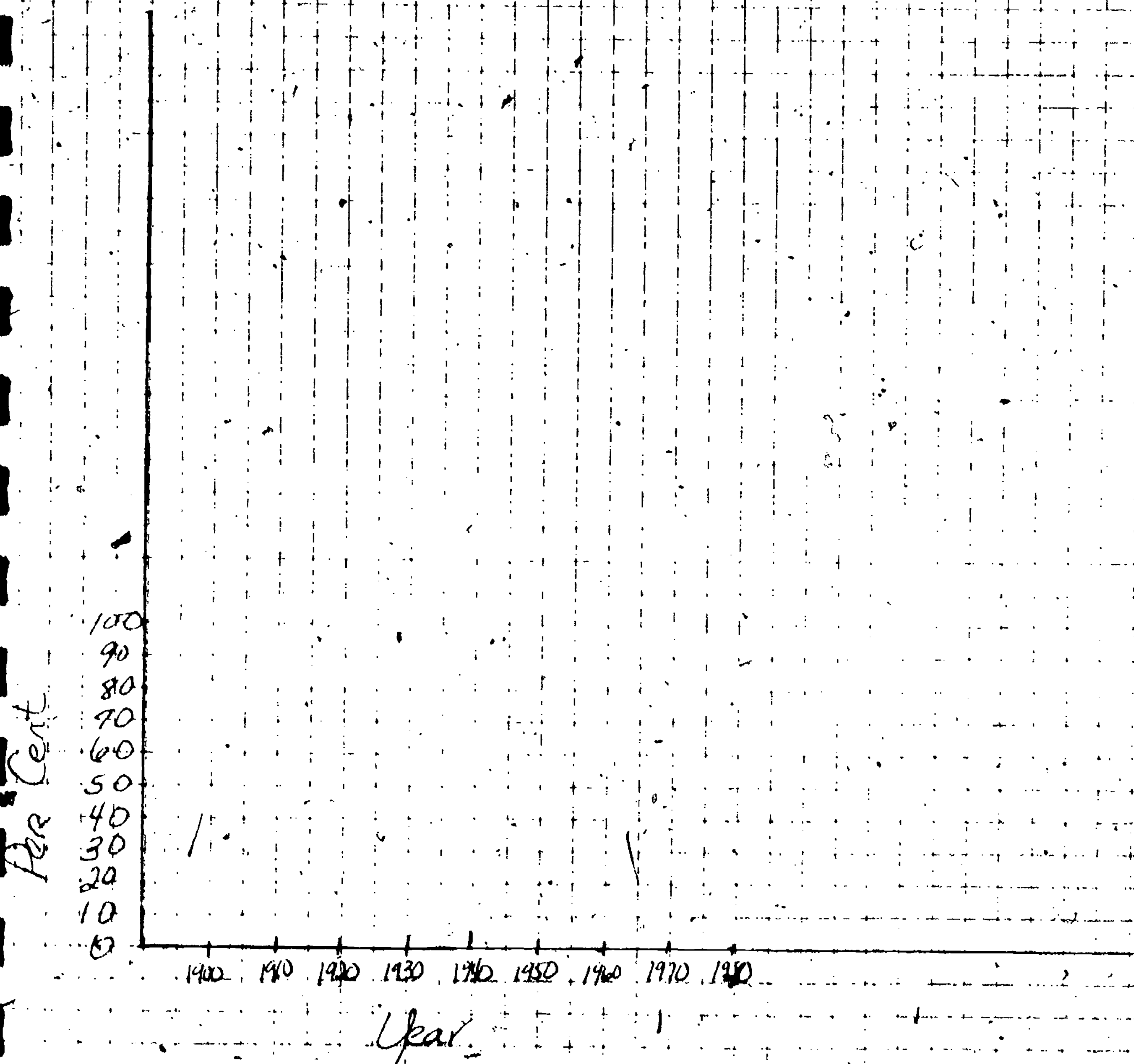
U.S. Dept. of Energy Data

Year	Percent
1900	96
1910	90
1920	88
1930	68
1940	58
1950	42
1960	23
1970	17
1979	18

* For extra credit, make one graph showing both sets of data on both of the preceding graphs.

U.S. Coal Use as a Fraction of Total Energy Consumption

Use the data on the preceding page to complete this graph.



Objective- Students will answer questions on coal used in the production of electricity.

COAL IN THE PRODUCTION OF ELECTRICITY

In the U.S., the great majority of electric power plants are steam turbines. High pressured steam is used to generate electricity. The steam spins the wheels of turbines which drive the generators that produce electricity. About 80% of the electricity used in the U.S. is produced in this way, and coal burning plants account for most of this output.

Bituminous coals have long been the preferred coals for electric power production. These are the most plentiful coals and have the highest heating value. But 50% of our nation's bituminous coal has a medium or high sulfur content. But nearly all the subbituminour and lignite coals in the U.S. have a sulfur content of less than 1%, So to meet federal and state pollution standards more and more power plants have switched from bituminous coal to subbituminous or lignite.

1. Why is bituminous coal no longer the most preferable coal for generating electric power?

2. In the U.S., most of our electric power plants are ________ ________.

3. Coal is used in these plants to make steam. How is the steam used to produce electricity?

In Europe and Asia, coal is widely used for heating homes and other buildings. But in the U.S., natural gas and fuel oil have almost entirely replaced coal as a heating fuel. However since the rising cost of oil and natural gas and other fuels, some factories and commercial buildings have switched back to coal. Anthracites are the cleanest burning coals, so they are preferred for heating homes. But since anthracites are the most expensive coals, bituminous coals are often used. It takes larger quantities of subbituminous and lignite coals to heat effectively, so they are seldom used.

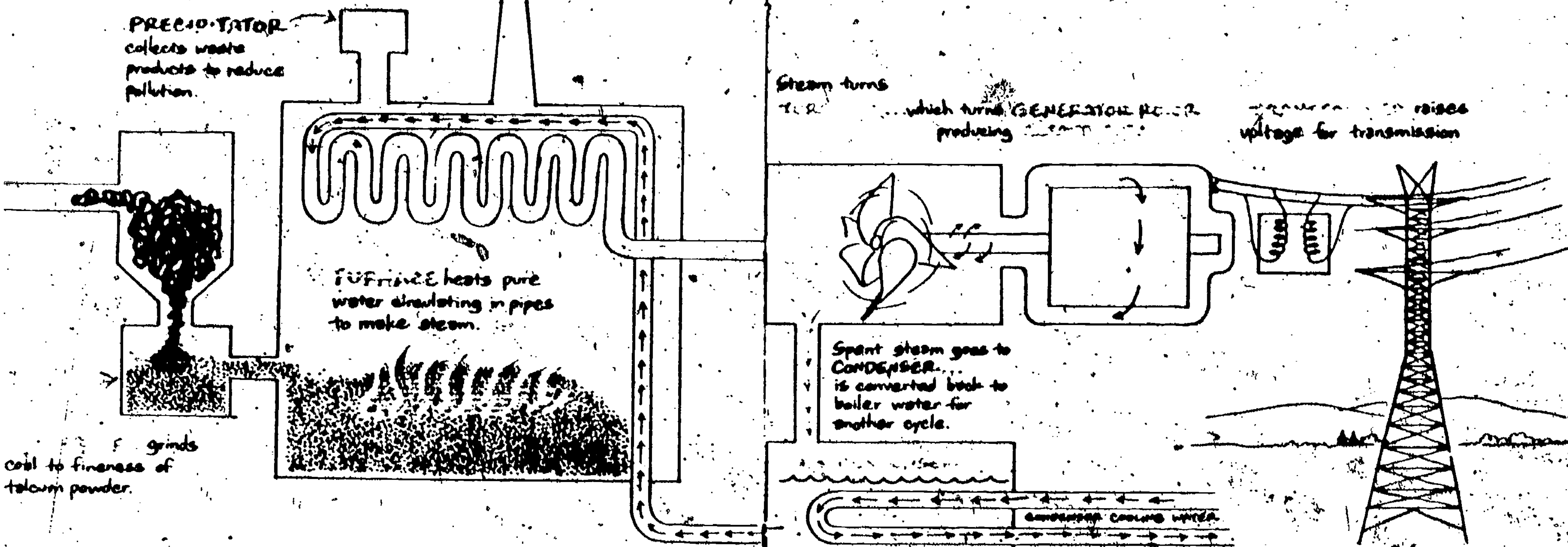
1. What has happened to cause industries to switch back to coal use?

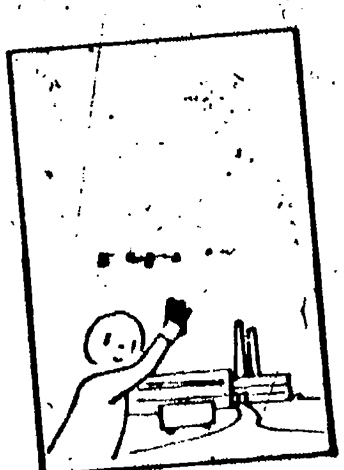
2. What coal type is preferred for home heating?

3. In the U.S., what other fuels have almost replaced coal as a heating fuel?

How an electric POWER PLANT operates

The diagram below shows coal being used to produce steam.





supplies 77.6% of America's electricity

Burning coal, gas or oil heats water to steam, which spins turbine which turns generators -- converting heat energy into electrical energy.

supplies 10.4% of America's electricity

The pressure of falling water (e.g., of a major dam) spins turbine which turns generators -- converting mechanical energy into electrical energy.

supplies 11.8% of America's electricity

Produces electricity in much the same way as a fossil fuel plant except the furnace is called a reactor and the fuel is uranium.

is ordered--
it's DELIVERED
to you!

Coal Car

The scramble for petroleum has finally provided the auto industry with an incentive to experiment with electric cars and diesel engines. In June, General Motors demonstrated another type of car, a coal-fired vehicle that the company's executives hope may be the one to free Americans from their heavy reliance on oil.

The two prototype cars burned coal that was ground finer than confectioners' sugar. A stream of compressed air carried the coal from a tank to the engine, where in the process of burning it became a gas, compressed enough to drive the turbine.

According to Albert Bell, who is in charge of the project, coal cars have become feasible only since new processing methods have made it possible to grind coal to an ultrafine powder that burns well.

The coal car's engine will have to be developed further before the vehicle can be placed on the market, Bell adds, and powdered coal will have to be made commercially available. When it is, General Motors estimates, it could be produced at \$4 per million BTUs (British thermal units); crude oil costs more than \$7 per million BTUs. "Despite the advantages of inexpensive and plentiful coal," adds Bell, "companies will have to set up commercial plants that refine the black fuel before coal cars become a reality."

Discover Aug. 1981

Objective- Students will be able to list raw materials made from coal and understand their value in our modern world.

COAL AS A RAW MATERIAL

Many substances made from coal serve as raw materials in manufacturing. Coke is the most widely used of these sunstances. Coke is made by heating bituminous coal to about 2000° F (1100°C) in an airtight oven. The lack of oxygen (O_2) prevents the coal from burning. The heat changes some of the solids in the coal into gases. The remaining solid matter is coke. Coke is a hard, foamlike mass of nearly pure carbon. It takes about 1½ short tons of bituminous coal to produce 1 short ton of coke.

About 90% of the coke produced in the U.S. is used to make iron and steel. Most coking plants are parts of a steel mill. The mill burns coke with iron ore and limestone to change the ore into the pure iron required to make steel. This coke making process is called carbonization. Some of the gases produced during carbonization turn into liquid ammonia and coal tar as they cool. Through further processing, some of the remaining gases change into light oil. Ammonia, coal tar and light oil are used to make such products as drugs, dyes and fertilizers. Coal tar is also used for road surfacing and roofing. Some of the gas produced during carbonization does not become liquid. The coal gas burns like natural gas, but it has a lower heating value and gives off large amounts of soot as it burns. Thus coal gas is used chiefly at the plants where it is produced. It provides heat for the coke and steel-making process.

Coal is a Raw Material

Find a word in the puzzle to correctly answer each phrase. List any extra related words you find but that are not answers for 1-12 below.

