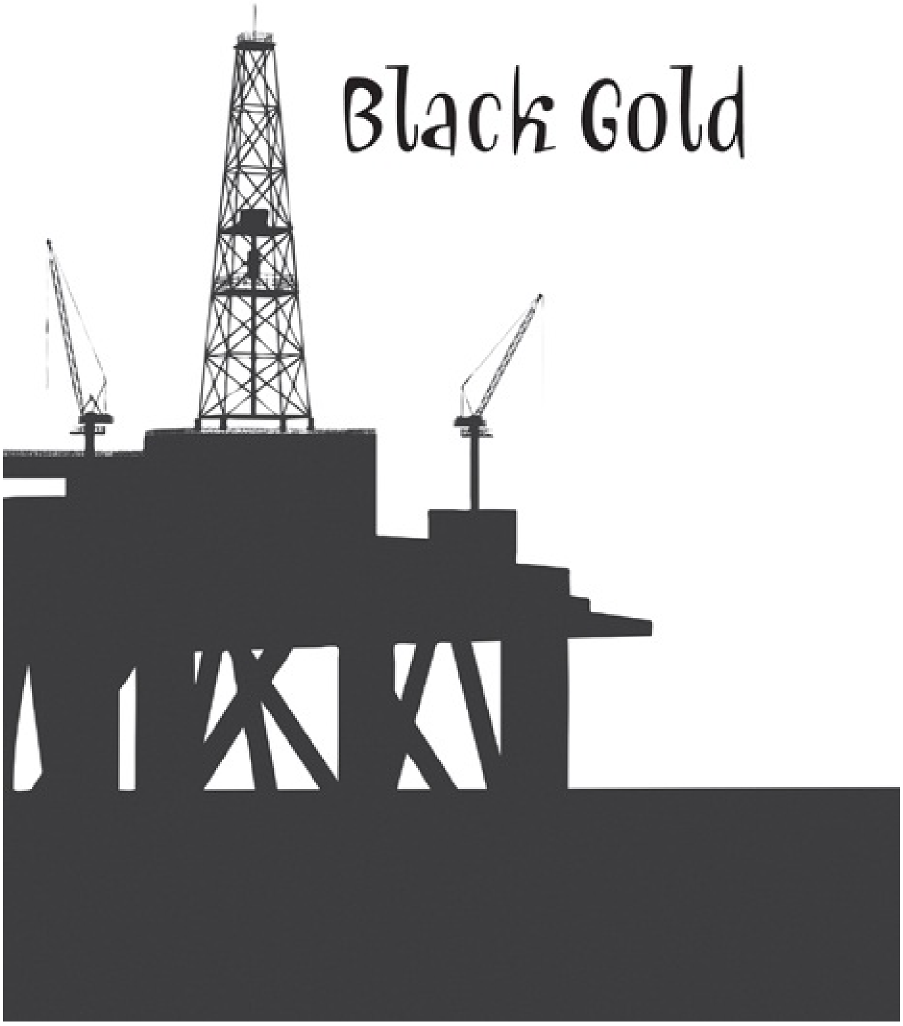
BLACK GOLD

The Story of OIL in Our Lives

National Book Award Finalist for FLESH & BLOOD SO CHEAP

ALBERT MARRIN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For today's young people, who will be confronted by the problem of black gold tomorrow.

There is nothing new in the world except the history you do not know.

—President Harry S. Truman

CONTENTS

Prologue

How Daddy Nearly Blew Himself Up

I've had this book in me for most of my life. In 1943, when I was seven years old, we lived in New York City. World War II was raging, and my father headed an important construction project in another state. Usually, if we were lucky, he drove home on weekends. Though gasoline was rationed, and most people could only buy a few gallons a week, it was never a problem for Dad. He had a government "priority," which meant that his work allowed him to get as much as he needed.

One night, he did not come at the time we expected. We were worried, until we heard the key turning in the lock. Dad was dirty, bruised, and shaken. Instead of the usual suitcase, he carried a clock, torn from the dashboard of the family car, with black wires dangling from it. A souvenir, he said, from "the Old Lady," as he called our beloved car. She had skidded on an icy road, turned over, and slid down an embankment, landing on her roof. Luckily, the highway patrol arrived and pried him from the wreck. He had just enough time, before the explosion, to pull out the clock.

