HEADJAM
Crude Energy

Instructional Guide

Made Possible by

ConocoPhillips

Crude Energy provides a back-stage pass to the world of petroleum, where students learn about finding oil while protecting the environment, take a trip in a super fuel-efficient car and discover the dozens of petroleum-derived products they use daily.

Crude Energy Teaching Guide

This teaching guide is designed to complement the 20-minute video, Crude Energy.

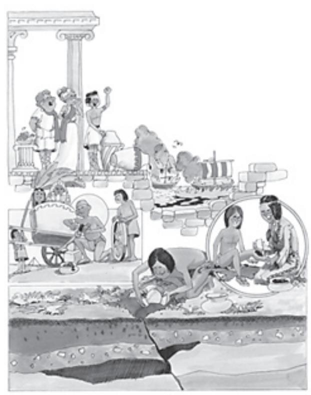
Black Gold: Its Story

Finally, there's a streak of good luck. The "15-items-or-less" lane is open and no one is in line. A teenage cashier scans the bar codes on a tube of lipstick and a pair of tennis shoes and places them in plastic bags.

On the surface, these two purchases seem to have nothing in common. But take a closer look. Lipstick and shoes both are made from oil-derived products, and they are not alone. Everyday, millions of people worldwide purchase thousands of oil-related products. Oil is used to manufacture everything from plastics, detergents and drugs to preservatives, clothing and appliances.

6000 Years Ago

It is hard to say when humans first began using oil. Some historians say it was known at least 6,000 years ago. Ancient stories tell of a Chinese village where dark liquid seeped from the ground. Alarmed farmers prayed to their gods for help because the substance was ruining their crops. When a feudal lord learned of the problem, he discovered that oil could be used to polish swords and armor. He sent workers to gather the liquid in jars, solving the farmers' problem and paying them for the oil.



Records written on stone in ancient Egypt suggest oil was used to grease the axles of the pharaohs' chariots. Egyptians also used asphalt, a thick form of oil, as a coating to help preserve mummies. They also may have paved roads with asphalt.

Legends say the Greeks destroyed an enemy fleet by pouring oil on the sea and setting it afire. Later, a Roman general had a similar idea. He smeared pigs with oil, ignited them, and drove the swine into an enemy camp. In fact, the Romans came up with the term petroleum, from the Latin words petra, meaning rock, and oleum, meaning oil.

Two thousand years ago, Mayan Indians in Mexico described a liquid ointment that was used to anoint the bodies of priests in rituals. It was also used as fuel for fires during religious ceremonies.

Oil and its uses are mentioned in the Bible as well. Pitch, a form of natural asphalt, was said to have been used to caulk ships. Babylonian writings about the Great Flood say that Noah used pitch to caulk his ark.

In Venezuela, pirates in Lake Maracaibo caulked their ships with natural tar.

Third-Century B.C. Drilling

Historians say the Chinese used petroleum as early as the third century B.C. Oil lamps and cooking stoves are two of the known uses of petroleum in China at the time. They used long, metal drills to reach the oil within the ground and then pushed bamboo tubes into the holes. As the oil gushed to the surface, they collected it.

Besides fuel, the Chinese also used oil for medicinal purposes. After it was filtered through cloth, the fine oil was used as balm for skin. The Chinese combined oil with other substances and took it internally to relieve pain from stomachaches and intestinal problems.

The Chinese were probably among the first to use natural gas as well. They often built ovens and hearths in locations where natural gas escaped from the ground since they had no means to transport it.

Native American Medicine

When colonists from England arrived in America, they found the Native Americans skimming oil scum from the surface of streams and lakes. Using blankets to collect the oil, Native Americans used it as medicine. During the Revolutionary War, Native Americans taught George Washington's troops how to treat frostbite with oil.

Of course, oil and gas aren't the only products that come from a reservoir rock. In the early 1800s, many oil wells were drilled to bring the salty water, known as brine, to the surface. After the water evaporated, the salt was left behind to be sold.

Demand for oil began to increase from the middle of the eighteenth century. During the Industrial Revolution, oil was needed for lighting homes and factories. Before petroleum, whale oil was commonly used to make candles and as fuel for lamps. However, the supply of whale oil was running low and the price had skyrocketed. At that time petroleum was obtained by distilling it from coal, by skimming it from ponds and streams, and by oil shale retorting. None of these processes could meet the rising demand for oil.

Birth of an Industry

On Aug. 27, 1859, a forty-year-old former railroad conductor, Edwin L. Drake, struck oil at his well near Titusville, Pa. The oil industry was born. Soon oil exploration began to spread throughout the world.

Today, we can't drive on a highway, attend school, shop at the grocery store or go home without encountering products that are made directly or indirectly from oil.

Gasoline, Petrochemicals

The oil product probably most familiar to us is gasoline. Gasoline is produced in a wide variety of blends and types refined for many different purposes. In the 1920s and '30s, airplanes used the same type of gasoline as cars. Over the years, engineers developed new fuels for aircraft that would increase power. Fuels derived from crude oil today include liquefied petroleum gas, aviation fuel, gasoline, kerosene, diesel engine and road vehicle fuel, and gas oil and fuel oil, which are used in boilers.

When oil and gas are converted to chemicals, they are called petrochemicals. We are surrounded by products made from petrochemicals, including plastics. In the 1920s there was an abundance of hydrocarbons at petroleum refineries. Manufacturers took advantage of this and developed uses for the cheap raw materials. The petrochemical industry evolved.