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

______ 1. Most widely used raw material in coal

______ 2.
______ 3. 90% of coke is used to make ______

______ 4. coke making process

______ 5. Used to surface roads

______ 6. Pollutant given off by coal gas

______ 7.
______ 8. products of ammonia, coal tar and light oil
______ 9.

______ 10. Coke is a hard, foamlike mass of nearly pure ______

______ 11. Chief use of coal is to produce ______

______ 12. Cleanest burning coal

COAL PRODUCTS

In 1974, every person in the U.S. used about thirteen pounds of coal every day. But most people never see any of the coal they used. Coal has many uses as can be seen from the list below.

electricity
lighting
heating
steel- autos, trucks, ships, railroad cars, stoves, refrigerators, washing machines, buildings, bicycles, bridges
cement
rubber
man-made fibers such as nylon
drugs such as aspirin
perfumes
food flavorings
dyes
paint
plastics
waterproofing materials
phonograph records
explosives
insecticides
lead pencils
benzene
carbon
coal tar
coke
creosote
toluene

Coal Products

Circle the coal products in the puzzle.
List those you find below.

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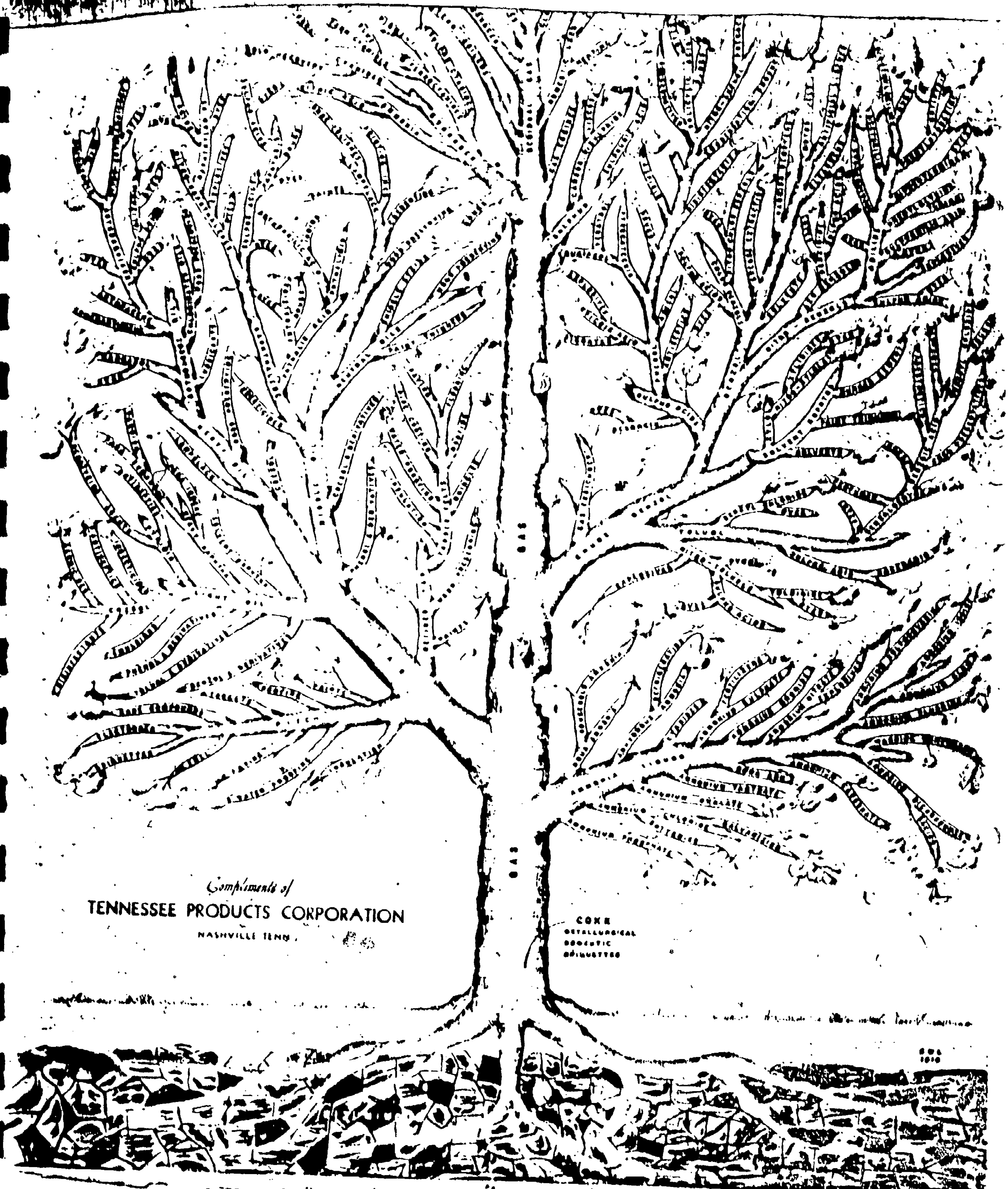

Compliments of
TENNESSEE PRODUCTS CORPORATION
NASHVILLE TENN.
COKE

Objective- Students will become aware of coal research processes and their projected use in our energy future.

GASIFICATION AND FURTHER RESEARCH

Gas can be produced from coal directly by various methods. The simplest gasification method involves burning coal in the presence of forced air or steam. The resulting gas has a low heating value and produces soot. Coal can be used to make high energy liquid fuels such as gasoline and fuel oil. The present methods of producing these fuels from coal are costly and complex. Researchers are working on ways to develop cheaper and simpler methods. Underground gasification techniques are also being researched.

Other research is being done in the area of hydrogenation or liquefaction. In a typical method, a mixture of pulverized coal and oil is treated with hydrogen gas at high temperatures and under great pressure. The hydrogen gradually combines with the carbon molecules, forming a liquid fuel. This process can produce such high-energy fuels as gasoline and fuel oil if sufficient hydrogen is added. Again this method is costly and more research is needed, but plants have been set up for this process.

1. Describe a simple gasification process.

2. Describe a typical method of liquefaction or hydrogenation.

3. Why are these processes not used on a large scale now?

Objective- Students will become acquainted with the history of coal use in our world.

HISTORY OF COAL USE

No one knows when people first discovered that coal could be burned to provide heat. The Chinese were the first people to develop a coal industry, and by A.D. 300's, they were using coal to heat buildings and smelt metals. In Europe, coal was not widely used until the 1600's when a wood shortage developed. England became the leading coal producer by the late 1600's until the late 1800's. The process of making coke was developed in England by brewers. In 1710, coal became the chief fuel for iron making. As the industrial process developed, and especially with the Industrial Revolution, coal became even more important in Europe and in North America.

North American Indians used coal for baking pottery long before the first white settlers arrived. In the 1800's, coal became important in manufacturing and in transportation (steam powered engines). By the late 1800's, the U.S. replaced England as the world's leading coal producer. In the 1950's, as the use of petroleum and natural gas increased in the U.S., Russia surpassed the U.S. in world coal production.

The growing scarcity of petroleum and natural gas has led to a sharp rise in the demand for coal. According to some U.S. government statistics and estimates, the production of coal will double in the U.S. by 1985. The increased output would be used for electricity production mainly. Coal exports are expected to increase also. The use of coal will depend upon many factors such as conservation, demand for energy and oil and alternative gas availability.

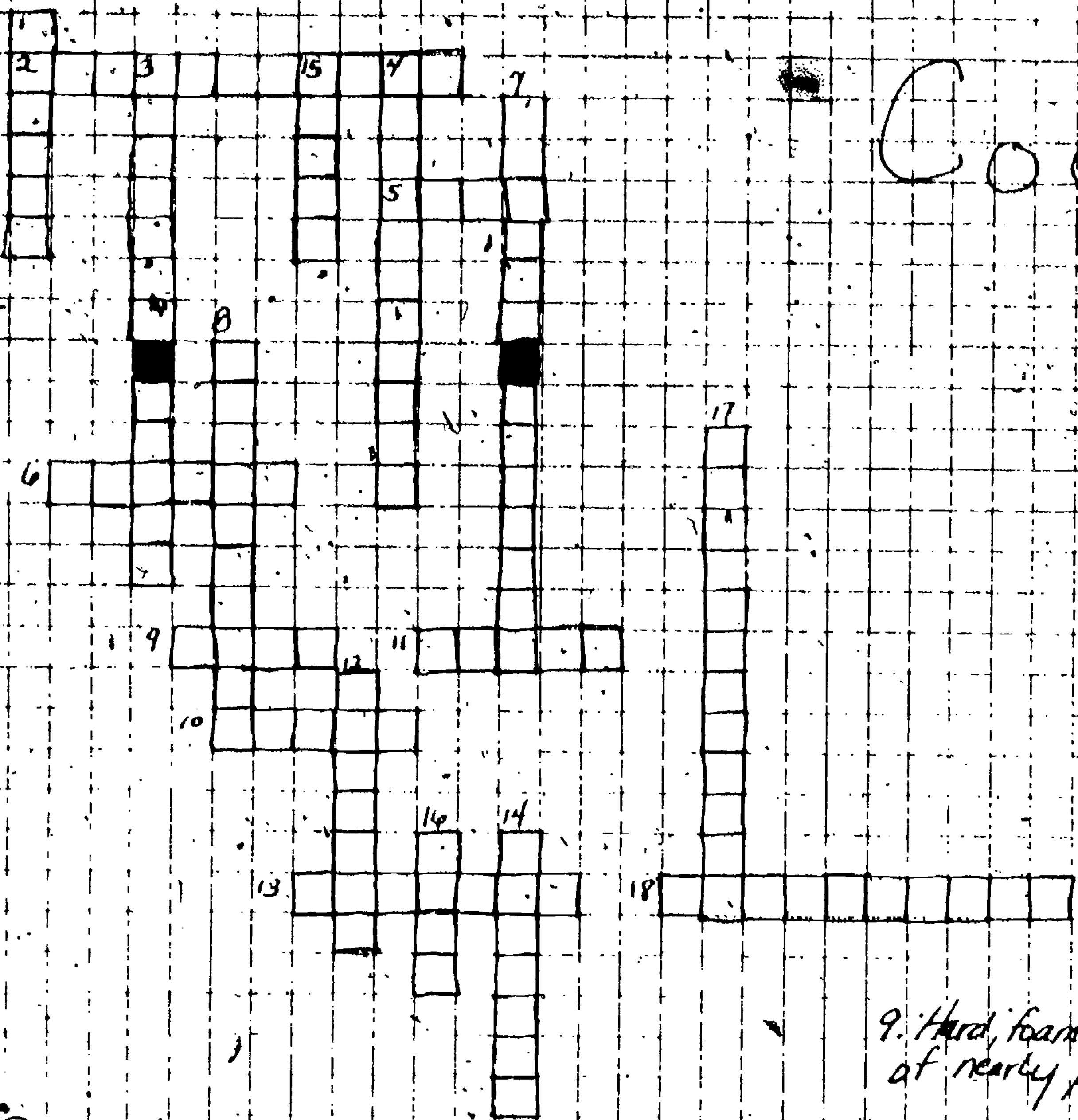
1. When did coal become important as a fuel in the United States? Why?

2. What caused a decrease in coal production in the U.S. in the 1950's?

3. Presently, what has led to an increase in coal production and use in the U.S.?

4. Who first industrialized coal use?

5. In the future, coal will be primarily used to produce ______________.



Coal

DOWN

1. main element in coal used to rank it

3. amount of heat a given amount of coal will yield

4. 68% of our coal is used for producing ____

7. poisonous gas given off from burning coal

8. most plentiful coal but 50% has medium or high sulfur content

1[illegible]. product made for coal used by many women

1[illegible]. brown coal with low heating value

15. 1st country to industrialize coal.