"Explosion?" my mother asked, stunned. "Why an explosion?"

Well, he explained, he had (unwisely) filled the backseat with cans of gasoline. He was taking it to another job in New York, "just in case."

"Why?" Mother asked, hardly believing her ears.

"Don't you know," he said, "that gas is precious these days? This stuff runs the world."

I have never forgotten those words. For nothing has changed since that long-ago night. Today, as then, oil and its chief by-product, gasoline, still run the world. However, nothing lasts forever. The amount of oil is limited. As it becomes harder to find and more expensive to get out of the ground, it will grow yet more precious. Controlling its supply, and finding substitutes for it, will shape much of the social, political, and military history of the twenty-first century. That is what this book is about.

I
A FREAK OF GEOLOGY

The stuff we pump into our gas tanks is a freak of geology, the product of a series of lucky breaks over millions of years.

—Tim Appenzeller
Science Editor, National Geographic

Of Earth and Living Beings

Oil is not pretty. When it is taken from beneath the earth's surface, it is called crude oil, or crude for short. Although crude can be green, red, straw-colored, or chocolate brown, it is usually black. Because it is so valuable, in the late 1800s people in the industry nicknamed it "black gold." Since then, it has made fortunes for the lucky few and provided jobs for millions of ordinary folks.

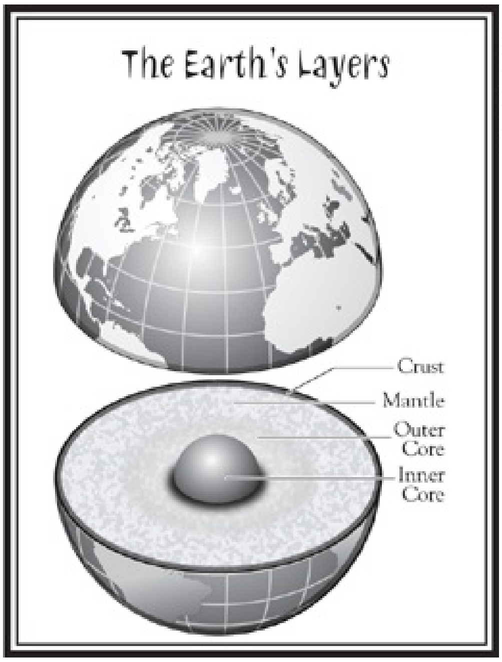
Thick and slippery, crude oil has an evil smell, giving off vapors that make eyes watery and throats sore. Yet without it, life as we live it today would be impossible. Oil fuels the engines that move us and our goods from place to place. It heats our homes and powers the machines that make the everyday things we take for granted. Thousands of products, from drinking straws to plastic shopping bags, from plant fertilizer to computers and medical equipment, begin as crude oil. So do most school backpacks, knee guards—even the yellow "rubber" duck floating in your bathtub. Modern weapons such as tanks, aircraft, and ships are so much metallic junk without oil products to make them run.

Oil influences every aspect of modern life. It has helped shape the history, society, politics, and economy of every nation on Earth. Nations have fought wars for black gold and, sadly, probably will do so in the future. Yet few who rely on this vital substance know much about it. What, exactly, *is* oil? How was it formed? When? Where?

To understand oil, we must begin with a key rule of science: change alone is changeless. This may sound odd, but it is true. Nothing stays the same forever. Change governs everything in the universe, from distant galaxies, stars, and planets to tiny bacteria and giant whales—and us humans, too. Many changes in nature, such as the formation of mountains, happen too slowly for us to notice, unfolding over many lifetimes, even millions of years. When we do see rapid and sudden changes, they are usually bad for us. For example, the people of the Italian city of Pompeii had lived for generations in the shadow of Mount Vesuvius, a dormant, or "sleeping," volcano. In the year AD 79, the sleeper awoke with an outburst of flame and fury. Within hours, it sent clouds of hot ash and gas to choke over 20,000 people, nearly all of Pompeii's residents.