The list of petrochemical-derived breakthroughs is endless, including such products as ball-point pens and sunglasses, trashbags and nylon rope, crayons and toothbrushes, deodorant and nail polish and tennis shoes and lipstick — and so many more.

Just a few more of the thousands of products derived from oil are candles, paint, carpet, soap, perfumes, balloons, photographic film, insecticides, margarine, cassettes, telephones, and polyester.

Medical Industry

One particular area that has its share of oil-produced products is the medical industry. What would life be without hearing aids, bandages, artificial limbs and heart valves, contact lenses and hundreds of medications derived from petroleum? As the source of such important products, there is concern about the amount of oil left on Earth.

Dr. Colin Barker, McMan professor and chairman of the geosciences department at the University of Tulsa, said the end of the oil supply may not come in our lifetime, but "it will run out."

Barker suggested that as oil becomes harder to find, prices will rise until a more economically feasible alternative is found.

Discussion Questions...

1. Will the Earth ever run out of oil?
2. Do you think there are other significant uses for oil that haven't yet been discovered?
3. When oil was first drilled in the United States, it created a boom. What other industries have experienced such booms?

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Crude Energy Classroom Activity

Oil, Oil Everywhere

Have students bring department store magazines or sales papers to class. First, talk about various products for sale that are made from oil. Then have students try to find products that use oil in no way, including packaging. That will be tougher to do than it at first seems.

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Energy in Rocks

A scientist demonstrates how petroleum is contained inside the pores of rock. First, a piece of petroleum-bearing rock is crushed into small pieces.

Then, the crushed rock is placed in a test tube.

The rock is heated, releasing the petroleum inside and creating a flame at the opening of the test tube.

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Recipe for Oil

Take tons of tiny animals and plants and place them in a hot oven. Then cover them and let them sit for millions of years.

No, it's not the recipe for Mom's tuna casserole. Actually, it's a simple explanation for how petroleum is formed.

Petroleum is made primarily of mixtures of hydrocarbons, compounds of carbon, and hydrogen. Scientists believe petroleum hydrocarbons come from the remains of tiny animals and plants that lived millions of years ago.

Dinosaurs? No.

The idea that oil was created from dinosaurs is a myth, according to Dr. Colin Barker, McMan professor and chairman of the geosciences department at the University of Tulsa. He said even though dinosaurs were huge creatures, there simply weren't enough of them to create such large amounts of oil. So if the quantity of dinosaurs wasn't sufficient to make oil, how did tiny sea animals and plants become oil?

Barker compared today's elephants to yesterday's dinosaurs. He said the total mass of elephants on the earth is probably less than the total mass of ants because ants outnumber elephants by such a large margin.

When tiny organisms die, they sink to the bottom of the sea and are mixed with mud and silt. Over time, hundreds of feet of mud containing the organisms accumulate. Bacteria removes most of the oxygen, nitrogen, phosphorus, and sulfur, leaving mainly hydrogen and carbon. Lack of oxygen keeps the animals and plants from decaying completely.

The partially decomposed organisms create a slimy mass, which is then covered with layers of sediments. Many sediments are tiny particles that come from the breakdown of larger rocks, usually by weathering. Over millions of years, many layers of sediment pile on top of the once-living organisms. The weight of the sediment compresses the mud into a fraction of its original thickness.

Now We're Cooking!

When the depth of burial reaches about 10,000 feet, heat, time and pressure turn the organisms into different types of petroleum.

Barker likens the process to cooking. "If I turn the temperature of the oven up, things cook faster. If the temperature is turned down, it cooks slower," Barker said.

Higher temperatures usually produce lighter petroleum. Lower temperatures create a thick material, like asphalt. As the heat continues to alter the substances, gas is often produced. Depending on how much gas is present, sometimes it will stay mixed with the oil and sometimes it will separate. At temperatures above 500 degrees Fahrenheit, the organic matter is destroyed and neither oil nor gas is formed.

The mud and silt become more and more compressed and turn into a rock known as shale. As the mud is being compressed into shale, the oil, gas and saltwater are squeezed out. The fluids move from the original rock, known as the source rock, to a new rock, called a reservoir rock.

Porosity

It is economically unfeasible for humans to extract oil and gas unless worthwhile amounts are trapped in reservoirs. Many people assume petroleum is contained in underground hollow cavities, or lakes. In truth, an oil reservoir is a rock with many pores which hold petroleum, much like a sponge holds water.

A pore is a small, open space in a rock. A rock's porosity is the ratio of pore volume to total volume and is expressed as a percentage.

The shapes of sediments affect the porosity of a rock. Generally, sediments are not perfectly round, but occur in many shapes. Sediment size and how closely sediments are packed also are variables. The third factor that determines a rock's porosity is the amount of material that precipitated from seawater and accumulated in the pores. A porosity of 5 to 20 percent is usually considered average for sedimentary rocks.

If the pores are connected, the rock is said to be permeable. Permeability is the ease with which a fluid can move through a porous rock. Sandstone is the most porous and permeable of the sedimentary rocks. That's why much of the world's oil and gas occurs in sandstone. Carbonate rocks such as limestone and dolomite are also good reservoirs for oil and gas.

Reservoir Rocks

A reservoir rock must be able to contain oil, gas and water, which are the reservoir fluids. Pores in the reservoir rock are first filled with saltwater from the sea. When oil and gas flow into the rock, some of the water is displaced. However, not all of the water is forced out. Therefore, oil drillers usually find water with high concentrations of oil and gas.