16. Pollutant given off by coal gas.

17. making gas from coal

ACROSS

2. Coal type with largest amount of carbon

5. 80% of fuel left in U.S. is ____

6. Element found in coal that combines with O_2 to produce a poisonous gas.

9. Hard, foamlike mass of nearly pure carbon

10. Most coke is used in the production of iron and ____

11. Coal is used in turbine plants to generate ____

13. product of coal used in fertilizer

18. The ____ revolution created a great demand for coal

QUIZ- Uses of Coal

True or False

_____1. Coal is a true mineral.

_____2. Coal is usually classified by the amount of carbon it contains.

_____3. Lignites have the greatest heating value of all coal types.

_____4. Coal provides about 18% of our energy needs in the U.S..

_____5. Our government predicts that coal use will decrease in the next five years.

_____6. Research is being done in using coal to fuel cars.

_____7. Hydrogenation is a process where coal is treated with hydrogen gas to form a liquid fuel.

_____8. Coal was first used industrially in England.

_____9. Coal gas has a high heating value and is pollution free.

_____10. Liquefaction is a process where coal is made into a liquid fuel.

_____1. In the U.S., there is enough coal to last A) 20 years B) 200-300 years C) 1000 years

_____2. The most widely used coal type is A) anthracite B) bituminous C) lignite

_____3. A poisonous gas that is given off when coal is burned is A) CO_2 B) $HS)_2$ C) SO_2

_____4. Coal that is best for heating homes is A) anthracite B) lignite C) bituminous

_____5. The chief use for coal is A) raw materials B) the production of electricity C) home heating

_____6. Which is not a raw material or by-product of coal? A) perfume B) coke C) ammonia D) sugar

_____7. Coke is made in a process called A) carbonization B) liquefaction C) gasification D) naturalization

_____8. In 1950 in the U.S., A) coal use increased because wood was not convenient B) coal use increased because of industrial growth C) coal use decreased because of the increase in use of natural gas and petroleum.

_____9. Lignite has A) a high heat value and high sulfur content B) a low heat value and low sulfur content C) a high sulfur content and low heating value

_____10. The 2 things that determine how coal is used are A) chemical content and moisture content B) where it is mined and how it is transported C) the energy shortage and OPEC

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1 ENVIRON-MENTAL Problems with Using Coal

AIR WATER STRIP MINING

2 MINE SAFETY

By

MARY HERRON

July 28, 1981 TSU

BEHAVIORAL OBJECTIVES:

(1) The student should be able to write the chemical formulas for: sulfur dioxide, carbon monoxide, carbon dioxide, and water.

(2) The student should be able to list 5 major air pollutants produced from coal combustion and list major environmental effects of each pollutant.

(3) The student should be able to define 12 terms related to environmental effects of coal use.

(4) The student should be able to describe, in general, the steps of "strip mining" for coal and the process of reclamation of strip mined land.

(5) The student should be able to demonstrate the complexity of the issues of energy use/environmental problems.

VOCABULARY LIST

1. aquatic--refers to water
2. chlorophyll--green pigment in plants necessary to enable plants to produce oxygen, and sugar from sunlight, water, and carbon dioxide.
3. combustion--burning
4. corrosion--wearing away of solids, especially by chemical action
5. emit--give off, produce, send forth, release
6. fly ash--solid particles produced by burning of a substance
7. ppm= parts per million
8. reclamation--restoring strip mined lands to a "usuable" condition
9. sedimentation--solid particles (usually soil) that settle into water (streams, ponds, etc)
10. siltation--(see sedimentation)
11. thermal pollution--addition of heat to the environment, usually to a body of water
12. CO--chemical formula for carbon monoxide
13. CO_2-- " " " " dioxide
14. H_2O-- " " " water
15. SO_2-- " " " sulfur dioxide

COAL

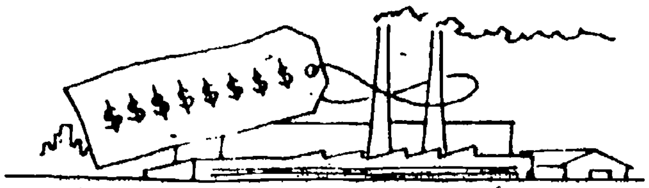
The U.S. has vast reserves--enough to last 500 years or longer at present usage rates. Only about 19% of our energy is now supplied by coal.

The government wants to double this by substituting more coal for oil and natural gas to generate electricity.

However, it won't be easy, because of--

EXPENSIVE TECHNIQUES

To meet clean air regulations, pollutants in coal must be removed with costly devices called "stack gas scrubbers," or by using expensive new gasification, liquefaction, or other techniques.



POSSIBLE CLIMATE CHANGES

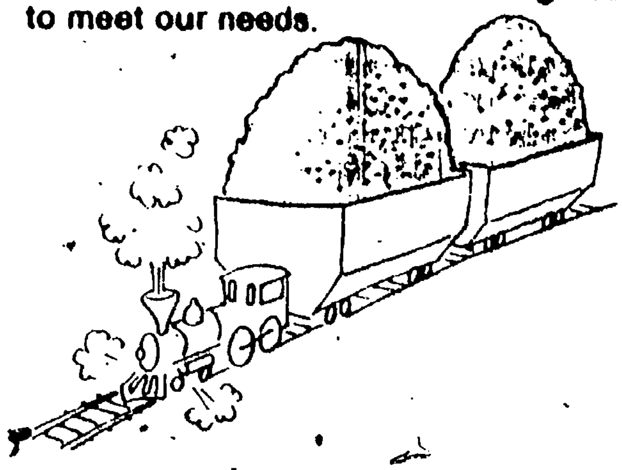
There are also fears that if too much coal is burned our climate might be affected.

POLLUTION PROBLEMS

Burning much greater amounts of coal would worsen the "acid rain" problem. The hot fumes from smokestacks react with moisture in the atmosphere to form sulfuric acid, which returns to earth as acid rain -- with devastating effects on plant and animal life.

TRANSPORTATION PROBLEMS

There is also the question of whether our rundown railroads can haul enough coal to meet our needs.



FACT SHEET: WATER POLLUTION
"Thermal Pollution"

Thermal pollution is the addition of heated water into rivers and other bodies of water. The burning of coal releases immense amounts of heat, much of which is released into some body of water. Especially at fault are steam generating plants that produce electricity.

PROBLEMS:

(1) Warm water holds less oxygen than cool water. Aquatic life is affected.

(2) Most chemical reactions take place faster in warm water.

SOLUTIONS:

(1) Heat may be dissipated by cooling towers or ponds.

(2) Sometimes the same water is used over and over for cooling (ex: Gallatin Steam Plant).

(3) Experiments are being carried out with catfish grown in the warmer discharge water. Good results have been obtained so far.

FACT SHEET: WATER POLLUTION
"Sedimentation"

Sedimentation often refers to soil particles that become suspended in, or fall to the bottom of, streams and ponds. Sedimentation is often the result of strip mining of coal.

PROBLEMS:

(1) Siltation cuts down on the amount of light entering the water--plants thus grow poorly.
(2) Suspended silt in water absorbs heat. Thus water with significant amount of silt then to be warmer than normal.
(3) The eggs and larvae of some animals (especially shell-fish) are very sensitive to silt.
(4) Silt makes water unsuitable for drinking by humans.
(5) Silt causes abrasion to organs of water animals.

SOLUTIONS:

(1) Careful management of strip mined land.
(2) Sedimentation pooools for settling water before it enters streams.

FACT SHEET: WATER POLLUTION
"Acidity"

Acidity is the lowering of the ph concentration in waters. Acid waters often are formed from coal mines (mainly deep or shaft mines). The sulfur in the coal forms sulfuric acid in water.

PROBLEMS:

(1) Many aquatic organisms are very specific as to the ph of the environment in which they can exist.

(2) Acid water adds to the acidity of local water supplies.

SOLUTIONS:

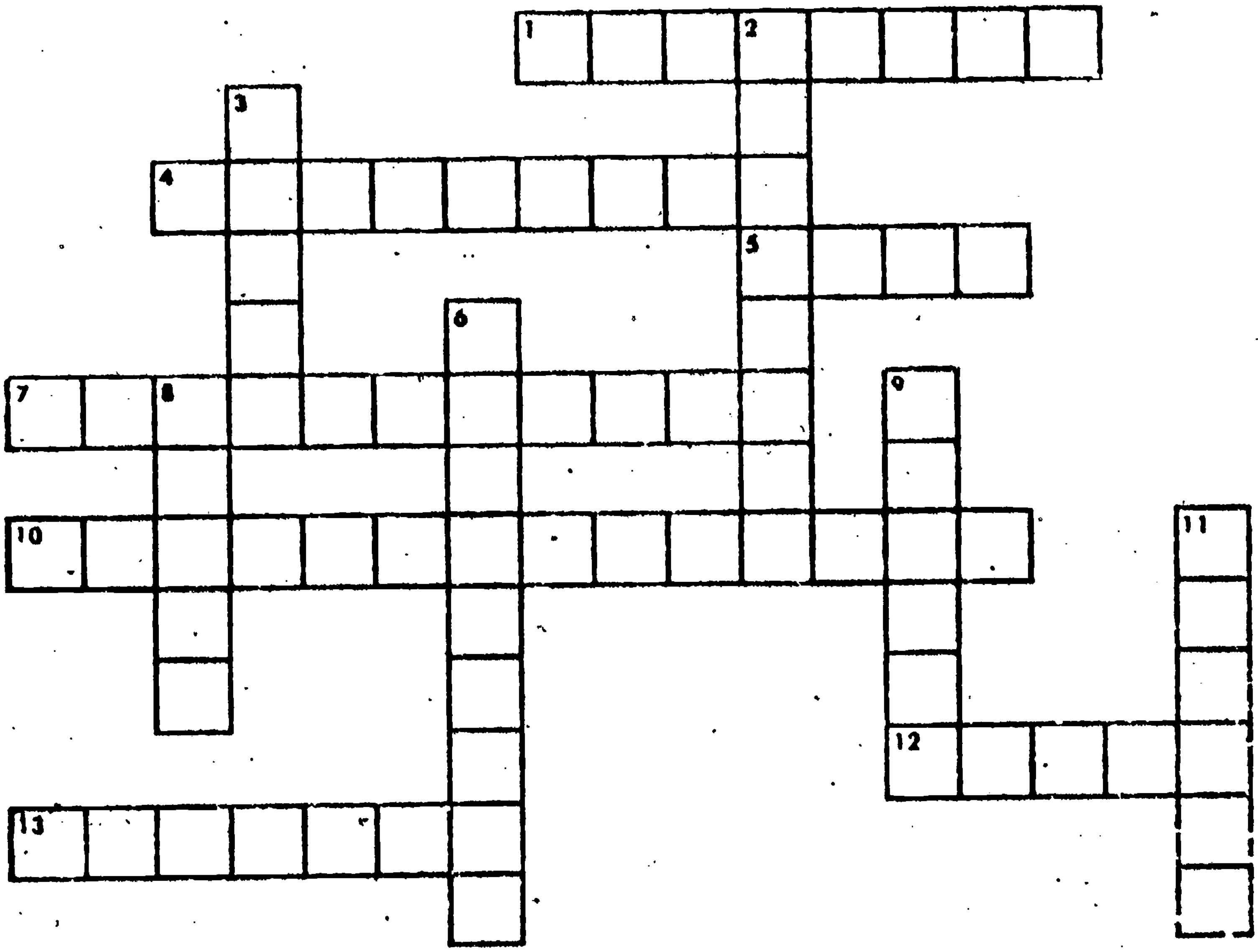
(1) Mine acid can be neutralized by using a base such as limestone. (This is very expensive and also adds "hardness" to the water.)

(2) Prevention of the entry of the acid water into the local water supply can be accomplished by dams on strip mined land or the early establishment of ground cover such as grass or trees on reclaimed stripped land.

Directions: Words and terms relating to water pollution are given with the letters scrambled. Read the definition for each and unscramble the letters.

1.	DTPSEEISIC ________	– Poisonous chemicals often eventually deposited in our waters and used initially for destroying insect pests
2.	RLONCHEI ________	– A chemical used to purify water and destroy germs
3.	ARW WESGAE ____ ________	– Untreated wastes from sanitary sewers
4.	LATUPOTLN ________	– Any substance that pollutes the water or other substances
5.	TRAMNETET ALPTN ________ ________	– A place where raw sewage is treated before disposal
6.	LEWFILID ________	– Organisms other than human life which suffer from water pollution
7.	COLXITOOGY ________	– The science dealing with the detection, effects, and antidotes for poisons
8.	LASOPSID ________	– The act of eliminating unwanted waste
9.	TIONFURPICIA ________	– The act of making a substance free of contamination
10.	ATHE ________	– Discharged by power plants in the cooling process and thereby upsetting the water ecology
11.	MESDITEN ________	– Fine particles of matter which settle to the bottom of water or other liquids
12.	ALAEG ________	– Water plant life which in normal amounts help to maintain the oxygen balance in lakes and streams
13.	RLFEISREZTI ________	– Usually a combination of phosphates, nitrogen, and other plant nutrients used to promote plant growth; often washed into our waters and causing a spurt in algae growth with dire consequences

POLLUTION OF OUR WATER



ACROSS

1. ________ may get sick or die by drinking water from polluted streams.
4. ________, where goods are made, often pollute streams.
5. ______ water is safe to drink.
7. ________ ________ carry rain water from towns and cities to streams. (2 words)
10. A place where sewage is treated (2 words)
12. Water running over ________ in a stream is not always safe to drink.
13. Not clean

DOWN

2. The act of getting rid of something
3. Clean ________ in lakes or streams is becoming hard to find.
6. A cleaning product that often pollutes our water
8. The large body of salt water, called an ________, also has pollution.
9. A ship used for carrying oil
11. Any ________, a chemical dangerous to man, may pollute our streams.