Mountain ranges and volcanoes are features of the geology of the planet Earth. Geology is the science that studies the structure and history of the earth as recorded in the rocks. If you could slice deep into the earth, you would find that it is arranged in layers. Geologists—earth scientists—believe that the topmost layer of rock, or crust, is between four and forty miles thick. Earth's crust is like an eggshell broken into ten enormous slabs and numerous smaller ones. These slabs, called plates, float on a layer of partially molten rock called the mantle—that is, the layer of rock between Earth's crust and core.

Every continent and ocean floor rests atop one or more plates. Driven by heat currents from Earth's core, plates are always in motion, always changing position. Although the plates move slowly, just a few inches a year, their movements have shaped Earth's crust—and still do. Moving plates push against, slide past, and grind under one another. When two plates scrunch together, they trigger earthquakes that create volcanoes and mountain ranges such as the Rockies, Andes, and Himalayas.



Joe LeMonnier

Yet not even a mountain range can resist the force of flowing water. Water is invincible. Given enough time, it will erode—wear away—the hardest rocks. Rushing rivers break off bits of rock. Carried downstream, these bits bounce along a river's bottom, or bed, further shattering into coarse gravel or grains of fine sand.

Inevitably, rivers lose power as they run off from a continent and enter an ocean. In doing so, they drop the materials they carried, called sediment, into the coastal waters. Tides and currents move the sediment into deeper waters, far from shore. Settling on the ocean floor, it slowly builds up in layers that may become miles thick. As the lower, older sediment layers get buried deeper, the weight of the upper, younger layers compresses and hardens them, turning them to stone. These are the layers we see along the walls of deep cuts in Earth's surface, such as the walls of the Grand Canyon of the Colorado River. The mighty Colorado carved its canyon over millions of years, as it still does today.

Life began in the oceans, thanks to the sun. Nearly ninety-three million miles from Earth, the sun, like other stars, is a glowing ball of hot gases. Most of the sun's energy, in the form of light, is lost in deep space. However, a tiny fraction reaches Earth, where it drives the weather by heating the atmosphere and oceans, fueling life.

Ancient peoples worshipped the sun. For them, sunlight symbolized life, while darkness symbolized death—eternal night. Although the ancients could not explain why, modern science has shown how sunlight sustains life on Earth. From about 3.8 to 2.5 billion years ago, the first plants and animals developed in the oceans. Over millions of years, some of these changed, or evolved, in ways that allowed them to move onto the land. Every land plant and animal alive today has ancestors that once emerged from the oceans.

Like their modern kin, the earliest life-forms were what scientists call self-feeders. These are green plants, which trap solar energy through photosynthesis—that is, the process of turning sunlight into chemical energy. Energy is the power to do work or to act. Green plants store chemical energy and use it to live, especially to turn it into food for themselves. Thus, they are self-feeders.

Animals are other-feeders, or consumers. No animal can make its own food. To live, some animals must feed on plants, absorbing the chemical energy stored in them. Other animals, however, get their energy in another way. Carnivores, or flesh eaters, eat the plant eaters and other flesh eaters, too.


Tony Mitchell

A fossil of a carboniferous leaf, *Alethopteris serii,* unearthed in Somerset, England.

Most living beings vanish after they die. Microscopic bacteria nearly always consume the remains of the dead, leaving no trace. We call this decay. Yet, occasionally, some naturally preserved remains survive. These remains of ancient life-forms are fossils, from the Latin word *fossilis,* for "dug up." Generally, only the hard parts survive as fossils. These include bones, teeth, shells, and the woody parts of plants that become petrified, or turned to stone, by absorbing minerals from the earth. Other fossils are not the actual remains of an animal or plant at all, but imprints of them left in mud that hardened before decay set in. Studying fossils can help us understand what Earth was like in the distant past and how life-forms changed over time. But most of us have no use for such fossils in our daily lives.

Fossil Fuels

Fossil fuels *are* useful. A fuel is any material that stores energy. Like ordinary fossils, fossil fuels are the remains of plant life from the distant past. Yet they are nothing like the plant fossils we see in museums. Instead of resembling the plants they once were, fossil fuels have a different appearance because chemical changes have taken place. Nevertheless, fossil fuels store the chemical energy the original plants took from sunlight ages ago. Burning fossil fuels releases their captured energy so that we can put it to work for us.

