Activity Book

POWER FROM COAL

AMERICAN COAL FOUNDATION

PHOTOS PROVIDED BY:

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WHERE'S ALL THIS COAL COMING FROM?

Take a minute to think about what you did this morning. You woke up, perhaps switched off the clock radio reached for the light switch, and went into the bathroom to wash your face, brush your teeth or take a hot shower. Did you use a hair dryer? Did you scramble an egg or toast a piece of bread for breakfast this morning? Did you play a video game or VCR? If you did any of these things, you were using electricity - a full-time energy servant that most Americans take for granted.

There is something else you probably never think much about - coal. It's very likely you've never seen a piece of coal, although you may remember your grandparents talking about the coal they used to shovel into the furnace to heat their home.
What's the connection? What does coal have to do with electricity? Isn't coal part of the past? Isn't electricity about as up-to-date as you can get? After all, it's electricity that allows us to watch television, use a computer, cook on the stove or in the microwave, enjoy stereo music, heat and cool our homes, read at night - all these things and dozens more that take place daily.

There is a connection between coal and electricity. More than half of the electricity used in the United States comes from coal that's burned at electric utility plants. Burning coal heats water to create the steam that drives a huge turbine which makes electricity. The electricity is transmitted to our homes, schools, businesses and factories.

Since this power plant is on a river, it receives its coal by barge. The coal is used to generate the electricity the power plant sends to factories, businesses, and homes.

COAL USES

Electricity

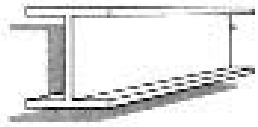
If your family uses an electric stove, it means that you use about half a ton of coal a year. If your water heater is electric, that's two tons a year. And another half-ton is burned to power your electric refrigerator. That's three tons a year, just for three appliances. That doesn't include the lights, electric washer and dryer, air conditioner - or any of the other electric appliances you use.

Coal isn't the only fuel used to make electricity. Natural gas, nuclear power, oil, power from moving water (hydro) and even the sun also make electricity. But right now and for years into the future, coal will continue to prove the majority of the electricity we use.

Heat

Major industries use coal in their factories or manufacturing processes. Coal provides heat and power to make paper and glass, and to process the food we eat.

Steel



The iron and steel industries use a special kind of coal in the steel-making process. The "metallurgical" coal is made into coke, the main fuel in a blast furnace. The blast furnace makes pig iron, that, along with scrap metal, is used in the steel-making process.

Expots

Coal is also exported to other countries, where it provides fuel for electricity and other uses. Canada, Japan, Brazil and Netherlands are major users of American coal. It seems odd, doesn't it, that this fuel that most of us never see, plays such an important role in our lives?

States With Largest Demonstrated Coal Reserves - 2003

(Billion Tons)

State	Total Reserves	Underground	Surface	% of Total U.S.
Montana	119	71	48	24.0
Illinois	105	88	17	21.2
Wyoming	65	43	22	13.1
West Virginia	33	29	4	6.7
Kentucky	30	17	13	6.0
Others	144	88	56	29.0
Total U.S.	496	336	160	100.0

Figures are rounded.
Source: U.S. Energy Information Administration

WHY COAL?

Do you wonder why we still use coal? After all, we have oil, nuclear power and even the sun as power sources. It's a good question and there are several answers.

There's A Lot of Coal

For one reason we have a lot of coal. If we used all the recoverable coal we have in the United States at the same rate we're using it today, there is enough coal to last more than two hundred years. We have much more coal than oil or natural gas. And eve though nuclear power can be used to generate electricity, it has become more and more expensive and difficult to build this type of power plant.

What about the sun or other renewable sources? In some places, wind power, geothermal energy, wood, waste and solar technologies supply energy directly to homes and businesses. These alternative sources are spread out geographically, vary with the the weather and the seasons, and produce expensive energy. Therefore, no single current technology can supply a major portion of the huge amounts of electricity demanded by homes, factories and businesses.

We Can Afford It

Another reason for using coal is the cost. Most energy sources are expensive. Over the long term, coal is usually cheaper than other fuels. If your town or city uses coal to make electricity, chances are that your family's electric bill is less than in other areas where other fuels are used.

We Know Where It Is

We already know where most of the coal is located. If you owned a company that was looking for oil or natural gas, you might spend millions of dollars trying to find these fuels, many times without any luck. Looking for coal costs money, but it is easier and cheaper to find than oil and natural gas.

We Can Protect the Environment

Early in the 20th century, coal use had a bad image because of the soot, dirt and pollution it created. But in modern times, our air has gotten cleaner even though we use much more coal today than we did 50 or 75 years ago. This improvement has come because of technologies that help reduce emissions from coal and the greater use of lower sulfur coals. In the same way, great care is taken by coal companies to restore the land which is temporarily disturbed during mining (see "Putting Back the Land - Reclamation").

Coal is a logical fuel because we have lots of it, we can afford it and we know where it is. Now let's find out how we get it out of the ground.