FACT SHEET: AIR POLLUTION
"Sulfur Dioxide" (SO_2)

Sulfur dioxide is a gas produced primarily by coal combustion (approximately 87% of all sulfur dioxide in the U.S. comes from coal combustion--Ohio is thought to be the state with the heaviest SO_2 emission)

PROBLEMS:

(1) "acid rain" is produced by the combination of SO_2 and water. Sulfur dioxide may be transported hundreds of miles in the air before it "falls out" as acid rain.

(a) acid rain corrodes marble, limestone, mortar, steel, iron and zinc. (The Taj Mahal and Parthenon show evidence of this)

(b) Although experts disagree, there is some evidence that acid rain "spots" plant leaves and leaches nutrients from them.

(c) highly acid waters affect the development of fish eggs

(2) SO_2 in the atmosphere :

(a) increases the drying time of some paints

(b) high atmospheric concentrations of SO_2 for short times causes dead areas on plant leaves; lower atmospheric concentrations over a longer period of time causes yellowing of leaves and lowers the amount of chlorophyll in a plant.

(c) SO_2 is absorbed by leather and consequently weakens it

(d) Paper absorbs SO_2 and becomes discolored and brittle.

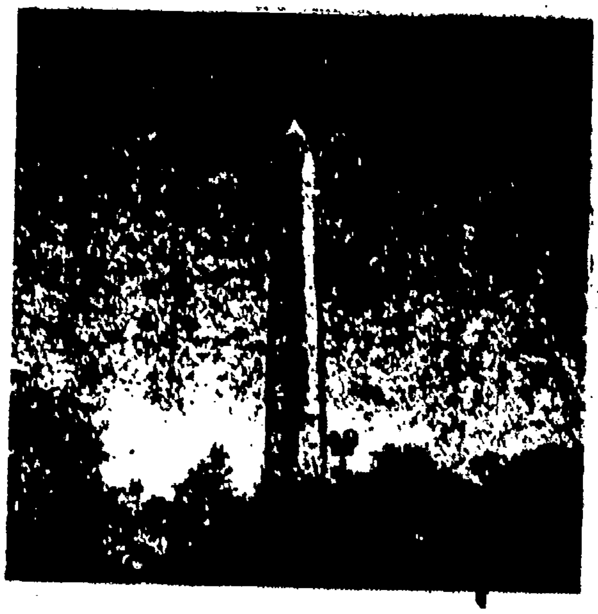
SOLUTIONS(?)

(1) Burning low-sulfur-content coal.

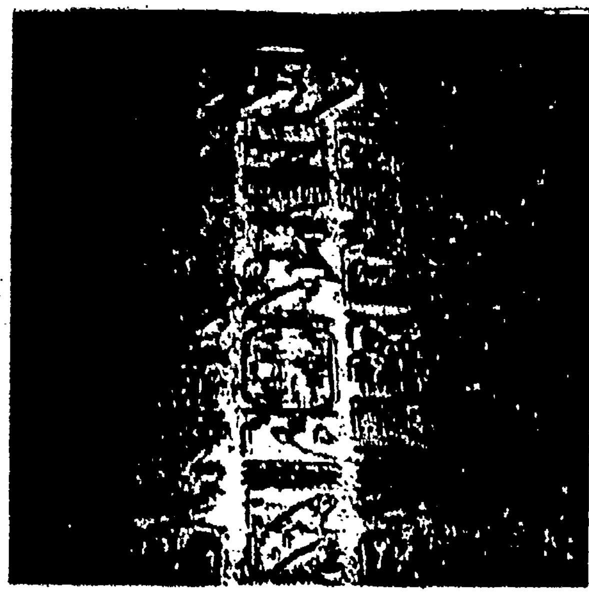
(2) Cleaning coal before burning it

(3) Fluidized bed combustion--crushed coal is burned in a bed of limestone which captures the sulfur chemically. Then the waste product is discarded (another problem).

(4) The 1977 Amendments to the Clean Air Act of 1970 requires all new coal burning industries to use smokestack scrubbers to remove sulfur, and most existing facilities to retro-fit scrubbers when feasible. (Most industries consider scrubbers uneconomical as they are expensive, and tend to break down often.)



Cleopatra's needle" in NYC is an example of air pollution. It was sent to the U.S. in 1880's.



This is the east side of the monument. The inscription is clear and legible.

This is the west side of the monument. The chemicals in NY's air, carried by the prevailing westerly winds, have destroyed the hieroglyphics in 90 years!

This picture shows on the left a healthy birch leaf. On the right is the same leaf after 2 hours of exposure to air containing two parts per million of sulfur dioxide.

FACT SHEET: AIR POLLUTION

"Carbon Monoxide"

Carbon monoxide (CO) is a gas produced by coal combustion (in the U.S., automobiles produce more than 180 times the carbon monoxide that coal combustion produces).

PROBLEMS:

(1) high levels cause suffocation of humans and animals

(2) very high levels may inhibit bacterial-nitrogen-fixation of legume plants

SOLUTIONS:

experts seem to agree that no significant impact on vegetation and animal life is likely

FACT SHEET: AIR POLLUTION
"Nitrous Oxides"

Nitrous oxide is a gas produced by coal combustion (however, coal combustion accounts for only 1/3 as much nitrous oxide as do automobiles).

PROBLEMS:

(1) nitrous oxide affects people and animals' respiration (100 ppm is lethal to most animals).

(2) causes damage to plants exposed to it--spotting, even rotting (10 ppm= a 60-70% decrease in the rate of photosynthesis).

(3) can form "acid rain" when NO_2 (nitrous dioxide) combines with water (H_2O)

(4) NO_2 and NO (nitrous oxide) are main ingredients of photochemical smog (NO_2 and NO react with sunlight to produce ozone--O_3)--photochemical smog damages food crops

FACT SHEET: AIR POLLUTION
"Carbon Dioxide."

Carbon dioxide is a gas produced naturally by plants and by the combustion of coal.*

PROBLEMS:

(1) Carbon dioxide (CO_2) in the atmosphere causes the atmosphere to retain more of the sun's energy than it now does. This could raise the average temperature of the earth which could:

(A) Melt polar ice caps if the earth's temperature increases 7-12 degrees--this could flood coastal areas as seas rose. This warming of the earth is often called the "greenhouse effect".

SOLUTIONS (?)

At the present the federal government has declared no acceptable or official policy on CO_2 emissions.

* Since 1850 the amount of CO_2 in the atmosphere has increased by 10 %. ½ of that increase has occured in the last 10 years. Predictions are that in 1990 the CO_2 level will be double what it was in the mid '70's. The National Energy Plan I (1977) encouraged large users of oil and natural gas to switch to coal when possible. Therefore levels of CO_2 from coal combustion will continue to rise.

FACT SHEET: AIR POLLUTION
"Particles"

Particles (often called fly ash) are released into the air by the combustion of coal.

PROBLEMS:

(1) Particles MAY interfere with photosynthesis in green plants.

(2) Particles reduce visibility by scattering light.

(3) Particles speed up corrosinn of materials by serving as nuclei to which moisture may adhere.

(4) Particles may damage paint especially on cars.

(5) Particles may be decreasing the amount of the sun's radiation reaching the earth.

(6) Particles cause wear on substances by causing more frequent cleaning of surfaces.

SOLUTIONS:

(1) Settling chambers may be used.

(2) Wet scrubbers may be used.

(3) Electrostatic precipitators may be used (these remove 99+% of fly ash.

FACT SHEET:

"ENVIRONMENTAL IMPACT OF STRIP-MINING (SURFACE MINING) OF COAL"

WHAT IS SURFACE MINING?

Some coal seams are near enough the earth's surface that it is economically feasible and technologically possible to "strip" off the covering earth to reach the coal. Enormous machines ("Big Muskie"--the world's largest earth mover can scoop 325 TONS of earth in one bite) scoop off the earth and dig out the coal. Until very recent times, much of this damaged ("raped") land was left useless and unprotected.

WHAT ENVIRONMENTAL PROBLEMS ARE CAUSED BY STRIP MINING?

Wildlife habitats are destroyed by the changes in land.
Soil erodes and is often deposited into local streams.
Sulfuric acid is formed from water running over exposed coal.
Land and property values near strip mining sites often decline in value.
Un-reclained land is an eye-sore (visual pollution).
Flooding often occurs due to lack of cover crops (grasses, trees) on stripped hills.

WHAT SOLUTIONS ARE THERE?

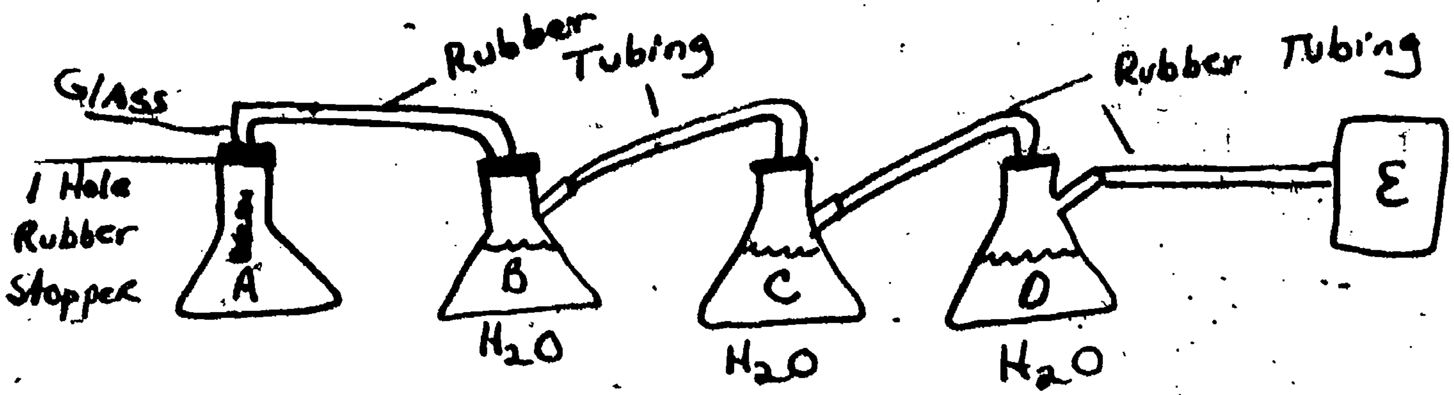
In 1977 the Surface Mining Control and Reclamation Act (SMCRA) was passed by the federal government. This law requires mine operators to plan reclamation (to ecological vitality) of land before they are issued a permit to mine; to provide for inspections and penalities for violations of strip mining operations.

The power of enforcing this law lies mainly with the fifty states.

Reclamatinn involves soil studies and wildlife studies

before mining begins. It also requires that water quality tests be carried out during the mining operation. Many small mining companies cannot afford the cost of these procedures. The mining company is to reclaim the land, not necessarily to its original state but "to avoid or correct damage to land and waters of the vicinity, and leave the area in a usable condition". Grading of land and planting of some cover (grass, shrubs, etc.) is done to prevent soil erosion and begin re-vegetation. Sometimes reclamation takes place as the mining proceeds.