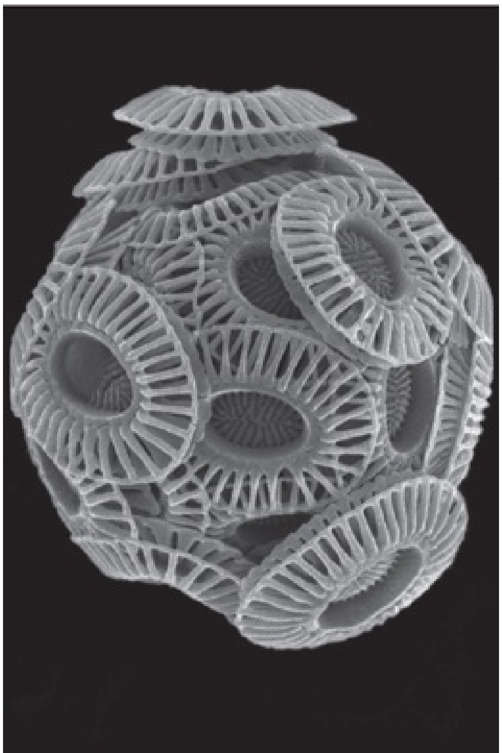
Fossil fuels were formed when ancient plants died and were buried under layers of sediment deposited by water. There are three kinds of fossil fuels: coal, oil, and natural gas. Scientists use a special term for such fuels: hydrocarbons. This is because each contains various amounts of hydrogen and carbon, the chemical building blocks of all life on Earth. Hydrocarbons supply nearly all the energy that powers today's world.

Coal deserves its nickname, "buried sunshine." It is the most abundant fossil fuel and the one that humans have used the longest. Most coal formed during the Carboniferous Period, the time in Earth's history from about 360 million to 285 million years ago; *carboniferous* is Latin for "coal-bearing." The world's climate then was warmer and moister than it is today, even at the North and South Poles. Swamps covered vast areas of the continents. Towering trees, ferns, and other leafy plants grew in the swamps. Giant dragonflies, often with wingspans two feet across, darted through the air, chasing other giant insects. The first reptiles, ancestors of the dinosaurs, roamed the land.

Coal began to form when the remains of dead plants sank to the bottom of the swamps they grew in. Sediment deposited by streams and rivers covered the remains. Centuries passed as generation upon generation of plants died and were buried under layers of mud and sand. New layers constantly formed. And as they did, the weight of the younger layers bore down on the older layers beneath them. Gradually, increasing pressure squeezed out the water, so the remains of the plants, all scrunched together, hardened and lost their original shape. Or most of them did, for miners sometimes find leaf impressions made in coal millions of years ago. Pressure and hardening drove out the hydrogen gas and other ingredients like sulfur, leaving black carbon: coal.

Yet not all coal is equal. Coal's hardness depends on the amount of pressure and time it took to form. The more carbon it contains, the more energy it will release in the form of heat.