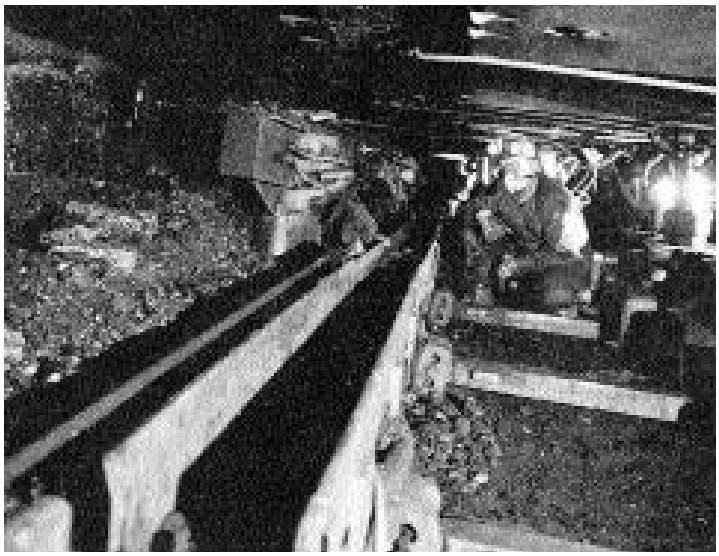
GETTING COAL OUT OF THE GROUND - MINING

The big expense in mining coal is getting it out of the ground.
Mining takes lots of equipment, many people and a good deal of planning

Underground Mining

One way to get coal from the ground is to dig a hole, or shaft, all the way down to the coal. The shaft can be as deep as several hundred feet below the earth's surface. It's like digging a well, except that when you reach coal, tunnels are dug back into the coal seam. The tunnels are used for travel, air circulation and moving coal. It is hard to imagine how an underground mind looks. The tunnels are streets and the coal represents the blocks of buildings.

Most underground mining is done by large machinery. The continuous miner has a big drum covered with metal teeth. The drum spins in a circle and the teeth break the coal from the face, the place in the mine where the cola seam is being worked. The same machine has moving arms that load the coal onto a short conveyor. The coal from the conveyor is loaded into shuttle cars. Miners drive the shuttle cars to a longer conveyor which carries the coal to the surface.



In longwall mining system, a shearer (in center) slices off coal from an underground block sever hundred feet long. Movable steel props (right) which support the roof advance after the shearer passes. Behind them, roof strata are allowed to collapse.

Every few minutes the continuous miner is moved to another area and miners using a roof bolting machine secure the roof. The machine drills deep holes in to the rock in the mine's roof. Steel rods are inserted into the holes to hold the rock in the roof together. This helps to make the mine a safe place to work.

A newer underground mining technique is called longwall. It uses a rotating shearing blade on a mining machine that moves back and forth across the coal, cutting it from the seam and transporting it away in an automatic conveyor. This type of mining produces more coal in less time than any other underground mining method.

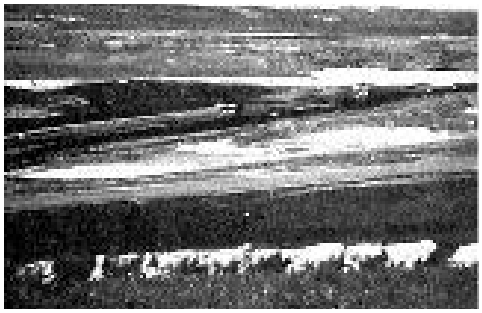
Surface Mining

Surface mining is another way to mind coal. If the coal is fairly close to the surface, usually 200 feet or less, there is no need to dig a shaft. Heavy equipment clears the land. Topsoil is removed and stored in another part of the mine to be used later in reclamation, a process which returns the land to the way it was before mining occurred. Then holes are drilled into the rock and dirt above the coal seam. The dirt and rock are called overburden. Each hole is loaded with explosives. The explosives are set-off, shattering the rock. Giant earth-moving machines, such as draglines or large power shovels, clear way the broken rock and soil until a large area of coal is exposed. Smaller power shovels scoop up the coal an load it into trucks, which take the coal from the mine to a preparation plant for cleaning and sizing.

Putting Back the Land - Reclamation

What happens to the land after the coal has been removed by surface mining? The reclamation process begins. The overburden is returned to the same pit from which the coal was removed. Next a bulldozer smooths the land. The topsoil is replaced and the area is seeded and fertilized. In other words, it is treated like a giant garden. Before too long, the land looks the same as it did before mining.

Reclamation is the last phase of modern surface mining. Examples of successful reclamation are throughout the country. If you live in Ohio, there is a huge campground and a wildlife preserve that was once a surface mine. In Pennsylvania, a golf course was built on mined land. Indiana has several parks in the southern part of the state that are reclaimed areas. How about West Virginia? There's a high school built on a mountaintop, where not too long ago, draglines and trucks were mining coal; and a hospital built on reclaimed land. Out west, in Arizona, there are cattle grazing on land restored by coal companies. If you drove past these places you would not be able to tell the reclaimed land from land that had never been mined.