Scrubber Demonstration



A. Put a Burning match / Lighted paper in flask A

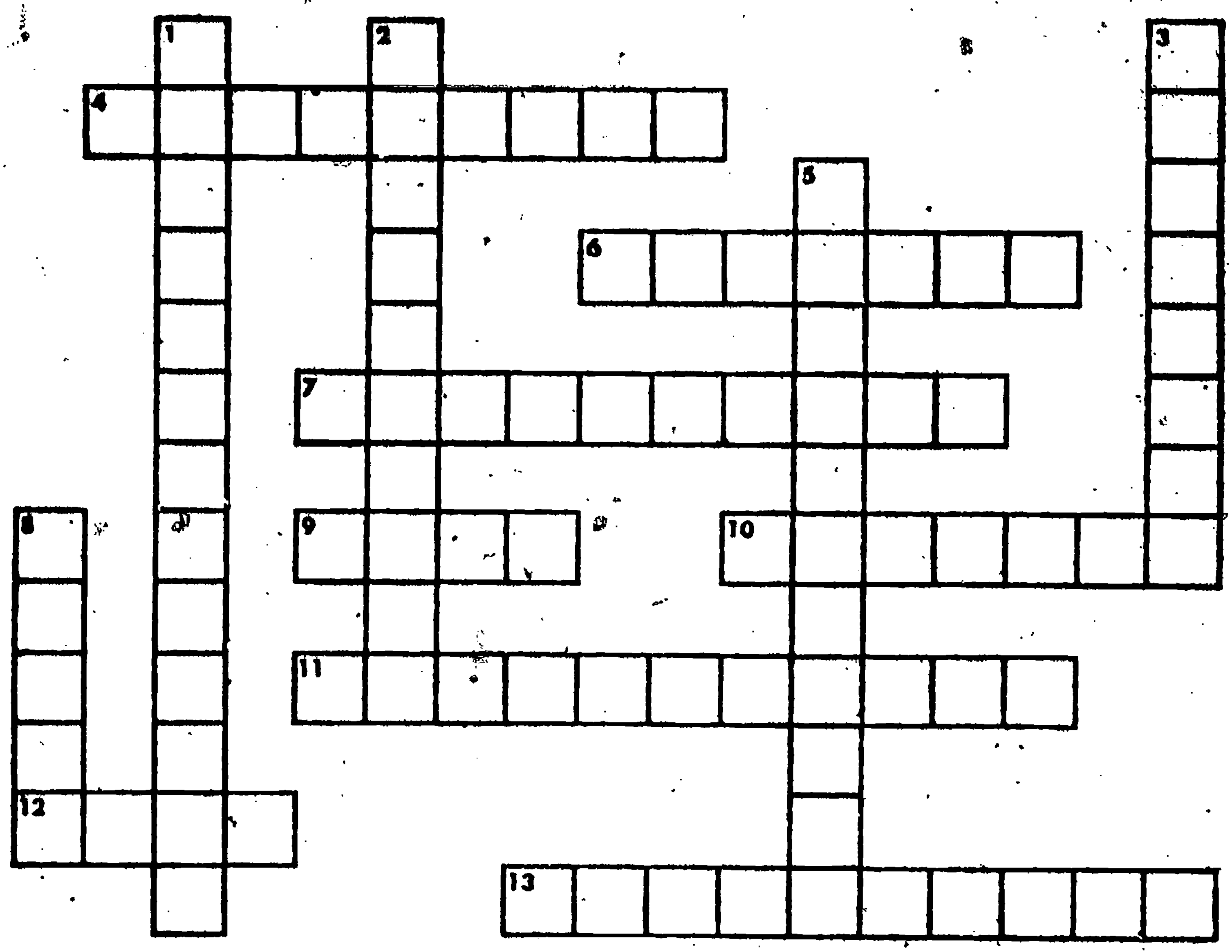
B. Water in FLASK B becomes dirty as smoke impurities are caught in water

C. Water in Flask C also contains some discolaration

D. Water in Flask D contains an even smaller degree of discolaration

E. a vacuum pump is used to pull smoke through B, C, D.*

* B, C, D are simple water scrubbers



ACROSS

4. Any substance that pollutes other substances or materials
6. The escape of gases into the air from an engine
7. The motion or process of burning
9. The __________ often carries air pollution to other areas.
10. A manufacturing plant that often pollutes the air
11. Air pollution may cause ________________ diseases.
12. A mixture of smoke and fog found in many large cities
13. A chimney or pipe that discharges smoke into the air

DOWN

1. The result of being made impure by mixture or contact
2. A transportation vehicle usually guilty of polluting the air
3. The quality or state displaying a lack of purity
5. Being capable of emitting particles of radiation
8. The part of the living body first affected by air pollution

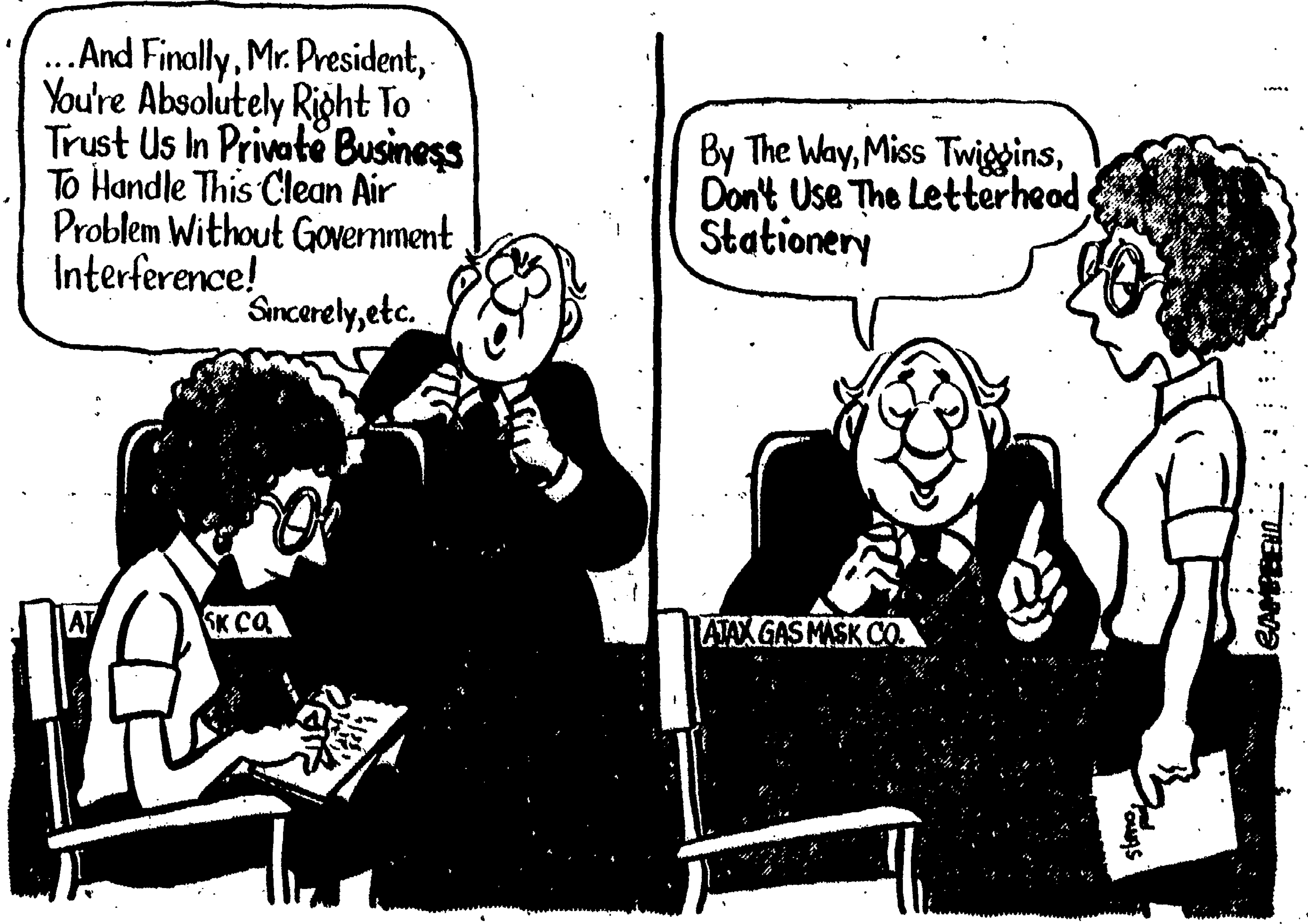
ACTIVITY:

"What does it mean"

Instructions:

(1) Choose one of the following cartoons. Discuss on paper what you think it means.


WHY YES, THE LOADED COAL TRUCKS DO GO THAT-A-WAY. HOW'D YOU KNOW?
CAMPBELL


...And Finally, Mr. President, You're Absolutely Right To Trust Us In Private Business To Handle This Clean Air Problem Without Government Interference!
Sincerely, etc.
By The Way, Miss Twiggins, Don't Use The Letterhead Stationery
ATAX GAS MASK CO.
CAMPBELL

FACT SHEET: COAL MINE SAFETY

Most mine accidents occur in underground mines rather than surface mines. Since 1900, more than 100, 000 miners have been killed in U.S. coal mines.

Mine accidents fall into 4 basic categories:

(1) accidents involving machinery (the majority of strip mining accidents are of this type).
(2) accidents involving roof and wall failures of mines.
(3) Accumulations of gases in mines.
(4) concentrations of coal dust.

SOLUTIONS:

(1) To help prevent accidents involving machinery (and all other accidents) all new miners are given a course in mine safety.
(2) Mining engineering helps prevent roof and wall failures. As coal is dug out, pillars of coal are left to help support the "roof" of the mine. Bolts are also used in the roof structure.
(3) Methane occurs naturally in coal seams. Methane of 5-15% in air can cause a violent explosion. Carbon dioxide (CO) is a poisonous gas that causes suffocation. Blasting in an underground mine may produce dangerous levels of CO. A powerful fan at the surface of the mine forces fresh air in and polluted air out. All underground mines have an automatic methane detector that shuts the mine down if methane levels reach 2% or more.
(4) Coal dust mixed with methane is explosive. Coal dust particles are also responsible for the respiratory disease "black lung". Coal dust is controlled by straying the mine surfaces with water and powdered limestone which dilutes the coal dust.

EVALUATION ENVIRONMENTAL PROBLEMS IN USING COAL AND MINE SAFETY

match put the letter of tha answer. Some answers will be used MORE than ONE TIME!!!!!!

_____1. Main component of photochemical smog

_____2. If levels get high enough, may raise the average temperature of the earth's atmosphere

_____3. particles formed from burning

_____4. electrostatic precipitators are used to remove this pollutant

_____5. a gas capable of suffocating

_____6. an air pollutant that is produce Mainly by coal combustion

_____7. a gas that might be eliminated by burning low sulfur coal

_____8. cuts down on the amount of light entering a stream when it is present in the stream

_____9. a "Major" problem resulting from strip miing

_____10. heavy concentrations may reduce visibility by scattering sunlight (also damages paint--especially on automobiles)

A. carbon monoxide

B. sulfur dioxide

C. carbon dioxide

D. nitrous oxides

E. fly ash

F. sedimentation

11. List one effect of "acid rain".

12. Explain how coal combustion can cause acid rain.

13. What is meant by the "greehouse effect"?

14. What are the purposes of strip mine reclamation?

<u>match</u> put letter of correct answer in blank

_____15. thermal pollution	a. green pigment used by plants in making food
_____16. photosynthesis	b. refers to water
_____17. combustion	c. refers to burning
_____18. reclamation	d. process by which green plants produce sugar and oxygen
_____19. chlorophyll	
_____20. aquatic	e. refers to adding heat to the environment, (usually adding hot water to cooler water)
	f. process of making strip mined land "usuable"

Discuss

21. What is the major way that dangerous gases are managed in underground mines?

22. SO_2 is the chemical formula for ____________________

23. CO is the chemical formula for ____________________

24. H_2O is the chemical formula for ____________________

25. CO_2 is the chemical formula for ____________________

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Health Problems Associated with Coal

I. Respiratory Structures

II. Health Disorders Related to Coal Mining

  A. Pneumoconiosis

  B. Silicosis

  C. Anthracosilicosis - Coal Worker's Pneumoconiosis

III. The Effects of the Combustion of Coal on Humans

  A. Particulates

  B. Carbon Monoxide

  C. Sulfur Oxides

  D. Nitrogen Oxides

  E. Hydrocarbons

Behavioral Objectives

At the end of this unit, the student will be able to:

1. describe the differences between internal respiration and external respiration.
2. label a diagram of the respiratory structures.
3. match a description with the correct respiratory structure.
4. trace the path of a molecule of oxygen from the time it enters the respiratory system until it is absorbed by the blood. Listing over what structures it passes, and describing the effects each has on the oxygen molecule.
5. list six factors which appear to be associated with the development of silicosis.
6. describe how particle size affects the contraction of silicosis.
7. define - silicosis, pneumoconiosis, anthracosilicosis, and anthracosis.
8. describe how the Federal Coal Mine Health and Safety Act of 1969 has improved the working conditions of miners.
9. describe some physical symptoms associated with silicosis.
10. describe how the upper respiratory system provides a protective mechanism for the body.
11. list five occupations commonly associated with silicosis.
12. list five primary pollutants found in the atmosphere.
13. define particulate and pulmonary edema.
14. describe how carbon monoxide poses a threat to the health of humans.
15. describe how sulfur oxides affect the body.
16. describe how nitrogen oxides affect the body.
17. describe how hydrocarbons affect the body.
18. describe how particulates affect the body.
19. write the chemical formulas for - sulfur dioxide, nitric oxide, nitrogen dioxide, carbon monoxide, carbon dioxide, carboxyhemoglobin, and oxyhemoglobin.