Oil and gas travel through pores of the reservoir rock, with the help of water, until they reach an impermeable layer of rock through which they cannot pass. Shales are the most common impermeable rock.

Oil Traps

Oil traps usually form because of rock movements deep within the Earth's surface. Over many years, rock formations break and slide, causing spaces where petroleum is trapped. The most common type of trap is an anticline, where rocks are pushed up to form a dome. Oil and gas might lie in reservoir rock just under the top of the dome, which is capped by an impermeable layer of rock.

Another common type of trap is the fault trap, which is formed by a fault, or fracture, of the layers of rock. The rock on one side of the fault sometimes slips down so that a porous reservoir rock is next to a nonporous rock formation. This creates a seal, and the petroleum is trapped.

When parts of the reservoir rock itself are impermeable, often oil is trapped. This is known as a stratigraphic trap. The stratigraphic trap category also includes side-by-side changes from one type of rock to another.

Now that the oil has been cooked, moved and trapped, it will stay there until rock formation movement causes a change in its surroundings, or until humans decide to drill a well in that spot.

Synthetic Oil

If time and temperature are all it takes to make oil, why can't it be made by humans? It can be and is made synthetically, Barker said, but mostly just for research. The process of creating an oil-like substance in a laboratory is called pyrolysis. Referring to his cooking analogy again, Barker said the amount of time it takes to make oil is decreased in the lab by increasing the temperature. The only problem is, it takes more energy to create the oil than energy the oil could provide.

Discussion Questions...

1. In the pores of a reservoir rock, oil floats on top of the water and gas rises above both. What causes this?
2. How do scientists find oil traps that are deep below the ground?
3. What are some common myths about how oil was formed and how it is contained underground?

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Crude Energy Classroom Activity

Rock Solid?

An ordinary piece of rock looks solid. But take a closer look at certain types of rock, sandstone or limestone, for example, and you will see many tiny openings called pores. Pores can be thought of as veins through which oil, gas and water can flow.

Have each student bring a small piece of rock to class. Examine the rocks under a microscope to see which are most porous. Use library resources to categorize the rocks and determine which would most likely contain oil.

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Finding Oil

Most of the money spent by the petroleum industry in exploring for oil is used for geophysics (the physics of the earth, including seismology, gravity and magnetics, among others). Geophysics provides techniques for imaging the subsurface (seeing below the ground) before drilling, and this can be key in avoiding “dry holes.”

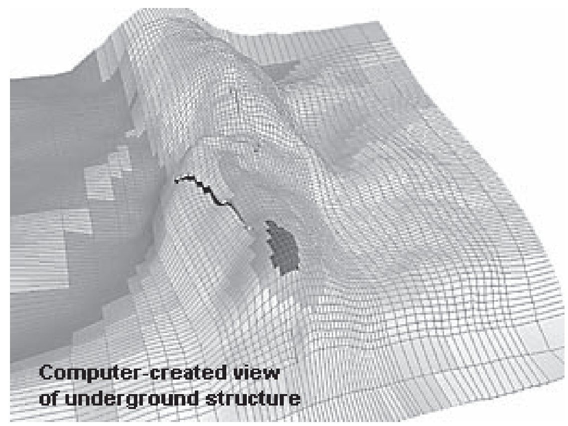
Not realized by the general public is that most of the holes drilled are dry and do not yield commercial oil or gas. Locating an oil and gas reservoir (a place where a great amount of oil and gas has collected) and drilling oil and gas wells is very expensive (offshore wells can cost $15 million or more; in fact, some offshore platforms cost more than $4 billion). That’s why it is so important to utilize state-of-the art exploration and production technologies to keep costs as low as possible.

Finding Oil
Above the Ground!

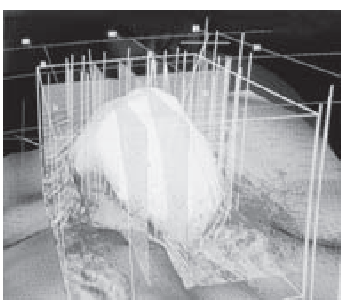
Supercomputers and other high-tech tools allow earth scientists to “discover” oil that 10 years ago could not be detected.

ConocoPhillips, for example, deploys one of the world’s largest and fastest supercomputers, a Cray T3D/1350 system, to process seismic data and to produce accurate images that identify the best location and trajectory for drilling wells.

In complex regions like the North Sea and Gulf of Mexico, advanced 3-D seismic imaging (producing an image in three dimensions–width, length and depth–of an area beneath the earth’s surface or ocean floor) has played a key role in locating wells and in reducing finding and development costs. With the aid of its supercomputer, ConocoPhillips has overcome some of the world’s most difficult seismic and engineering challenges in hostile environments.



Computer-created view of underground structure



A 3-Dimensional view of an oil field as constructed by a ConocoPhillips supercomputer.

Geoscience and Reservoir Technology

Oil companies realize the importance of research and development, commonly referred to as R&D. A significant part of ConocoPhillips’ Corporate Technology/R&D Division, for example, is the Geoscience and Reservoir Technology Group, an organization that includes expertise in geophysical, geological and petrophysical areas and drilling engineering, reservoir engineering, improved oil recovery technology (IOR) and production engineering. This group also manages the use of the Cray T3D/1350 supercomputer system for advanced seismic and reservoir engineering applications.