Cattle grace on land that has been reclaimed after surface mining.

People Who Mine

Many people, men and women, are needed to mine coal. Geologists explore and evaluate the coal reserves. Engineers design the mine. Skilled equipment operators and highly trained individuals run the continuous miners, roof bolting equipment, shuttle cars, draglines, coal loading shovels and trucks. Safety inspectors make sure that rules of the company and government are followed. In the maintenance shop, mechanics work on machines that need to be repaired. At surface mines, reclamation and wildlife experts oversee the reclamation process and a mine superintendent directs the complete operation of the mine in much the same way that your principal oversees operation of your school. These are just some of the jobs available in the coal industry.

What is it like living in a mining town? You may already know if you are from certain parts of West Virginia, Kentucky, or Wyoming. (Those three states mine much of our coal.) In the past only men mined coal, but today about 1,000 women work as coal miners. Miners usually work eight hour shifts, sometimes at night. They are paid well and live like other people around the United States. They drive cars and pick-up trucks, shop at malls, go to movies, fish and hunt. They work hard and take pride in coal mining.

More than half of the coal produced in the United Sates comes from surface mines. This surface mine is in the Midwest. The dragline removes the dirt and rock above the coal seam. The shovels in the pit sit on top of the coal seam and load the coal into trucks that remove the coal from the pit.

Safety First

Safety is very important. At underground mines, each miner wears several items to protect himself/herself. A miner wears a hard hat with a battery-powered light to see in the mine. A self-rescuer, strapped to a miner's belt, filters out harmful gas in case something happens to the air in the mine. Ankle straps hold the miner's pant legs so they don't get caught in the machinery. A miner also wears safety glasses to protect his/her eyes. Steel-toed shoes are worn to protect his/her feet from moving machinery and rock. At surface mines, each miner wears steel-toed shoes, a hard hat and safety glasses.

When coal is mined, methane, an explosive gas, is released. The methane was trapped in the coal when it was formed millions of years ago. To be sure the mine is a safe place to work, large fans move fresh air through the mine. Miners check the air every twenty minutes to make sure enough fresh air is moving through the mine to take away harmful gases.

When you learned to ride a bike, or learn to drive a car, there are certain safety rules you must obey. The same is true for miners. They work with powerful machines, electricity, moving conveyors and vehicles, and heavy tools. You can imagine how important it is to do all these jobs carefully. Before miners work in a mine, they go to classes that train them to work safely.

This coal miner is operating a roof bolting machine that drills a hole into the rock in the roof of the mine. A long steel rod, which is inserted into the drilled hole, holds the rock together. This helps to make the mine a safer place to work.

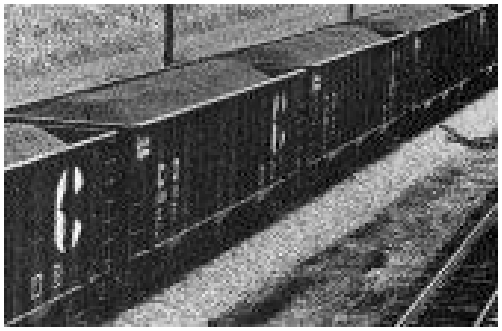
To Market, to Market

Once coal is mined, it has to be transported to the user. Trains carry most of the coal. Often a train will have 100 cars or more. This is called a unit train. A typical unit train can carry at least 10,000 tons of coal in a single shipment. The train travels directly from a mine to the user without stopping.

If a mine is located near a river, the coal may travel by barge like ones you can see on the Ohio, Mississippi, and Tennessee Rivers. Barges also move coal on the Great Lakes.

There are other ways to move coal as well. If the mine is closer to the user, coal can be sent by truck or conveyor.

Out west, coal is mixed with water and sent through an underground pipeline from Arizona to Nevada



The train loaded with coal is headed to a customer. The coal may be going to a power plant or to a factory where it will produce heat or power to make power to make paper or other products that we use.

Cleaning the Air

The sulfur in coal can cause air pollution when coal is burned. But complying with strict laws - such as the Clean Air Act - and the use of new equipment and coal burning methods have helped to greatly reduce pollution while allowing more coal to be used to generate electricity.

Some types of coal are low in sulfur and can be burned with little pollution. Other types of coal have large amounts of sulfur that must be removed.

There are two types of sulfur. The first kind may be removed by processing the coal before it is burned. The second kind of sulfur has to be removed after the coal is burned. The gases from the burned coal contain sulfur. These gases are collected in a giant piece of equipment called a scrubber. In the scrubber, the gases are combined with chemicals that remove most of the sulfur. After passing through the scrubber, the gases are released into the air. Taking the sulfur out of the coal is expensive and probably means that your family's electric bill is higher, but that is the price we pay for clean air.

Several new ways to burn coal are being tested. One way is to remove the sulfur while the coal is burning. The coal is crushed and combined with limestone and air. The limestone combines with the sulfur while the coal is burning and removes the sulfur; thus, a scrubber is not needed.