Health Problems Associated with Coal

Since coal dust and the gases associated with the combustion of coal have their greatest effect on the respiratory system, a review of the human respiratory structures may be presented in conjunction with this section of the unit.

Respiratory Structures

Respiration is a combination of two distinct processes, one mechanical, the other chemical. External respiration is a mechanical process controlled by the pressure of the atmosphere and the action of certain body muscles. It functions to bring air into the lungs where oxygen is absorbed by the blood, and to remove gaseous wastes brought from the body to the blood. Internal respiration is the exchange of oxygen and carbon dioxide between the body's cells and the fluids which circulate around them. This is a chemical process.

The first part of the human respiratory system with which air normally comes in contact is the nasal cavity. The nasal cavity is divided internally into two smaller cavities by a wall, called the septum.

From the nasal cavity, the air enters the pharynx. This is the region in the back of the mouth which serves as a passageway for both air and food. The lower end of the pharynx ends at the glottis. This is the opening into the larynx, or voice box. The glottis is a narrow slit, around the rim of which are the vocal cords, whose vibrations produce sound. The epiglottis acts as a trap door to close the glottis during swallowing.

The glottis opens into a roughly triangular chamber, the larynx, or

voice box. The larynx may be quite conspicuous in some men and it is commonly called the Adam's apple.

Below the larynx is the trachea or windpipe. The trachea is not a perfectly round tube, being slightly flattened along the rear surface. Its walls are composed of alternate bands of membrane and cartilage. This cartilage is quite firm but is also somewhat elastic. Thus the partial rings of the trachea maintain an open passage for the air at all times. The lining of the trachea is composed of ciliated cells that secrete mucus. The function of the cilia is to carry small particles of debris from the lungs upward to the mouth or nasal cavity so that they can be eliminated.

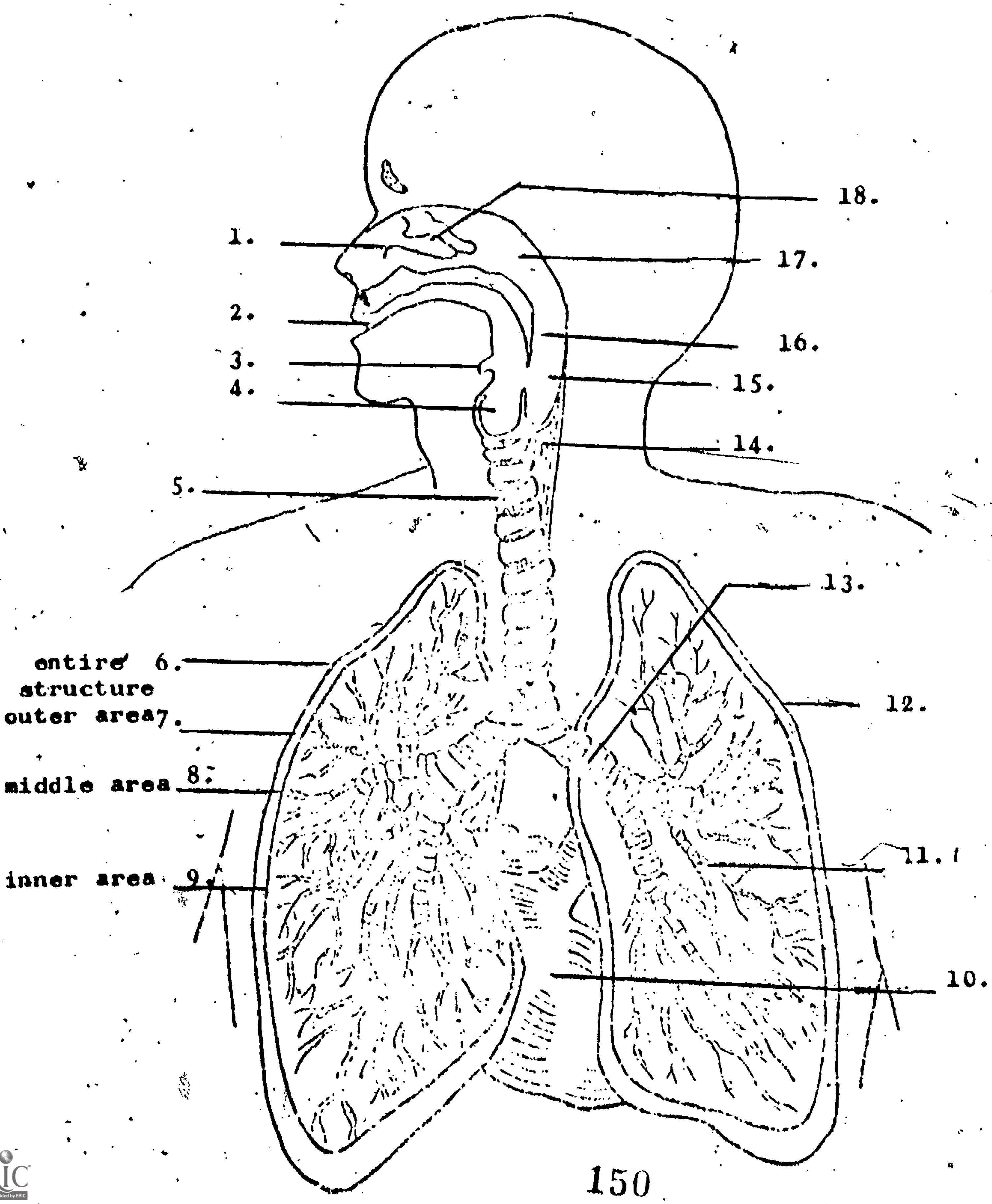
The lower part of the trachea divides into two parts, the bronchi. Each bronchus then divides many times, each division having a Y-shaped form. These small branches the bronchioles, eventually form a very large number of minute terminal branches which end in air sacs. This huge number of smallest air passages affords an adequate pathway for the passage of air into the lungs and the exit of gases from it.

The walls of the air sacs have protruding pouches called alveoli. It is through the walls of the alveoli that the actual exchange of gases takes place. Through the thin walls of the alveoli and capillaries the blood is able to obtain oxygen from the air, and give up waste gases to the spaces.

RESPIRATORY SYSTEM

Place the following labels on the diagram:

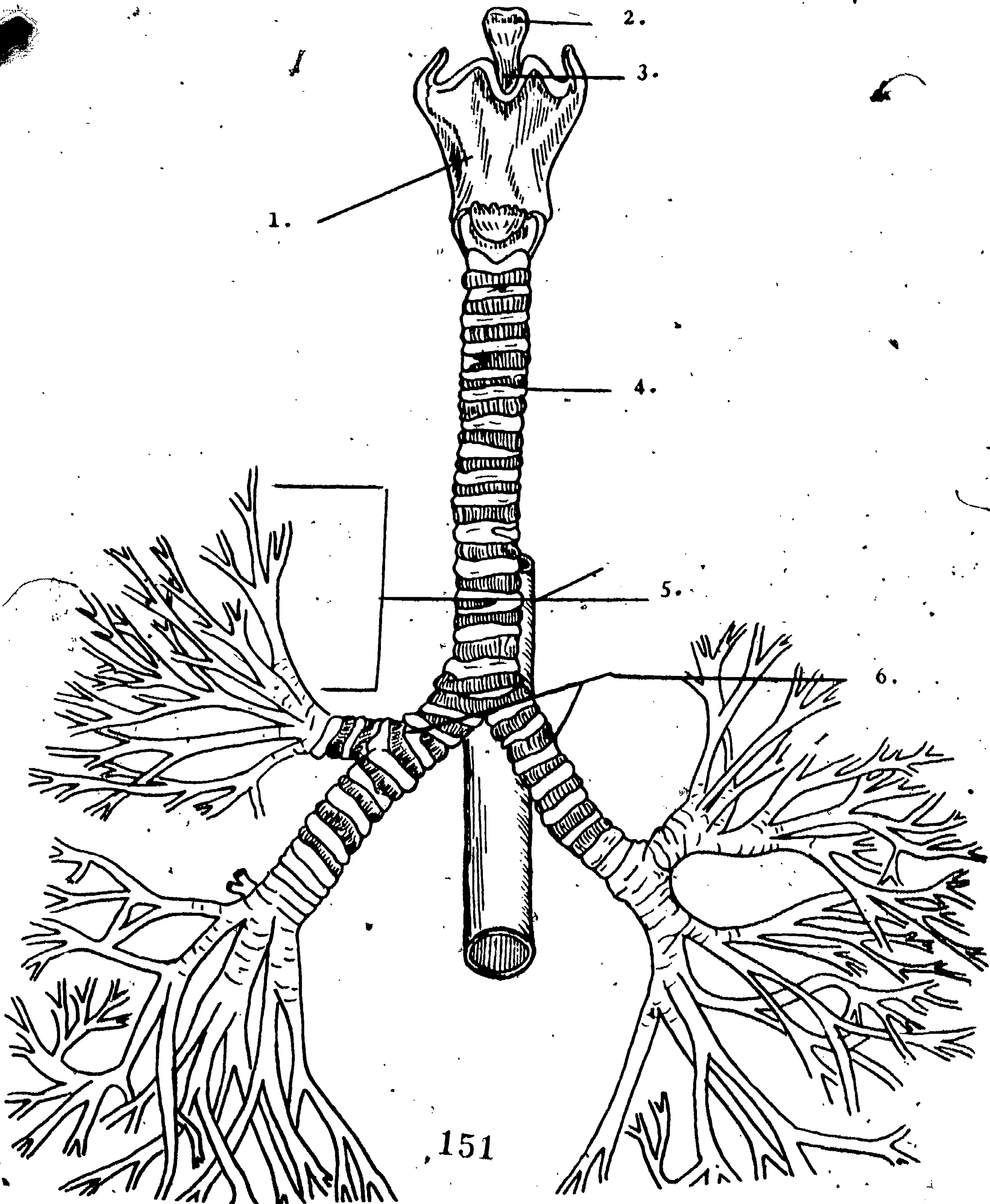
heart	trachea	nasal cavity
bronchiole	left lung	parietal pleura
oral cavity	right lung	pleura cavity
nasopharynx	bronchus	pulmonary pleura
laryngeal pharynx	epiglottis	oral pharynx
esophagus	larynx	nasal conchae