Science at Work

Some of the greatest oil and gas discoveries of the last decade have taken place above ground, or as the late Wallace Pratt, renowned petroleum geologist, phrased it many years ago, “Oil is found in the laboratories, computers and team meetings of scientists, engineers and field personnel.”

Technology plays a critical role in finding, developing and producing hydrocarbon (oil and gas) reserves. Technology enables oil companies to identify eventual drilling targets that would be missed using standard exploration techniques; reduce the risk of drilling a dry hole; complete drilling projects faster, which reduces costs; reduce costs by knowing which production equipment is best suited for use in a drilling area; and get the most oil and gas (improve recovery) from a new or formerly drilled oil and gas well by combining the efforts of geoscientists, engineers and scientists.

Geoscientists continually work to develop new ways to combine and use data from diverse sources in order to form a highly accurate picture of an area's subsurface geology. The results are new discoveries, improved recovery rates, faster development and greater efficiency.

Identifying Opportunities

When considering an area for drilling, oil companies typically begin by collecting and analyzing geologic, production and commercial data on an entire geological basin, a likely place for oil and gas to have collected over millions of years. This often includes satellite photographs, gravity and magnetic information, plus existing 2-D seismic data (data showing the width and length of a subsurface area).

From this information, a basin model is formed to help assess potential. If it shows promise, the company conducts a seismic program that includes 2-D or 3-D data. If oil and gas are discovered, additional technologies help determine the best plan for utilizing the reservoir. The technologies indicate the most likely ways to get long-term production and financial returns.

Then, let the drilling begin!

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Crude Energy Classroom Activity

Air vs. Water

Show your class the difference in media, comparing air to water as part of an explanation in how drillers tell the difference between the substances they are drilling underground.

Take a watertight container, possibly an aquarium, along with a spring and any small object with a flat bottom (an empty thread spool or a piece of wood will work). Attach the spring to the bottom of your airtight container.

First, try the experiment with only air as your resistor. Load the spring with the object, pressing down to maximum resistance on the object. Caution! Stand back and let it go. Time how long it takes it to pop up into the air and measure how high it goes.

Then, fill your container with water. Load your spring and push down on it. Let go and again measure the timing and height it rises. The differences will help students understand that different media, depending on the density of molecules, will determine how quickly a driller can bore and how he or she can tell into what they are boring.

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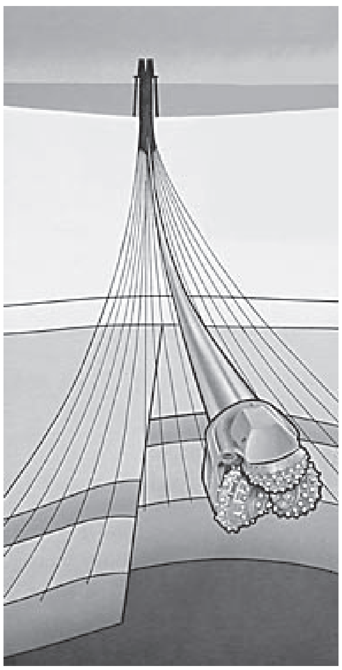
Extracting Oil from Mother Earth: Advances in Technologiy

From the first official oil well drilled in Titusville, Pa., in 1859 to today's wells drilled on land, in oceans and beneath lakes, oil exploration and gathering have changed a lot.

Today's oil and gas industry workers, including geologists who find crude oil and natural gas deposits; site supervisors who oversee field operations; and refiners, use computers and other technology to make their work easier, more efficient and less costly.

In the words of David Pletcher, an independent geologist, he and others want more than anything to "find oil cheaper and more effectively." And doing that is becoming easier as technology comes into play -- especially in the last decade, when using computers for everything from finding gas and oil deposits to testing the purity of such finds became common.



Advanced electronic tools installed at the ends of drill pipe help guide drill bits to precise targets miles below the surface.

Innovations in Drilling

"Large operations have a definite advantage when it comes to using technology, since advanced technology costs more than small outfits can afford or justify for limited use. A lot of the technological innovations are not feasible except for big oil companies," Pletcher said.

But some pieces of technology are available to all, and even the "little guys" have latched onto them. Some of the top technologies in drilling include logging while drilling, horizontal drilling, "smart" drill bits, and miscible methods for recovering oil.

Logging while Drilling

Basic forms of logging while drilling, where a driller views the inside of the hole being drilled in one way or another, have been around for some time.

The word logging may bring visions of big burly men yelling "Timber!" as a tree falls in a forest. But logging is used here in the sense that you log, or check and write up, what is happening as it occurs. Keeping track of what you are hitting or missing helps in future drilling.

Logging while drilling includes visual wall-logging, in which a geologist physically inspects the wall of a hole being drilled. In this field technique, an area being drilled is sampled as progress is made.

In core logging, samples are drawn from the hole to determine what is being drilled. These samples, once brought to the surface, are tested both physically and chemically to confirm findings.

With borehole camera logging, after a hole is drilled, a still or broadcast camera is put into the hole, which allows drillers to photograph or film what they are drilling.

Radioactivity logging involves measuring radioactivity beneath the ground, which can help determine what type of substance is being drilled, be it rock, shale, natural gas or crude oil.

A recent innovation allows what is called open-hole logging. With this technique, a magnetic resolution induction log, working on the same premise as a medical MRI, uses two magnets to determine substances being drilled. One continually fixed magnet reflects intermittent pulses from an electromagnet. The pulsing changes rates of speed with varying substances, giving off one rate for shale and another for oil and yet another for natural gas.

"The tool actually measures the decay time," Pletcher, the geologist, said.