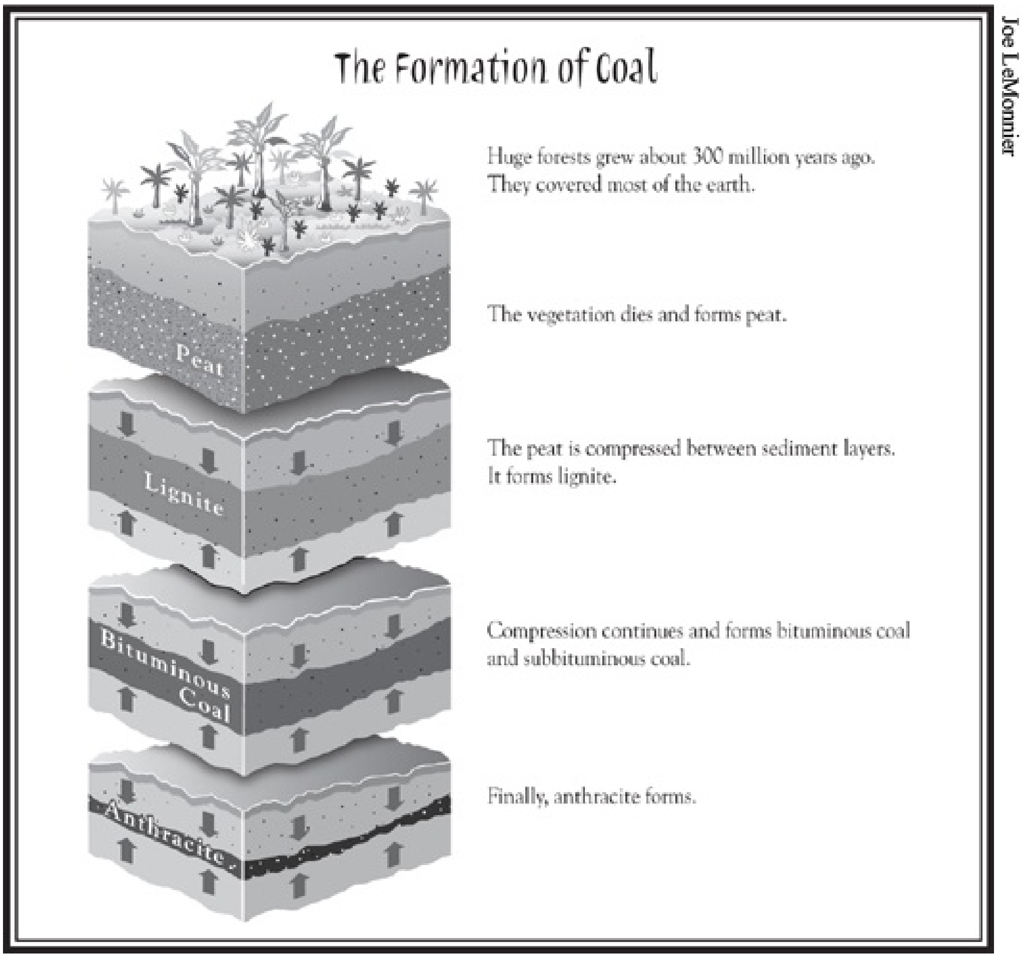
Coal begins as peat (60 percent carbon), a tangled, soggy mass of decaying roots, branches, stems, and leaves. Although used for fuel, especially in Ireland, where it is abundant, peat gives off little heat and much smoke. Next comes lignite, or brown coal (73 percent carbon), a harder substance that burns hotter than peat, but not much. Power plants burn lignite mainly to generate electricity and because it is cheap. Bituminous, or soft, coal (85 percent carbon) is black in color and harder than lignite; it gives enough heat for cooking and warming homes. Anthracite, the hardest coal of all (over 90 percent carbon), is buried deepest and longest. Because it burns hottest, anthracite is ideal for smelting—that is, heating certain types of rocks, called ores, to melt out the metal they contain. We get tin, copper, and iron this way.



One individual phytoplankton is about ten microns in diameter, or four ten-thousandths of an inch.

Photo Researchers

Oil and natural gas are formed differently from coal. Both are the remains of life-forms called phytoplankton that lived in the oceans between 10 million and 260 million years ago, in the time of the dinosaurs. "Phytoplankton" comes from the Greek words *phyton* (for "plant") and *planktos* (for "wanderer" or "drifter"). Too small to move on their own, phytoplankton float near the surface, in the sunlit zone of the ocean, to carry on photosynthesis. While there are hundreds of species of plankton, most are plants no larger than a grain of sand or a pinhead. Diatoms, perhaps the most common type, are single-celled plants covered by two shells that look glossy. Scientists have named about 20,000 species of diatoms. Given the right conditions, a single diatom can produce 100 million offspring each month. Like other plants, phytoplankton chemically store sunlight as energy to make food.