Coal and the "Greenhouse Effect"

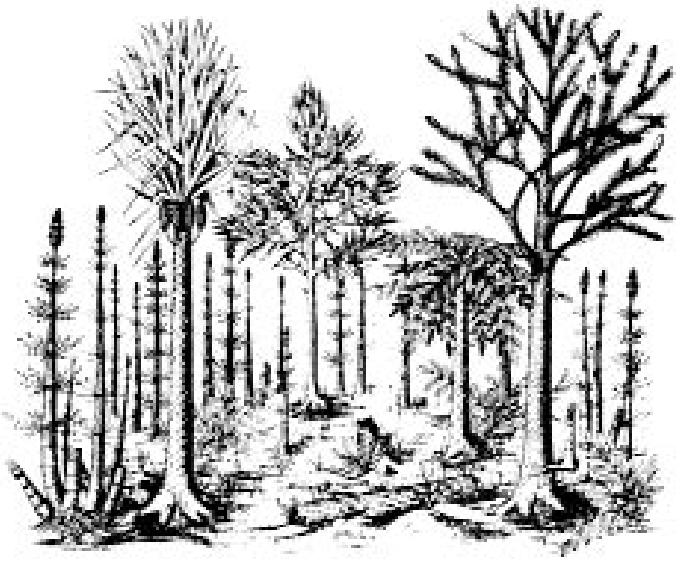
The carbon in coal makes it burn. Some scientists believe that adding carbon dioxide to the atmosphere - mainly from burning coal and other fossil fuels - will help trap too much heat and make the earth's climate become warmer over time. Other scientists do not believe this is likely, or have said the climate is made up of many complex factors we do not fully understand. Still others research indicates the earth could benefit rather than be harmed from increased carbon dioxide, which makes plants grow larger. More time is needed for researchers to gather information on these questions.

FROM PAST TO PRESENT

Way Back When

All this coal we're using today was formed millions of years ago. If you look closely at a piece of coal, you will see layers. If you would carve off a thick slice and put it under a microscope, you would see bands of yellow, red, orange and black. What you see magnified hundreds of times, are tiny pieces of carbon and sulfur. That's what was left over from the plants and trees that died millions of years ago to form coal.

Coal is sometimes called buried sunshine. It is made up of plants that originally got their life form the sun. Back in the Carboniferous Age, or coal-forming period, there were giant ferns, and when they died, water and mud washed over them. Room was left for new plants. Over the years, layers and layers of these plants were buried under prehistoric forest and seas. The weight of the water and mud compressed these plants, leaving a rich layer of carbon. Today, we call it coal.



This is a drawing of what the world may have looked like millions of years ago when coal was being formed.

How Has Coal Been Used?

The North American Indians used coal long before the first settlers arrived in the New World. Hopi Indians, who lived in what is today Arizona, used coal to bake the pottery they made from clay.

European settlers discovered coal in eastern North America during the first half of the 1600's. By the end of the 1750's, small mines in Pennsylvania, Ohio, Kentucky, and West Virginia supplied coal to blacksmiths and ironmakers.

The Industrial Revolution played a major role in expanding the use of coal. This period began in the latter part of the 1700's when people began to give up farming to work in factories. A man named James Watt invented the steam engine, which made it possible for machines to do the work that men or animals had to do before. Mr. Watt used coal to make the steam to run his engine.

The Industrial Revolution spread to the United States during the first half of the 1800's. By then, coal was used not only in manufacturing but also for transportation. Steamships and steam-powered railroads were becoming the chief forms of transportation and they used large amounts of coal in their boilers.

During the second half of the 1800's, coal's use continued to increase. Coal was used during the Civil War to manufacture products and make weapons. The coke industry (coal is used to make coke, the primary fuel in steelmaking), began during this time. By 1875, coke replaced charcoal as the primary fuel for iron blast furnaces. Oil and gas used for lighting was made from coal. Coal-fired steam generators began to produce electricity in the 1880's.

During the 1900's and especially during World War I and World War II, the demand for coal increased. However, during the Depression of the 1930's, when the economy was bad, the demand fell.

After World War II, coal's use fell as plentiful supplies of oil and gas were discovered and used in the United States. Homes that had used coal for heat, now used oil and natural gas. Trains switched to diesel fuel.

More recently, the oil embargo of 1973 has had a significant impact on coal's use. The United States had become very dependent upon foreign supplies of oil. These supplies were cut off. The result was a national effort to reduce the amount of foreign oil Americans used and to depend more on energy sources that could be found in the United Sates. America once again turned to coal.

In 1974, we mined about 600 million tons of coal and today we mine more than one billion tons. As stated earlier, coal is our country's most abundant energy source. Electric utilities use coal to generate electricity; industry uses it for heat and manufacturing; the steel industry uses it to make coke; and other countries use it to meet their energy needs.

COAL GLOSSARY

Barge A long and large, usually flat-bottomed boat that is unpowered and towed by other boats or ships, used for transporting goods.

Carbon Dioxide A colorless, odorless, non-burning gas, produced by both natural sources and the burning of fossil fuels.