Such techniques make drilling more efficient, meaning less money is spent on getting to crude oil, which eventually could lower consumer prices for oil-related products, such as gasoline.

Horizontal Directional Drilling
Not all oil deposits are readily accessible to a traditional vertical well. In fact, in recent years many oil wells have been dug beginning on one piece of land and crossing underneath a body of water to another piece of land to reach the deposit.

The record is 10 miles for BP Amoco wells on the southern coast of England. These start onshore and penetrate an offshore field. The main reason for doing this is to minimize environmental impact in an area of great natural beauty.

At one U.S. site, a pipe stretches about two miles. Drilling on solid ground is much easier than doing so in a swamp or in water, which is why some wells are dug horizontally. Occasionally, a potential oil deposit is found beneath a town, which is another reason for getting at it from afar.

Here's how it works. Surface drilling equipment is offset from the oil deposit. At the start of the drill process, the well is drilled vertically, then a few degrees at a time it turns whichever direction is needed to hit the deposit. Sometimes the arc of the well is great, other times less, depending on how sharp a turn has to be made.

Horizontal drilling itself has been around for some time, but about 10 years ago it regained notoriety in its use to increase production from narrow, fractured formations, said Joe Hurt, director of land operations for the International Association of Drilling Contractors.

"When a vertical well is drilled through a narrow formation, its exposure to the formation is limited," he said. "But if the well is turned and follows the formation for a distance, the well bore to formation surface is greatly increased."

This increase in surface contact allows for easier retrieval of oil.

Drill Bits

The drilling part that actually tears or chips away at soil, rock and other materials as a well is dug, called a drill bit, is an essential tool to drilling a well. In recent years, technology advancements have made such tools more capable, longer lasting and less expensive.

Ten years ago, when Allen King and his two brothers formed Bear Production, a small drilling outfit based in Kinta, Okla., the brothers poured money into drill bits. Each tricone bit, known as a button bit, cost about $3,000. These bits are named for the three roller cones, which roll and gouge out material as they rotate. After digging about 2,000 feet, the bit would break, he said.

King now drills using an air hammer, which costs about $5,000, and flat-bottom bits, which cost only a few hundred dollars each and have a much longer life. These bits, which have carbide teeth and are specially designed for different types of material, can go between 30,000 and 40,000 feet before needing to be replaced.

Each of these bits is used with a drill using rotary, or rotating, motion to do the work. Beginning in the mid-1950s, rotary drilling gained popularity over cable tooling, in which a much more crude, chisel-shaped bit was attached to a cable then pounded into the earth. Intermittent stops were needed to remove the chipped-away rock and other material.

Rotary drilling allows the use of fluids or drilling mud as rock is chipped away. The fluid washes out the drill hole as it goes, making the process more efficient. The fluid also stops an oil well from bursting forth unexpectedly (known as a "gusher").

Around for many years, diamond drill bits were once used to drill, but their weak planes caused them to break easily. The individual diamond pieces are tough, and industry now makes a similar synthetic diamond powder used to coat carbide bits, making one tough bit.

Oil Extraction

In the best conditions, nature helps oilfield workers bring their find to the surface after a well is drilled. But after an initial surge, either large or small, pressure in the reserve decreases, meaning human creativity must be used to get the rest.

This is when artificial lift enters the scene. With this method, a pump sucks oil into tubing which then feeds into a storage container on ground level. Several years back, walking beams—arms which pump back and forth like a teeter-totter to suck the oil upward—were a common site in Oklahoma, Texas, Louisiana, California and other oil-producing states.

Another form of artificial lift involves pumping gas bubbles into oil to decrease its density, making it lighter and thereby allowing reservoir pressure to pump it out.

Both of these methods leave much oil in the reservoir, meaning other methods must be employed to get the rest.

Enter water or gas. With gas injection into the top of the reservoir, a gas cap forms, forcing oil to the bottom and then pressuring it out. To use water flooding, water must be entered into another well site connected to the well being worked on. The water floods into all wells, forcing oil to the top, since oil floats on water. To see this, take any common oil, such as the kind found in most kitchens, and pour some into a cup of water. The two fluids stay separate with the oil on top even after vigorous mixing.

Still more oil can be pulled from many reservoirs after other means are exhausted.

Natural gas can be pumped into a reservoir to mix with the oil, making it light enough to flow. The mixing is why the term miscible, meaning to be mixed, is used.

Another option is to use a surfactant or soap-like substance ahead of water and behind the oil. The substance forms a barrier around the oil, and water behind the substance pushes the oil to the surface. The soapy substance also ensures a thorough gathering of oil.

Heat also can be used to get oil flowing. Up to a million times thicker than water, oil can be thinned by blasting steam into the reservoir. Water is first pumped off, then oil is gathered.

Summary

From day to day, oilfield workers and their bosses are seeing oil drilling improvements. These improvements could lower the cost of many petroleum-related products. In another 10 to 20 years, who knows what will be out there? We shall see.

Discussion Questions...

1. What kinds of advances have been made in oil drilling and retrieval?
2. How can consumers like you benefit from these advances?
3. What ideas do you have to make drilling easier? (These can be creative and wacky.)

Classroom Discussion...

One of the largest oil fields in the world is found in Saudi Arabia. It measures 149 miles long and 22 miles wide. Can you think of anything that would have similar measurements?

Note: For easy-to-understand and readily accessible information on petroleum and the gathering process, see Encyclopedia Britannica online at www.britannica.com.