Phytoplankton have probably always been the oceans' most abundant life-form. Thanks to them, life there is an elaborate web, with each strand depending on the others for survival. Immense clouds of phytoplankton, each numbering trillions of trillions of individuals, drift from place to place, driven by winds and ocean currents. Light greenish-blue patches, or blooms, of phytoplankton have been photographed from satellites orbiting hundreds of miles above the earth's surface. Called the engine of the sea, phytoplankton form the first link in the food chain. All sea creatures depend on them, and all would die without them. Zooplankton—tiny, immature forms of sea creatures, such as snails, squid, crabs, lobsters, shrimp, and jellyfish—feed on phytoplankton, only to have small fish feed on them. Bigger fish, seabirds, penguins, seals, walruses, polar bears, and whales, in turn, eat small fish. People eat the fish and the larger sea animals. Indirectly, then, people living along seacoasts have always depended upon phytoplankton.

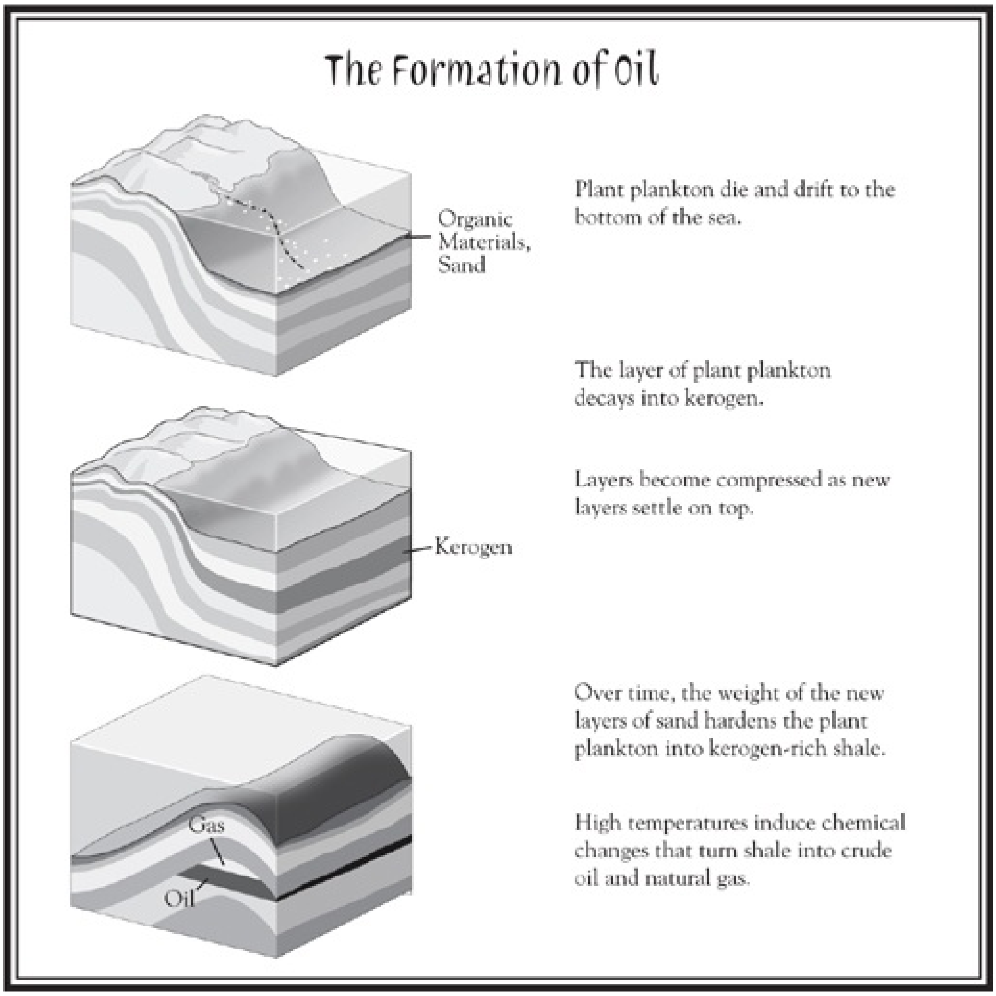
If conditions are right, nature begins to work a chemical miracle on the remains of phytoplankton. When an individual plant dies, it sinks to the ocean floor, where bacteria attack it immediately. Over a few days or weeks, the bacteria make the plant decay into a greasy, carbon-rich material called kerogen. Often, however, the kerogen mixes with mud. Now cut off from oxygen, and thus shielded from bacteria, the kerogen stops decaying. Gradually the kerogen-mud mixture forms a thick carpet, often dozens of feet deep. Layers of sand dropped by rivers cover the carpet. Over time, the ever-thickening sediments bury the mixture deeper and deeper. At a depth of 7,500 to 15,000 feet, it enters what geologists call the oil-gas window.