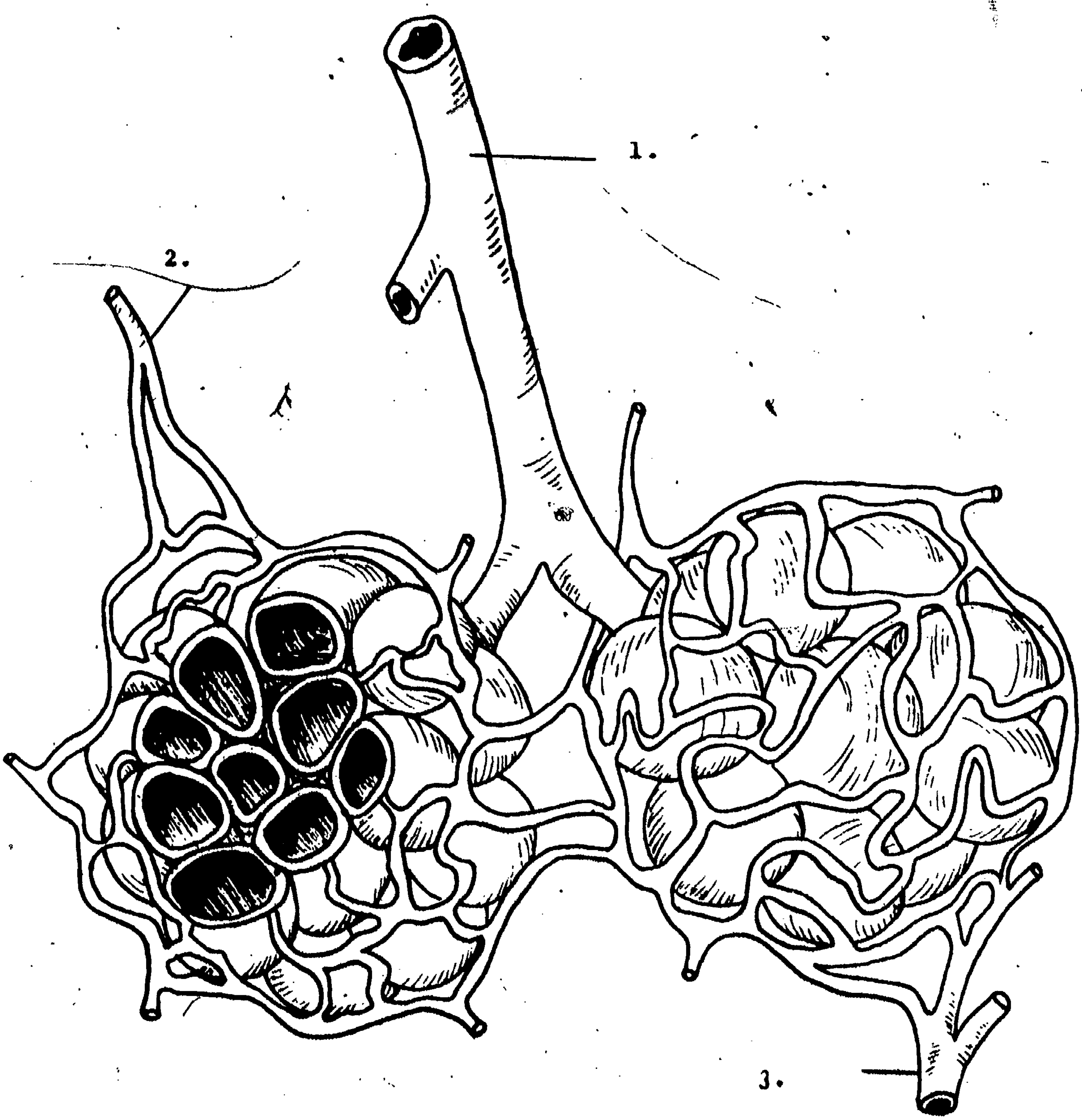
TRACHEA, BRONCHI, AND BRONCHIOLES

RESPIRATORY SYSTEM

Place the following labels on the diagram: bronchioles, esophagus, trachea glottis, epiglottis, and larynx



Place the following labels on the diagram: bronchiole, pulmonary arteriole, pulmonary venules



Matching - Match the description on the right with the correct term on the left. Use letter answers. Two answers are used twice.

____ 1. divides the nasal cavity into two halves

____ 2. a thin-walled structure through the walls of which the blood absorbs oxygen

____ 3. sometimes called the Adam's apple

____ 4. windpipe

____ 5. the region in the back of the mouth cavity which is a passageway for both food and water

____ 6. the trachea divides into a left and right of this

____ 7. the voice box

____ 8. passes downward from the pharynx anterior to the esophagus

____ 9. is used to close the glottis during swallowing

____ 10. a mechanical process of getting air in and out of the body

A. alveoli
B. bronchus
C. epiglottis
D. external respiration
E. larynx
F. pharynx
G. septum
H. trachea

Short Answer

1. Trace the path taken by a molecule of oxygen from the time it enters the respiratory system until it is absorbed by the blood. Tell over what structures it passes, and the effects each has on it.

2. Distinguish between members of the following pairs of terms:

A. air sac - alveolus

B. bronchus - bronchiole

C. glottis - epiglottis

D. pharynx - larynx

3. Describe the differences between internal respiration and external respiration.

Health Disorders Related to Coal Mining

Pneumoconiosis

Pneumoconiosis is a general term which refers to dust retained in the lungs. It is evident that everyone acquires some pneumoconiosis because varying amounts of particulate matter are retained in everyone's lungs. The coal smoke or soot pigmentation of the lungs of industrial city dwellers is a type of pneumoconiosis known as anthracosis. Autopsies have shown that the lungs of London dwellers have been black as a result of coal soot since the reign of the first Elizabeth, when England began to use coal in quantity.

Silicosis

It is necessary to use specific terminology when speaking of various pneumoconioses due to occupational dust exposures. The occupational inhalation of dust containing crystalline free silica (SiO_2) is silicosis. It results in fibrous nodules uniformly scattered in both lungs or the formation of scar tissue (fibrosis) which may be progressive with increasing impairment of lung function.

Silicosis will occur in an industry in which workers are exposed to sufficient concentrations of dust containing free silica in crystalline form in particle sizes below five microns over a long enough period of time. All types of mining in which the ore is found in quartz rock have produced silicosis.

Silicosis appears to develop as a result of certain factors, which are: 1. the percentage of free silica (SiO_2) in the dust inhaled; 2. the concentration of dust at the breathing level on the job; 3. the size of the dust particles; 4. the mixture of other dusts; 5. the time spent

in this atmosphere; and, 6. individual differences in susceptibility.

Usually it takes at least five years of exposure to concentrations of more than five million particles per cubic foot of dust with at least fifty per cent silica content to produce clinical silicosis. But, this does vary with individual differences in susceptibility.

All particles that are larger than ten microns in size are filtered out by the protective mechanism of the upper respiratory tract and bronchi. Dust particles less than five microns in size are carried by inhaled air to the alveolar ducts. These particles are engulfed by phagocytes and carried to the lymphatic stream and the pulmonary lymph nodes. Silica causes an excessive build up of scar tissue cells which results in silicotic nodules. When silica dust is excessive, individual nodules may become large and numerous, and this may cause overdistension of the lungs.

The onset of silicosis is gradual and not recognized. Often it is years before a diagnosis can be made. Then shortness of breath on exertion may precede other symptoms. Cough and wheezing appear next. Expectoration of dark grey or black spectum occurs with respiratory infections. When the third stage develops, there may be chest pains. Blood spitting usually means a complicating tuberculosis.

Pulmonary tuberculosis is the chief complication of silicosis. The cellular toxicity of silica tends to stimulate multiplication of tubercle bacilli. Silicotuberculosis often is progressive and is usually fatal. According to a study conducted by L. U. Gardner in 1937, coexistent pulmonary tubersulosis was found in 75 per cent of fatal cases of silicosis in South African gold miners and in 65 per cent of a large group of silicotic lungs drawn from a wide variety of industries. Chronic bronchitis also occurs in a high portion of advanced silicotics. Emphysema is a fairly frequent end stage of those with advanced silicosis.

The chest X-ray affords the basis for diagnosis. The nodules of simple silicosis are revealed on the X-ray film when they are about two millimeters in diameter. The degree of disability can be determined by testing the maximum breathing capacity or the maximal expiratory flow rate of the patient.

Silicosis is a permanent condition, irreversible by any treatment. With simple nodular silicosis the prognosis is good, provided that further silica dust exposure is reduced to a safe level or is stopped altogether and also provided that tuberculosis is prevented.

Anthracosilicosis - Coal Worker's Pneumoconiosis

Coal dust inhaled in heavy concentrations over many years results in simple dust accumulation and the formation of scar tissue which causes impairment of the lungs. Coal dust without any associated silica can cause damage to lungs because of bronchial irritation and emphysema. The results being the development of breathlessness and impaired ventilatory functions.

The effects of coal dust on the lungs has been studied in the anthracite mines of eastern Pennsylvania. Most disease occurring in anthracite miners either in anthracosilicosis (coal dust plus silicosis) or anthracosilicotuberculosis because hard coal mines entail much rock dust exposure high in silica content. Active tuberculosis has been quite prevalent in the silicotic hard coal miners.

In bituminous or soft coal, the silica dust exposure is decreased, and therefore, the incidence of active tuberculosis has been considerably less than in anthracite miners.

The incidence of coal worker's pneumoconiosis varies in different coalfields and even between different mines in the same coalfield. It is

more common among miners working in pits with small, deeply situated coal seams, and the incidence also rises with increasing mechanization.

Miners employed as hard headers and rockworkers in the construction of communicating shafts between adjacent seams or bridging geological fault, work almost entirely in hard siliceous rocks and are consequently exposed to a higher concentration of silica dust than those at the coal face.

Coal mine dust when inhaled is fairly evenly distributed throughout the lungs, but the maximal changes occur in the upper two-thirds of both lungs. The majority of the particles are ingested by macrophages and are removed by ciliary action which moves the bronchial mucus and trapped dust upwards to the trachea where it is either expectorated or swallowed.

Since 1969, the Federal Coal Mine Health and Safety Act has established uniform standards for coal dust concentration levels, mine ventilation, roof support, mine inspections, and equipment. The law provides for regular payments from the United States Government to miners who cannot work because they suffer from pneumoconiosis.

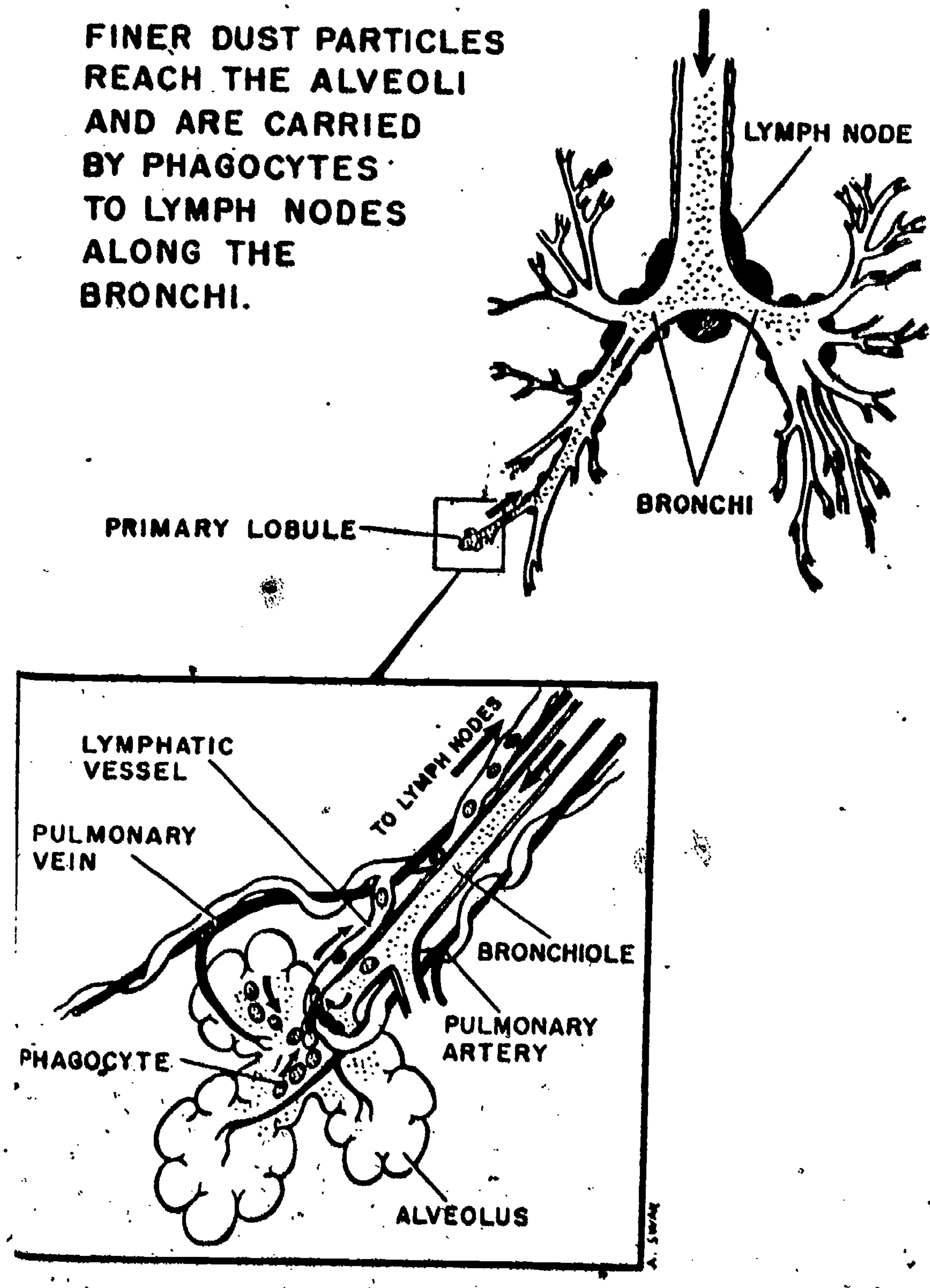
Occupations Associated with Silicosis
Table 1