Coal Miner Current data shows there are about 100,000 men and women working as coal miners in the United States. The workers are among the most skilled and best-paid in America's indutrial sector

Coal Seam A "bed" of coal. The term "seam" is usually applied to a large deposit of coal.

Coke A hard, dry substance containing carbon that's produced by heating bituminous coal to a very high temperature in the absence of air.

Continuous Miner A machine that removes or "cuts" the layers of coal where it simultaneously falls on a conveyor for removal to a shuttle car or larger conveyor belt system.

Conveyor A continuous moving belt that transports large volumes of material.

Demonstrated Reserves Coal deposits which are potentially minable using today's technology. Estimates show there are about 496 billion tons of demonstrated reserves in the United States.

Dragline A large machine used in the surface mining process to remove overburden, or layers of earth and rock, covering a coal seam.

Exports Goods or merchandise sent or carried abroad for trade or sale.

Fossil Fuels A naturally occurring fuel of an organic nature, such as coal, crude oil and natural gas.

Greenhouse Effect A warming of the earth produced by the presence of certain gases in the atmosphere. The greenhouse effect is a natural phenomenon necessary for life on earth - without it the earth's average temperature would be 0 degrees F.

Metallurgical Coal Different grades of coal suitable for making coke for steel manufacture.

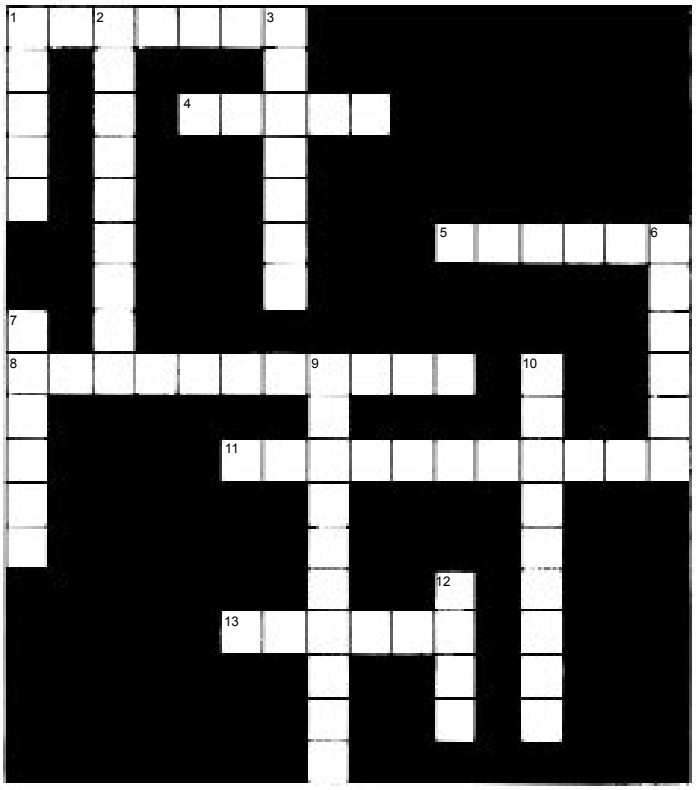
Overburden	Layers of earth and rock covering a coal seam. Overburden is removed before surface mining begins and is replaced after the coal is taken from the seam.
Pit	A deep hole in the ground either natural or man-made, such as a mine shaft.
Reclamation	Restoring the land to it's original appearance "or better," after the coal has been removed.
Recoverable Coal	The amount of coal that can be recovered from the deposits which are minable using today's technology .
Roof Bolting	A method of supporting the ceilings of underground mines by inserting long steel rods into holes to hold the rock in the roof together.
Scrubber	Any of several forms of chemical/physical devices which remove sulfur compounds formed during coal burning.
Self-rescuer	A canister-like device for immediate emergency use in the case of fire or explosion. A filter changes deadly carbon monoxide into harmless carbon dioxide.
Shuttle Car	A self-unloading truck used for receiving coal from a loading or mining machine and transferring it to an underground loading point, mine railway or belt conveyor system.
Surface Mine	A mine in which the coal lies near the surface and can be extracted by removing the covering layer or soil (see "overburden").
Underground Mine	Also known as a "deep" mine. Usually located several feet below the earth's surface, the coal is removed mechanically and transferred by shuttle car or conveyor to the surface.
Unit Train	A long train of between 60-150 or more cars, carrying coal from a single mine to its destination.

ACTIVITY #1

Let's See How Much You Know About Coal!

Words relating to coal are listed below. Use the words to complete the crossword puzzle. Read the clues then write the answer in the puzzle. Hint: all of the words will not be used in the crossword.

plant
unit
safety
Hopis
steel
sulfur
trucks
shaft
underground
hard hat
steam
surface
Canada
barges
overburden
carbon
trains
electricity
factories
exports
reclaimed



Across

1. Draglines, power shovels and trucks are used to _____ mine coal.
4. The _____ used coal to bake pottery made from clay.
5. _____ are used to transport coal on rivers or the Great Lakes.
8. In _____ mining, a shaft is dug to reach the coal.
11. Today, we use coal to produce more than half of America's _____.
13. Coal was formed millions of years ago and is made up mostly of _____.