Two things happen in the oil-gas window. First, as sediments thicken and pressure builds on the lower layers, sand hardens into shale, a rock we can grind up to make bricks and cement. Second, kerogen-rich shale turns into source rock, so called because crude oil and natural gas form inside it.

Deep burial increases pressure, in turn producing heat. Millions of years spent at temperatures of 180 to 280 degrees Fahrenheit “cooks” the kerogen, triggering a complex series of chemical changes that transform it into crude oil and natural gas. Crude oil forms at depths of between 7,500 and 10,500 feet. Natural gas forms at 10,500 to 15,000 feet. Kerogen buried below the oil-gas window gets too hot and is destroyed.

Although formed from the same material, crude oil and natural gas are very different. Crude oil is a liquid under pressure. Carbon accounts for about 80 percent of its weight, and hydrogen about 12 percent; the rest is oxygen, nitrogen, and sulfur. Natural gas is a mixture of gases, but mostly methane. (Methane gas is also produced by cattle. When a cow grazes, bacteria in its stomach aid digestion, breaking down the plant fibers while producing methane as a waste product. Cows give off tremendous amounts of methane—natural gas—through belching and farting.)

Fossil fuels trapped inside source-rock shale do not stay there forever. Since the plates that carry the continents and seabeds constantly shift, they push and pull the source rocks, squeezing out the oil and natural gas. Once freed from their rocky prisons, they can travel long distances underground, often hundreds of miles during millions of years. Because they are lighter than any rocks, they try to move upward through cracks and pores, tiny spaces between the grains of the rocks above, such as sandstone. These pores often join, forming a network of microscopic channels.



Joe LeMonnier

The story of crude oil and natural gas is one of waste, not by humans but by Mother Nature. These fossil fuels eventually rise to the earth's surface. Natural gas then escapes into the air and disappears. Crude oil collects in seeps, or pools, where it leaks onto the ground or into the water. Only 2 percent of "oil spills" in the oceans are from damaged tanker ships; the other 98 percent are from natural seeps. Oil may also trickle down the face of cliffs or ooze through cracks in rocks—thus the name "petroleum," from the Latin for "rock oil" or "oil from the earth." Once exposed to the air, most of it evaporates or is broken down by bacteria.

Just a tiny amount of crude oil and natural gas will ever become useful to us as fuels. For this to happen, these upward-moving fuels must not reach the earth's surface on their own. Instead, they must accumulate in a reservoir formed under a layer of cap rock—that is, a harder type of rock overlaying a softer or weaker rock type. The term "reservoir" is misleading. An oil or gas reservoir is not an underground lake or stream. It is merely a layer of reservoir rock, usually porous sandstone, able to absorb these fuels as a sponge soaks up water. If you drill through the cap rock into a reservoir, the sudden release of pressure, millions of tons per square inch, creates a blowout, or gusher—an uncontrolled release of crude oil or natural gas. A fountain of oil and gas bursts from the ground with a roar, as if you had opened a bottle of soda after giving it a violent shaking.

Explorers have found oil fields on every continent but Antarctica. They have also found them in deep offshore waters, proof that the plates continents ride on have moved over time. Today we live in the age of oil, for without oil and natural gas, our lives would be very different and very poor.

II

BLACK GOLD

What a blessing the oil has been to mankind!

—John D. Rockefeller

Oil in Antiquity

The story of people and oil begins in prehistoric times, before the invention of writing. About 40,000 years ago, Stone Age hunters used asphalt to "glue" hand-worked stone points to the shafts of their spears and arrows. Asphalt, also known as bitumen and tar, is crude oil that seeped onto the earth's surface. Upon contact with the air, but before bacteria could decompose it, the oil turned into sticky goo, then hardened. For example, the famous La Brea Tar Pits in Los Angeles, California, are really asphalt seeps that have turned solid over the centuries. La Brea is a fossil collector's paradise. Preserved in the asphalt are the remains of mammoths, giant elephants that stumbled into the pits and got trapped, along with the saber-toothed tigers that preyed upon them.