1. The mining of gold, tin, copper, mica and graphite
2. The quarrying of granite, sandstone and slate
3. The dressing of granite and siliceous rocks, and stonemasonry
4. Metal grinding, casting, coremaking and knockout, casting clearing and sandblasting
5. The manufacture of pottery and ceramics
6. The manufacture of refractories
7. The manufacture of abrasive powders containing silica
8. Enamelling
9. Boiler scaling
10. The manufacture of rubber fillers

PNEUMOCONIOSIS

ROUTE OF DUST PARTICLES

FINER DUST PARTICLES REACH THE ALVEOLI AND ARE CARRIED BY PHAGOCYTES TO LYMPH NODES ALONG THE BRONCHI.



Health Disorders Related to Coal Mining

I. Short Answer

1. List six factors which appear to be associated with the development of silicosis.

2. How does particle size affect the contraction of silicosis?

3. List occupations in which the danger of silicosis exists.

4. Define - silicosis, pneumoconiosis, anthracosilicosis, and anthracosis.

5. Describe how the Federal Coal Mine Health and Safety Act of 1969 improved the working conditions of miners.

6. Why is silicosis more prevalent in anthracite miners rather than bituminous miners?

7. How does silica affect the growth of the tubercle bacilli?

8. How are the majority of coal dust particles removed from the lungs?

9. Describe some physical symptoms associated with silicosis.

II. Fill in the Blank - Fill in the blank with the correct term or phrase to make the statement correct.

1. The occupational inhalation of dust containing crystalline free silica is ________________.

2. ________________ is the chief complication of silicosis.

3. ________________ refers to dust retained in the lungs.

4. All particles that are larger than __________ microns are filtered by the upper respiratory tract and bronchi.

5. Dust particles less than _______ microns are carried to the alveolar ducts.

6. ________________ are the basis for diagnosing silicosis.

7. When coal dust is inhaled, the maximal changes occur in the upper __________ of both lungs.

8. __________ is the chemical formula for silica.

9. The ____________________________ establishes uniform standards for mine ventilation, coal dust concentration levels, roof supports, mine inspection, and equipment.

III. Unscramble the Words - Place the correct spelling of the word in the blank.

1. ______________________ GYOPAHECT - a cell which engulfs into its cytoplasm particles from its surroundings, by a process of flowing all around them

2. ______________________ OCINOTHASIRIALCSS - coal dust plus silicosis

3. ______________________ SHOARMCPAGE - phagocytic cells widely distributed in the vertebrate body

4. ______________________ INNPUNCEOOIOSS - dust in the lungs

5. ______________________ LISICA - tends to stimulate multiplication of the tubercle bacilli

The Effects of the Combustion of Coal on Humans

When coal is burned, several gases and waste products are released into the atmosphere. Among those substances released are: carbon monoxide, sulfur oxides, nitrogen oxides, particulates and hydrocarbons. These five types of substances are known as primary pollutants and account for 90 per cent of the nationwide air pollution problem.

Particulates

Particulates are small, solid particles and liquid droplets which are present in the atmosphere in great numbers. These substances may include organic compounds, metals, dusts, and sea salts. They enter the human body almost exclusively by way of the respiratory system. The extent of penetration is related to the size of the particulate.

The respiratory system is often classified into an upper system, which includes the nasal cavity, pharynx, and trachea, and a lower system, which includes the bronchi and lungs.

In the upper respiratory tract, particles greater than five microns in diameter are filtered from inhaled air. Hairs in the nasal passage form the first line of defense, but particles may also be trapped in the mucous which lines the nasal cavity and trachea.

Particles smaller than five microns escape the upper respiratory tract and enter the lungs. These particles are usually removed by cilia which line the walls of the bronchi and bronchioles. A continual wave-like motion of the cilia has the effect of moving the mucous and particles up to the pharynx where they may be eliminated.

Particles less than 0.5 microns in diameter reach and settle in the alveoli. The removal of such particles is less rapid and less complete

than from the larger particles, since alveolar membranes have no mucous covering or cilia. Thus, particulates of smaller size penetrate the deepest into the lungs and remain there the longest.

Particulates may be toxic and directly affect the body. Many toxic materials are present in trace amounts. Eight metals found in the air are considered to be toxic, among them are: nickel, beryllium, cadmium, tin, antimony, lead, bismuth, and mercury.

Carbon Monoxide

Exposure of humans to high concentrations of CO can result in death. Carbon monoxide poses a threat to health because of its ability to react with hemoglobin (Hb) in the blood. Hemoglobin functions as a transport system in the blood to carry oxygen in the form of oxyhemoglobin (O_2Hb) from the lungs to the body cells and CO_2 from the cells to the lungs as CO_2Hb. When hemoglobin combines with carbon monoxide, carboxyhemoglobin (COHb) is formed. When this reaction occurs, the ability of the blood to transport oxygen is reduced. The affinity of hemoglobin for CO is more than 200 times greater than for O_2. Therefore, when both are present, CO will form a compound with hemoglobin and oxygen will not be utilized.

The health effects of CO are discussed in terms of the per cent of COHb in the blood. When the COHb blood level is less than one per cent, there are no apparent effects on the body. When the COHb blood level is between 1.0 to 2.0 per cent, there is some evidence of effect on behavorial performance. When the COHb blood level is between 2.0 to 5.0 per cent, the central nervous system is affected. There is an impairment of time-interval discrimination, visual acuity, and brightness discrimination. When the COHb blood level is greater than

5.0 per cent, there are cardiac and pulmonary functional changes. When the COHb blood level is between 10.0 to 80.0 per cent, the individual experiences headaches, fatigue, drowsiness, coma, respiratory failure, and death.

The national air-quality standards for CO established an upper exposure limit that corresponds to an equilibrium COHb level of 1.5 per cent.

Sulfur Oxides

When the concentration of sulfur oxide is below 25 parts per million, the gas dissolves in the moist mucous lining of the upper respiratory tract, and very little is believed to penetrate deep in the lungs.

Studies conducted under the Community Health and Environmental Surveillance System Program of the Environmental Protection Agency show a definite correlation between the incidence of respiratory infection in children and the level of sulfur dioxide pollution in their environment.

It has been shown that sulfur dioxide inhaled through the mouth produces greater effects than that inhaled through the nose. The nasal cavity absorbs large amounts of sulfur dioxide.

Most of the concern about the health hazard of current atmospheric sulfur dioxide concentrations is related to their effects on the elderly, asthmatics, and other susceptible people with chronic respiratory problems.

Nitrogen Oxides

Nitric oxide (NO) and nitrogen dioxide (NO_2) are potential health hazards. Nitrogen dioxide is about four times more toxic than nitric oxide. Nitric oxide is not an irritant, and is not considered a health

hazard.

The effects of nitrogen dioxide on humans and animals are confined to the respiratory tract and occur only with nitrogen dioxide levels higher than those now found in the environment. According to the experiments conducted on human volunteers for low concentration tests and animals for the high-dosage experiments, an increase in dosage resulted in the following effect sequence: odor preception, nasal irritation, breathing discomfort, acute respiratory distress, pulmonary edema (fluid accumulation) and finally, death. Concentrations of nitrogen dioxide greater than 100 parts per million were lethal to most animals, and 90 per cent of the resulting deaths were caused by pulmonary edema.

Hydrocarbons

Currently, there is no evidence to indicate that hydrocarbons, at present air concentrations, exert any direct undesirable effects on humans. Experimental data obtained from research on humans and animals indicate that hydrocarbons produce undesirable effects only at hundreds to thousands of times higher than those now found in the atmosphere. No effects have been reported for levels lower than 500 parts per million.

The following effects have been observed in humans exposed to ozone under experimental conditions: no ill effects were noted at concentrations up to 0.2 parts per million. A level of about 0.3 parts per million appeared to be the threshold level at which nose and throat irritation began. Exposure to ozone concentrations of 1.0 to 3.0 parts per million for a period of two hours produced extreme fatigue and lack of coordination in subjects. Exposure to

concentrations of about 9.0 parts per million for similar time periods produced severe pulmonary edema in most subjects.

TABLE 6-4 TOXIC TRACE METALS THAT MAY POSE AIR POLLUTION PROBLEMS

ELEMENT	SOURCES	HEALTH EFFECTS
Antimony	Industry	Shortened life span in rats
Beryllium	Coal, industry (new uses proposed in nuclear power industry, as rocket fuel)	Probably the most toxic of the eight, it accumulates in the lungs to produce berylliosis, a serious disease, carcinogenic to rats when inhaled.
Bismuth	Coal	Low order of toxicity, kidney and liver damage in large doses
Cadmium	Coal, zinc mining, water mains and pipes, tobacco smoke	Cardiovascular disease and hypertension in humans suspected, interferes with zinc and copper metabolism
Lead	Auto exhaust (from gasoline), paints (prior to about 1948)	Brain damage, convulsions, behavioral disorders, death
Mercury	Coal, electrical apparatus, other industrial fungicides	Nerve damage and death
Nickel	Diesel oil, residual oil, coal, tobacco smoke, chemicals and catalysts, steel and nonferrous alloys	Carcinogenic properties in animals, and in humans when inhaled as the carbonyl, $Ni(CO)_4$
Tin	Iron and steel production, coal, tin plating	Low order of toxicity, decreased life span in rats and mice, liver lesions in rats

Data from "A Sensible Look at Air Pollution by Metals," by H. A. Schroeder, *Archives of Environmental Health*, December 1970, p. 803, and "Trace Metals: Unknown, Unseen Pollution Threat," *Chemical Engineering News*, July 19, 1971, p. 30.

The Effects of the Combustion of Coal on Humans

I. Short Answer

1. List five types of substances known as primary pollutants.
2. Describe how particulate size affects the depth of penetration in the respiratory system.
3. What are particulates?
4. List eight toxic metals found in the atmosphere.
5. How does CO pose a threat to health?
6. What is the function of Hb in the blood?
7. What per cent level must be reached before death due to CO poisoning takes place?
8. What happens to the majority of sulfur oxides in the body?
9. What effect does sulfur dioxide have on children?
10. How does nitrogen dioxide affect the human respiratory tract?
11. What is pulmonary edema?
12. How do hydrocarbons affect human health?
13. At what level does ozone exposure produce pulmonary edema?

II. Write the chemical formula for each of the following compounds.

sulfur dioxide	________	carbon dioxide	________
nitric oxide	________	carboxyhemoglobin	________
nitrogen dioxide	________	oxyhemoglobin	________
carbon monoxide	________		

III. Have the students write reports on the following air pollution disasters.

Denora, Pennsylvania - 1948	New York, New York - 1953
London, England - 1952	London, England - 1962

IV. Have the students use the Micro Slide Viewer Set Number - 89, <u>Air Pollution and Human Health</u> - National Teaching Aids, Inc. 120 Fulton Avenue, Garden City Park, New York 11040.

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"We have met the enemy and he is us."

Porky pine, Impollutable Pogo, Walt Kelley