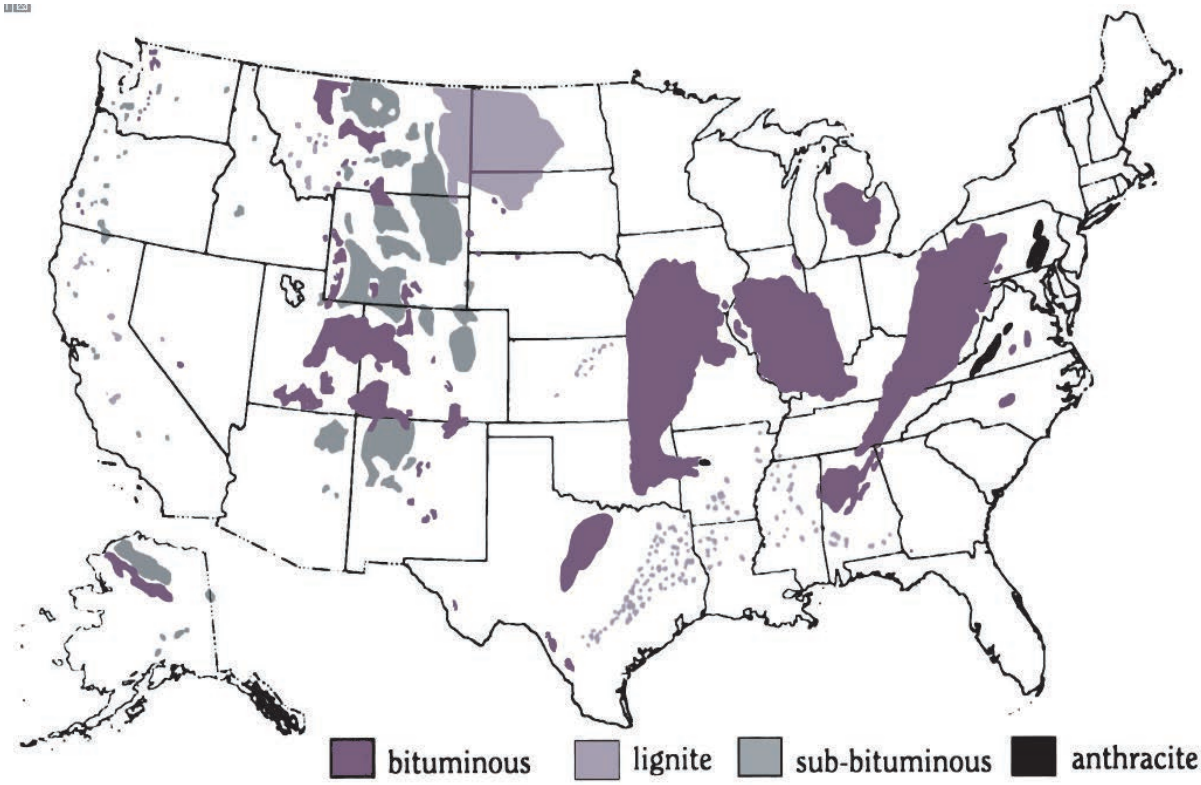
Down

1. Coke, made from coal, is used to make _____.
2. Parks and campgrounds are examples of land that has been _____.
3. A major market for coal is _____.
6. All miners are concerned about _____.
7. A scrubber removes the _____ after coal has been burned.
9. To reach the coal at a surface mine, draglines remove the _____ .
10. The heat from coal is used in some _____ to make paper and cement.
12. A _____ train is made up of 100 cars or more and moves coal from the coal mine to the user.

ACTIVITY #2

A Map of the Coal Areas in the United States

This map shows where various kinds of coal are found in the United States. It also tells you which states mine coal and how much they produced in the year 1995.



2003 U.S. Coal Production, by State
(Thousand Short Tons)

State	Total	State	Total
Wyoming	376,270	Ohio	22,009
West Virginia	139,711	Alabama	20,118
Kentucky	112,680	Arizona	12,059
Pennsylvania	63,725	Washington	6,232
Texas	47,517	Maryland	5,056
Montana	36,994	Louisiana	4,028
Colorado	35,831	Mississippi	3,695
Indiana	35,355	Tennessee	2,564
Illinois	31,640	Oklahoma	1,565
Virginia	31,596	Alaska	1,081
North Dakota	30,775	Missouri	533
New Mexico	26,389	Kansas	154
Utah	23,069	TOTAL U.S.	1,071,753

Figures are rounded.
Source: U.S. Energy Information Administration

Questions:

1. Fill in the names of the ten states that produced the most coal in 2003.

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

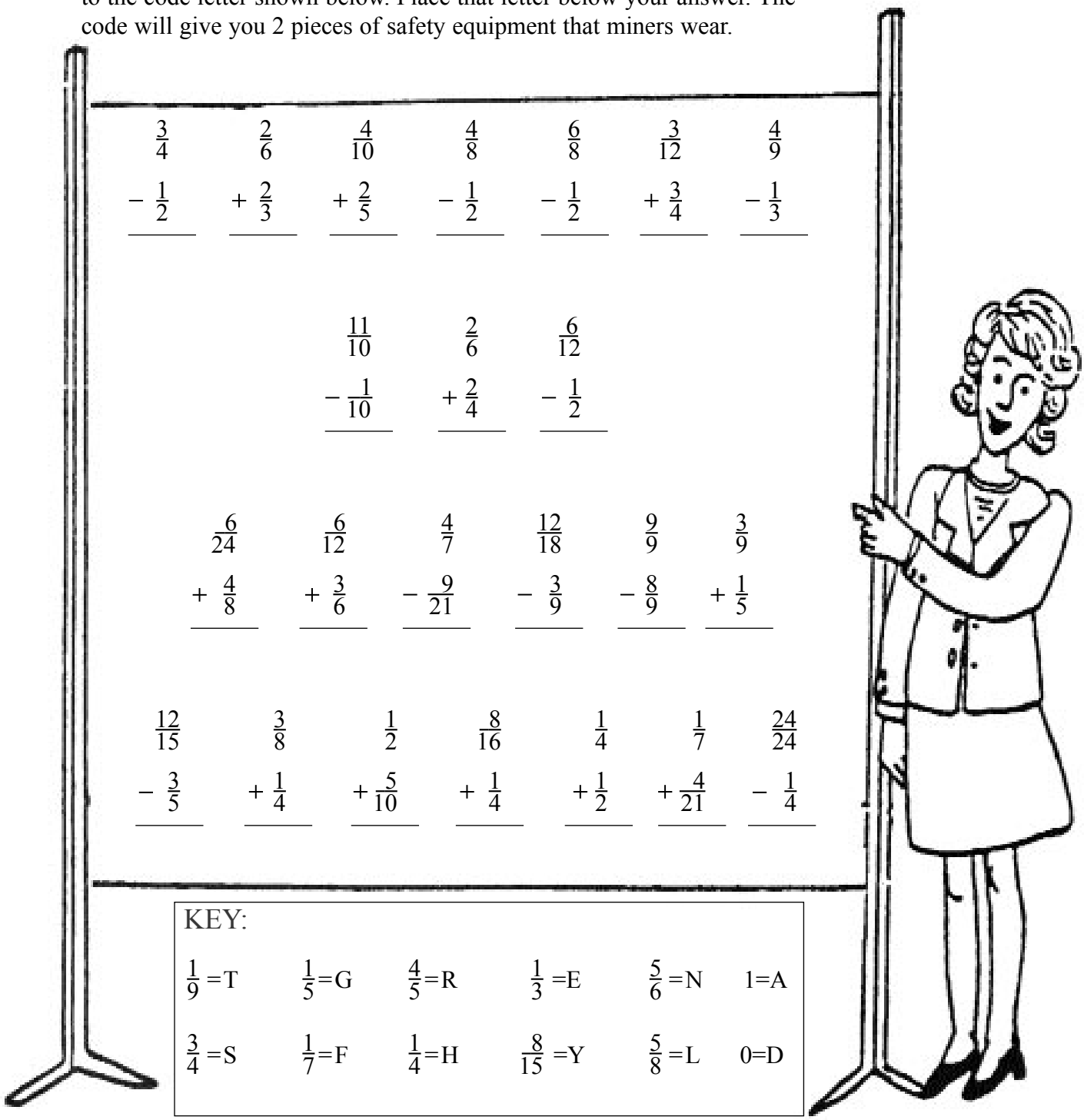
3. What region of the country does not have coal reserves?

4. Does your state produce coal? Does your electricity come from coal?

ACTIVITY #3

Addition and Subtraction

Add or subtract the fractions. When you get an answer, change that answer to the code letter shown below. Place that letter below your answer. The code will give you 2 pieces of safety equipment that miners wear.



$\frac{3}{4} - \frac{1}{2}$ $\frac{2}{6} + \frac{2}{3}$ $\frac{4}{10} + \frac{2}{5}$ $\frac{4}{8} - \frac{1}{2}$ $\frac{6}{8} - \frac{1}{2}$ $\frac{3}{12} + \frac{3}{4}$ $\frac{4}{9} - \frac{1}{3}$

$\frac{11}{10} - \frac{1}{10}$ $\frac{2}{6} + \frac{2}{4}$ $\frac{6}{12} - \frac{1}{2}$

$\frac{6}{24} + \frac{4}{8}$ $\frac{6}{12} + \frac{3}{6}$ $\frac{4}{7} - \frac{9}{21}$ $\frac{12}{18} - \frac{3}{9}$ $\frac{9}{9} - \frac{8}{9}$ $\frac{3}{9} + \frac{1}{5}$