This painting depicts animals trapped in the La Brea Tar Pits as they might have looked many thousands of years ago.

Our earliest written records come from the Middle East, known as the cradle of civilization. About 5,000 years ago, people there changed the way they lived. Instead of hunting wild animals and gathering wild plants for food, humans learned to grow crops and keep farm animals. In doing so, they formed the first permanent settlements—towns and cities. The invention of writing allowed farmers to keep track of how much they grew, borrowed, or lent to others, and the taxes they owed their rulers.

Ancient records describe fossil fuels. Writers tell of "eternal fires," natural-gas seeps probably set ablaze by lightning. Such fires do not easily burn themselves out. Some have shot fountains of flaming gas skyward for thousands of years. The Bible tells how Nebuchadnezzar, king of Babylon, plunged three devout Jews into a "fiery furnace" for refusing to worship his golden idol.[1] That furnace still rages near the Iraqi city of Kirkuk, amid one of the world's richest oil fields. During his journey to China in the 1200s, Marco Polo reported "eternal pillars of fire" at Baku on the western shore of the Caspian Sea, later a part of Russia. The roaring flames were so awesome that people believed they must be living gods demanding worship.[2]

Oil served both the living and the dead. Ancient peoples used it as an ointment to treat bruises, sores, and minor cuts. The soldiers of Alexander the Great, while conquering the known world for him, rubbed oil on their scalps to treat rashes caused by their bronze helmets. Arabs, pioneers in chemistry and medicine, praised oil's curative effects. In *The Book of the Powers of Remedies,* written in AD 683, an Arab physician wrote: "Warm naphtha [oil], especially water-white naphtha, when ingested in small doses, is excellent for suppressing cough, for asthma, bladder discomfort, and arthritis."[3] Perhaps some people did feel better, but we cannot be sure whether that was because of the treatment or in spite of it. Surely, no physician today would have a patient drink warm oil for any illness.

The ancients used asphalt as a construction material, as important to them as steel and concrete are to us. Egyptians, Greeks, and Romans waterproofed their ships by smearing layers of melted asphalt on the hulls. Most likely, Noah's ark and the basket Pharaoh's daughter used to hide the baby Moses had asphalt waterproofing, too. King Nebuchadnezzar’s masons bound together the bricks in the walls of his capital, Babylon, with asphalt mortar. By the year 800, the Muslim founders of Baghdad, capital of today’s Iraq, had made their city the wonder of the world; Arabs called it the Jewel of the World. A city of broad avenues, parks, and universities, Baghdad was also the first city to have paved streets. An Arab traveler named Yakut described how workers began by collecting hardened asphalt in woven reed baskets:

> They have large iron kettles placed over cauldrons which they load with known proportions of bitumen, water and sand. Then they light the cauldrons and heat the mixture until the bitumen melts and mixes with the sand while the workers are continually stirring it. When the stirred mixture reaches the right consistency it is poured over the ground as pavement.[4]

Modern roads are paved with tarmac, basically the same materials the old-time Baghdadis used.

Asphalt also helped the dead “live” forever. Ancient Egyptians believed in life after death. But to gain eternal life, a corpse had to be mummified—that is, embalmed and dried to prevent decay. Asphalt was a key ingredient in turning a corpse into a mummy; the word comes from *mumiyyah,* Arabic for “asphalt.” Since Egypt had little asphalt, merchants traveled to the Dead Sea, in what is today Israel, to trade with the local Arabs for it. The king of Syria, hoping to profit from the trade, sent an army to occupy the area. Furious that a foreign “thief” should control the fate of their dead, the Egyptians sent an army in 312 BC, thus winning history’s first war for oil.[5]

Library of Congress

The word “mummy” comes from *mumiyyah,* the Arabic word for “asphalt”—a key ingredient in mummifying a corpse.

Oil was not only a cause of war, but a tool of war. The ancient Persians wrapped oil-soaked rags around arrows, ignited them, and “fired” them at the enemy. The Romans armed their ships with catapults, machines that hurled spears, stones, and firepots hundreds of feet. Firepots were just that: clay pots