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Crude Energy Classroom Activity

Drilling for Customers

Have your class create a print advertisement for a horizontal directional drilling firm. Include the name of your company, a slogan, an artistic rendering depicting why consumers should choose your product and a couple of lines about why your drilling firm is unique. This ad should be appropriate for a trade magazine or other specialty publication aimed at industry-oriented types.

When finished, discuss your ads and why you think they would or would not work. Compile the best of each to make an ad designed by the entire class.

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Oil and the Environment

Oil may provide the ingredients for thousands of products we use every day, but it carries with it some potential problems. While oil is a product of the Earth, it can be harmful to the environment when it is brought to the surface if not handled properly.

Oil spills on land, rivers, bays and the ocean are mostly caused by accidents involving tankers, barges, pipelines, refineries and storage facilities. These accidents can be caused by human mistakes, carelessness or sometimes by natural disasters such as hurricanes or earthquakes. Deliberate acts by terrorists, countries at war, vandals, or illegal dumpers prove that oil spills aren't always accidents.

In ocean saltwater, oil floats. It usually floats when spilled in fresh water (rivers or lakes) too. Rarely, very heavy oil will sink in fresh water, but generally, it spreads out rapidly across the water's surface and forms a thin layer called an oil slick. As the spreading process continues the oil layer becomes thinner and starts to look like a rainbow. This fine layer is called a sheen. Sometimes after a rain, the same type of sheen is seen on roads or parking lots.

Birds are particularly susceptible to oil spills because oil clogs their complex feather barriers, allowing water and cold to penetrate.

Oil spills are often harmful to marine birds, mammals and, sometimes, fish and shellfish. Birds are protected from the elements by their feathers, which overlap like tiles on a roof. The separate strands on each feather are bound together by rows of tiny hooks, creating a tight weave. The bird's skin stays warm and dry underneath. However, oil can clog the feather's strands and hooks and allow water to penetrate to the bird's skin.

Oil also can damage the insulating ability of fur-bearing mammals such as sea otters. Many animals try to clean themselves but are poisoned after ingesting the oil.

Oil Spill Cleanup

When an oil spill occurs in the United States, the cleanup is sometimes taken care of by the responsible party but often requires the assistance of various local, state and federal agencies and volunteer organizations. The responsible party, however, is required by law to report the spill to the federal government.

Nearly 14,000 spills are reported each year in our nation, accounting for about 100 million gallons of oil. That's equal to the volume of about 100 average school gymnasiums.

The largest single U.S. spill was in Alaska in 1989. An Exxon oil tanker ran aground to cause a spill of almost 11 million gallons of crude oil. It was a big spill, but only the 35th largest in the world. Surprisingly, 11 million gallons is less than 2 percent of the oil our country uses in one day, which sheds light on the tremendous volumes of oil that are shipped and handled safely.

A wide range of tools and techniques are used to clean oil spills. Mechanical containment or recovery is the biggest defense against oil-spill damage in the United States. Containment and recovery equipment includes a variety of booms, barriers and skimmers, as well as natural and synthetic materials that absorb oil. Mechanical containment is used to capture and store spilled oil until it can be disposed of properly.

Generally, the first step is to contain the oil so that it doesn't spread more, said Brian Stanfield, executive vice president at Acme Products Co. in Tulsa, Okla., which specializes in oil spill cleanup. A common tool for containing oil is a boom, or a floating barrier. A boom, for example, may be placed around a leaking tanker to collect the oil. Stanfield said the goal is to increase the concentration of the oil in a smaller area so it can be collected easier.

A skimmer, which is a boat that skims spilled oil from the water surface, can then be brought in to collect the biggest part of the oil. Vacuum trucks often are used to vacuum oil from the water surface or beaches. Sorbents, big sponges that absorb oil, are particularly useful on oil sheens and thin slicks too scattered for skimming.

In-situ or "in-place" burning is a method of burning freshly spilled oil, usually while it's floating on the water. Dispersants, chemicals that act as detergents to break oil into tiny droplets and dilute a spill's effect, are commonly used as well.

Nature's Cleaning: Microbes

Aside from all the chemicals and gadgets that humans have produced to clean up spills, nature has a way of cleaning itself. One of the most interesting techniques for cleaning spills involves speeding up a process that has been around since millions of years before man. Biodegradation is a natural process by which microbes alter and break down complex compounds into simpler substances to gain energy and nutrients. The resulting products can be carbon dioxide, water and simpler compounds that do not affect the environment.

Microbes include bacteria, archaea, fungi and protists. Viruses might also be categorized as a major type of microbe, though there is debate as to whether viruses can be considered living creatures.

Microbiologists have found microbes living just about everywhere, including in soil, water, air, animals, plants, rocks and even in humans. A handful of garden soil contains hundreds if not thousands of different kinds of microbes. A single teaspoon of that soil contains over 1,000,000,000 bacteria, about 120,000 fungi and 25,000 algae. Microbes have been around for billions of years because they are able to adapt to the ever-changing environment.

However, the biodegradation process is relatively slow, and when an oil spill occurs, workers must act fast to protect the environment. Speeding up the process can be accomplished in two ways: adding fertilizing (nutrients) and/or seeding (adding more microbes). When technology is used to speed up the process, it is known as bioremediation. In recent years, the U.S. Environmental Protection Agency has determined that bioremediation is a safe and effective oil-removal option.