$\frac{12}{15} - \frac{3}{5}$ $\frac{3}{8} + \frac{1}{4}$ $\frac{1}{2} + \frac{5}{10}$ $\frac{8}{16} + \frac{1}{4}$ $\frac{1}{4} + \frac{1}{2}$ $\frac{1}{7} + \frac{4}{21}$ $\frac{24}{24} - \frac{1}{4}$

KEY:

$\frac{1}{9}$ =T	$\frac{1}{5}$=G	$\frac{4}{5}$=R	$\frac{1}{3}$ =E	$\frac{5}{6}$ =N	1=A
$\frac{3}{4}$ =S	$\frac{1}{7}$=F	$\frac{1}{4}$=H	$\frac{8}{15}$ =Y	$\frac{5}{8}$ =L	0=D

ANSWER:

ACTIVITY #4

How Much Coal Is Used Each Year

Here are examples of how much coal is used each year by the Smith family of four to produce the electricity needed to operate various appliances.

1. Electric water heater	3,375 pounds
2. Range	560 pounds
3. Color television	256 pounds
4. Iron	48 pounds
5. Hairdryer	20 pounds
6. Vacuum Cleaner	37 pounds
7. Clock	14 pounds

One ton of coal can produce 2,500 kilowatt hours (kwh) of electricity.
One ton equals 2,000 pounds.

Study the chart above. Use the information to solve the word problems. Round to the nearest pound, kilowatt or year.

1. If the Smith family uses all of their appliances listed in the chart above, how much coal is used in one year? _____

2. How much coal does each family member use in one year, if each member uses the same amount of coal? _____

3. In on year, how many kilowatt hours of electricity are used by the Smith family if they use all of the appliances? _____

4. How many years would the Smith family have to use the range to equal the amount of coal used by the electric water heater in one year? _____

5. If the Smith family bought their color television on September 1, how much coal did the television use for the remainder of the calendar year? _____

6. The Smith family decided to purchase an additional iron. How much coal is used by both irons in one year? _____

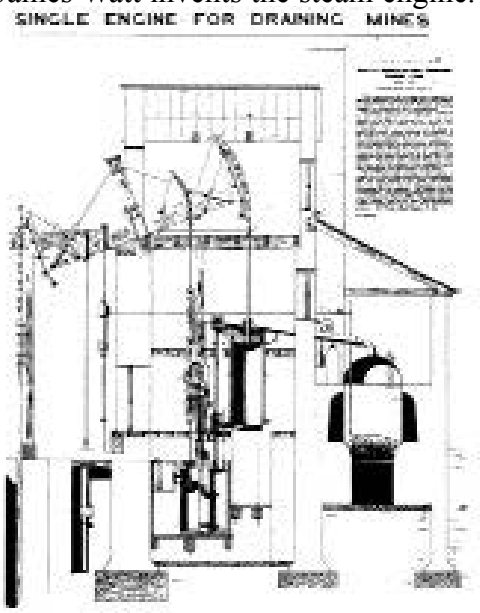
7. During a five year period, one iron worked for all five years. The second iron worked for three years. During the fourth year, the second iron worked for eight months and during the fifth year for two months. How much coal was used by both irons during the five years? _____

ACTIVITY #5

History of Coal

Using the number 1-6, with 1 representing long ago and 6 representing now, number the following statements to show what order they occurred in history.

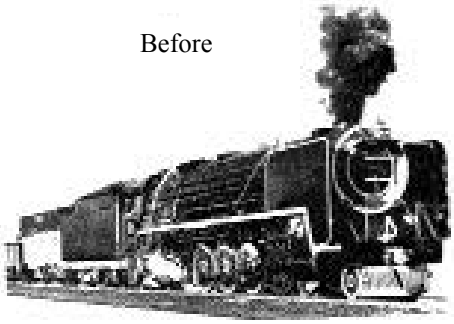
#_____
James Watt invents the steam engine.



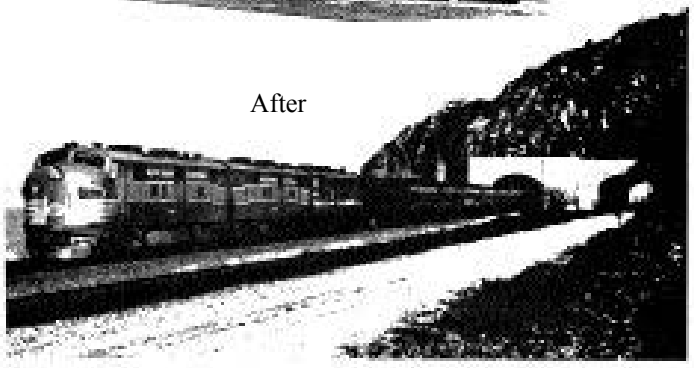
#_____
The Hopis use coal to bake the pottery they made from clay.

#_____
Trains switch from coal to diesel fuel.

Before



After



#_____
Coke replaces charcoal as the primary fuel for iron blast furnaces.

#_____
Coal production levels rise to about one billion tons annually.

#_____
Coal-fired steam generators begin to produce electricity.

NOTES

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