Oil isn't the only substance tested for cleanup by microbes. Certain U.S. Army installations have tested the effectiveness of using microbes to remove explosive products deposited in soil after years of ammunition manufacturing and disposal. First the explosives-tainted soil is mixed with water and placed in a treatment container. The mixture is given regular doses of oxygen and a food source, which spur growth in microbes that already live in the soil. While "eating" the food, the microbes break down the explosives so the soil can be returned to its original site.

Even the most complex science can't make up for the birds, animals and beaches that have been harmed by oil spills. That's why prevention is being stressed more and more. The oil industry is coming up with safer ways to produce, transport and store oil. Safer vessel designs play a big role. Examples include double hulls, improved steering systems, improved radar detection systems, satellite and radio communication and computer monitoring of the vessel's operations. Better aids for navigation systems also help reduce risks.

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Crude Energy Classroom Activity

Waves and Oil Cleanup

Materials
Glass jar with a lid, vegetable oil and water.

Instructions
Have students fill a jar about half full of water. Add a cup of vegetable oil. Close the lid tightly and turn the jar in every direction. The oil always floats to the top. On the ocean, however, conditions aren't always so calm. To simulate the effect of strong ocean waves or storms, shake the jar. The oil and water appear to mix. The oil blobs become smaller and smaller, creating what is called emulsified oil, or mousse. As soon as the shaking stops, the oil begins to separate from the water again.

Discussion Questions...
1. What effect would ocean waves have on an oil-spill cleanup operation?
2. What causes oil to float on water?
3. Why do the oil blobs become smaller as the shaking increases?

Crude Energy Classroom Activity

Feathers+Oil=Trouble

Materials
Medium-sized bowl, hot and cold water, dishwashing detergent, vegetable oil, three feathers, and cocoa powder (optional).

Instructions
Fill the bowl 3/4 full with water. To make the oil more visible, mix a little cocoa powder with it. Then, pour some oil on top of the water and wait for it to spread out. Dip the feathers in the bowl, imitating a bird landing on an oil slick. Examine the feathers and then wash one in cold water, one in hot water, and one with detergent and hot water. Examine the results.

Discussion Questions...
1. What did the oil dip do to the feather?
2. Which washing method worked best?
3. Could this method be used to wash a real oiled bird?

Crude Energy Classroom Activity

How Much Oil?

In March 1989, the Exxon Valdez spill occurred in Prince William Sound, Alaska. It was a big spill (10,800,000 gallons) but small when compared to the amount of oil used worldwide in a day: 3 billion gallons.

If the average school gymnasium can hold 1,300,000 gallons of oil, it would take about 8 gyms to hold the amount of oil spilled in Prince William Sound.

How many of the following would it take to hold that same amount of oil (numbers are approximate)?
1. Average house (holds 100,400 gallons)
2. Average classroom (holds 25,100 gallons)
3. Average living room (holds 14,000 gallons)

Solution
Divide 10,800,000 by each number.
Answers (rounded to the nearest whole number):
Houses -108
Classrooms - 430
Living rooms - 771 s

Crude Energy provides a back-stage pass to the world of petroleum, where students learn about finding oil while protecting the environment, take a trip in a super fuel-efficient car and discover the dozens of petroleum-derived products they use daily.

Crude Energy Teaching Guide

This teaching guide is designed to complement the 20-minute video, Crude Energy.

Transportation Solutions: Hybrid Cars Roll into the Future

Mention electric vehicles to most people and images of golf carts inevitably come to mind (or maybe the golf cart's beefier cousin–those beeping shuttles that sneak up behind us on airport concourses). And, of course, there are battery-powered wheelchairs and scooters that have become a boon for folks needing a little extra help in getting around.

However, as useful as they are, electric cars and carts have some considerable limitations. Battery-powered cars usually can travel 70-80 miles per trip at best, keeping them in the short-commute niche or limited to the above-mentioned golf course and airport. Recharge time is also a significant factor. It can take hours to replenish a battery after only one of those 80-mile trips.

Honda Insight HEV

Take the Wheel of an HEV!

Drivers don't notice when the HEV's gasoline engine automatically shuts down then restarts in stop-and-go traffic.

HEVs like this one offer high fuel economy combined with streamlined styling.

New Vehicles Combine Combustion with Current

But the future for electric transportation has moved onto the fast track, much to the delight of those concerned about the environment and/or the price and availability of gasoline in the years to come. Quiet, non-emitting, battery-powered cars, long championed by environmentalists, have been combined with traditional, internal-combustion gasoline-fueled engines and the result is a vehicle that has the best of both worlds–the HEV.

HEVs–or hybrid electric vehicles–are the newest innovations in the search for cleaner-burning, more efficient transportation. By combining electric motors and gasoline engines, HEVs expand the range of electric cars while operating more efficiently (some models, such as the Honda Insight, are advertised as getting 70 miles per gallon of gas). They're also cleaner and kinder to the environment. By using less gas, HEVs emit fewer pollutants. While HEVs, as they're currently designed, will never be zero-emission vehicles, the first models can cut emissions by a third to a half and later models may cut emissions even more.

They're also a reality after years of drawing-board designs, experimental models and prototypes. HEVs are actually showing up on showroom floors. And while there are some startup companies set to produce HEVs, the first models are being built by mainline automobile manufacturers, Honda, as well as General Motors, Ford and DaimlerChrysler.

Increased Efficiency

So exactly how does the electric motor increase the efficiency of the gasoline engine? The gasoline engine provides power to the wheels for normal driving and is augmented by a power boost from the battery-powered electric motor under heavier loads, such as accelerating, passing and hill climbing. The gasoline engine is never strained since the electric motor provides additional "zip" when needed. The electric motor also takes over when the car is idling, say at a stoplight. The gasoline engine shuts down when idle and automatically restarts when reengaged–a real plus in stop-and-go city traffic. The driver never notices the transition.

Regenerative Braking

And how does the gasoline engine complement the battery-powered motor? HEVs use what is called regenerative braking to make sure the onboard battery remains charged.

During deceleration, energy from forward momentum is captured and is then used to recharge the batteries.

The combination of the two systems doesn't mean you can drive until you run out of gas and use only the electric motor. The electric systems aren't designed to power the car alone. In fact, many experts agree that purely electrical vehicles are a long way in the future. Because the energy density of electric batteries will never equal that of liquid or gaseous fuels such as gasoline or propane, these will need to be a part of future vehicles for some time to come.

Efficiency by Design

Another important factor in the efficiency of HEVs is the car's body design. Eliminating drag (forces that resist a vehicle's motion) and weight are key to increasing the car's performance, a practice that's been more familiar on the racetrack than the highway. Take a look at NASCARs and Indy models and you'll notice the low silhouettes, aerodynamic shapes and airfoils, as well as lightweight materials. HEV designers have noticed as well.

The two principal types of drag that work on a car are aerodynamic and rolling resistances. By reducing these forces, the car requires less power to propel it. Body design elements that reduce aerodynamic drag include flush windows and recessed windshield wiper systems, cab-forward design, tapered rear end and clean trailing edges, partially covered rear wheels, smooth underbody that slopes up towards the rear, minimized body seams and a smaller, flow-optimized front grill for air intake. (One proposed model from Ford will even eliminate side-view mirrors, which cause drag by obstructing airflow around the body, and replace them with video cameras and onboard monitors to display side views to the driver. This system has the added benefit of eliminating that "blind spot" we've all gotten a few thrills from.) Rolling resistance can be reduced by using ultralight materials for the body and low rolling-resistance tires, wheel bearings and brakes.

By using these techniques and materials, aerodynamic drag can be reduced by more than 40 percent and rolling resistance can be cut by more than 50 percent over conventional models. And the aerodynamic design has an added benefit–aesthetics. The sleek lines and futuristic appearance help with its commercial appeal, which will play a key role in its public acceptance. Let's face it–we all want to do good, but it helps to look good in the process. And looks will help move the cars out of the showrooms, a fact not lost on the carmakers.

Economic Impact

The economics of HEVs – for both consumers and manufacturers–also will have an impact on how they are developed and accepted. Although HEVs don't currently qualify for an Energy Policy Act (EPAct) credit from the federal government, there is some discussion of including HEVs in the future. (EPAct was passed in 1992 to increase the use of alternative fuels in transportation, and currently available HEVs don't use alternative fuels.) Congress also has considered a $3,000 tax credit for the manufacture of HEVs, a move that would doubtlessly increase interest in HEVs by car companies.

The development of future HEVs is being encouraged by new government programs, including partnering with private, public, nonprofit and educational concerns. The Department of Energy (DOE) has an HEV program, begun in early 1993, that focuses on developing HEV powertrains and internal components, but does not deal with the chassis, body, aerodynamics and rolling resistance.

Students Get Involved

In September 1993, President Clinton and CEOs of the "Big Three" U.S. automakers announced the Partnership for a New Generation of Vehicles (PNGV) to complement the DOE's HEV program. The PNGV program has worked to develop HEVs that can get up to 80 miles per gallon.

A number of colleges and universities are also taking on the challenge of developing future HEVs. Michigan Technical University and the University of Idaho, among others, have joined in the Future Truck competition sponsored by General Motors, in which a stock GM truck is given to the school to be converted to an HEV and is judged in several categories. Virginia Tech and Cornell University have HEVTs (Hybrid Electric Vehicle Teams) which work on developing new and different approaches to HEVs.

So, with all the incentives and talent at work, can the 100-mile-per-gallon HEV be very far in the future? Or one with a voice-controlled radio and a rearview video camera instead of a mirror? One thing is sure–we'll all be breathing easier because of all the new developments.

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Crude Energy Classroom Activity

Road to Saving Energy

1. Streamlining the shape of HEVs is important to their efficiency. Discuss with students how when a hand is placed outside a moving car's window the wind slips over the hand held parallel to the road, but when the hand is held vertically, the wind buffets and pushes the hand.

The same is true for the shape of a car. To demonstrate, use two identical model or toy cars. Tape a piece of cardboard at a right angle to the front or back hood or top of one car. Put both cars on an inclined track and release to see which makes it to the bottom first. Or use an electric fan to conduct a simple "wind tunnel" experiment with the two cars, one with the cardboard "sail" and one without to see which is pushed back by the air.

2. A reverse experiment also can be tried. Use two identical model cars–try to find ones with a "blocky" or square body–and have the students design and attach streamlining shapes, such as a tapered nose or a tapering rear fin, and try the wind tunnel or race track tests. Have students chart the differences.

3. Since weight is also a variable, conduct an experiment with weighted cars. If possible, use two identical, battery-powered toy radio-controlled cars. Using fresh batteries for power (preferably from the same pack for test control) attach some weights to one car (enough small metal pieces, for example, to make a difference in their weights). Weigh both cars and then "drive" them until the batteries fail. Chart to see if the heavier car runs out of power faster. This experiment may require part of several class periods, so students will need to keep good records.