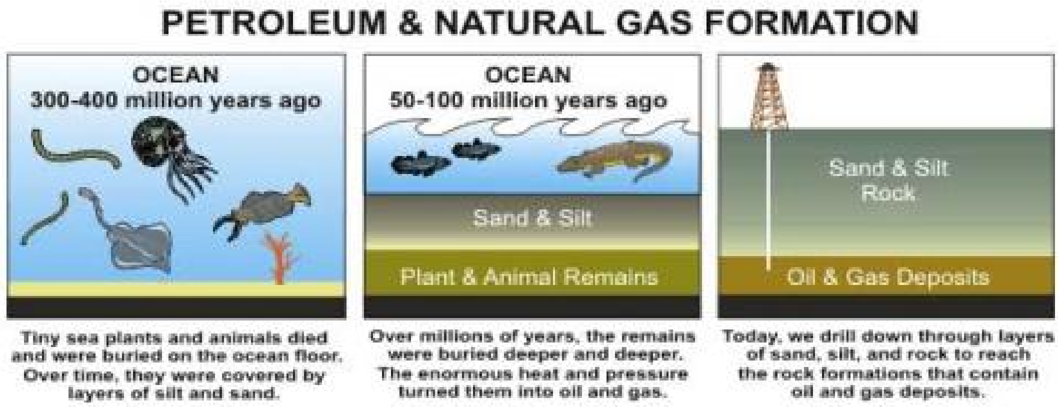
Chemistry of Life - What Makes Oil?



Most scientists agree that petroleum—such as crude oil and natural gas—started out as tiny plants and animals living in the ocean. When these tiny plants and animals died, they fell to the ocean floor.

When the remains of these micro-organisms were on the ocean floor, they were covered by silt and sand.

As the years passed, over geologic time, the remains of these micro-organisms were buried deeper and deeper and deeper in the Earth. In some places so much sand and sediment washed into the ocean that places which were once water-covered became land-covered.

Some of those tiny micro-organisms, still buried deep within the Earth, were now below land (where they had once been below water). Other tiny micro-organisms were still deeply buried below water (like the North Sea or the Gulf of Mexico).

In a process which scientists do not fully understand, the micro-organisms (formerly tiny plants and animals) were transformed from their original state into petroleum (liquid hydrocarbon mixtures, such as crude oil).

There's also something else—something discovered during the past few decades—which has scientists scratching their heads. The results of deep-drilling have revealed that bacteria are alive, and working, at about the same depths where drillers are finding oil.

How in the world can *this* be?

Michael Schirber tells us more in his *Live-Science* article:

> *Oil, the lifeblood of...transportation today, is thought to start with the remnants of tiny organisms that lived millions of years ago, but the exact chemical transformation is somewhat mysterious. New research is looking at the role played by microorganisms that live in the deep dark bowels of the Earth.*
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> *A minority of scientists say otherwise, but most geologists think that the petroleum we pump from the ground (and later refine into gasoline and other fuels) comes predominantly from the fossils of marine life, such as algae and plankton.*
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> *"There is a lot of evidence to support the biogenic origin," said Everett Shock, a biogeochemist at Arizona State University. "Some of the petroleum molecules, for example, resemble the lipids found in bacterial cell membranes."*
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> *Whereas most of the dead material in the ocean is recycled by bacteria, lipids are tough, fat-like molecules that "tend to be the least desirable to eat," Shock said. They generally get passed up and fall to the seafloor, where they become buried under layers of sediment and eventually cooked into petroleum.*
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> *Once the organic remains become entombed in rock, most scientists have assumed that biology ends and geology takes over. However, deep drilling expeditions in the past few decades have discovered bacteria living thousands of feet below the surface, at the same depths where petroleum is forming.*

Finding these microorganisms alive and well was the first surprise. The next question, though, is what are they *doing* at those depths in the Earth?

> *"Are these microorganisms directly involved in the reactions that turn organic material into petroleum?" asked Shock.*
>
> *He is leading a research group funded by the National Science Foundation that aims to figure out what these deep-dwelling microbes may be living off of and what influence they may have on petroleum chemistry.*

Does the sun play any role in the process of converting the remains of tiny plants and animals into oil? As it happens, the answer to that question is "yes."

> *Oil battery*
>
> *Even if some uncertainty remains over the exact chemical pathway to oil, the starting point is not in doubt.*
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> *"The ultimate source of energy is the sun, and oil is just a 'battery,'" said Barry Katz, a research scientist at Chevron.*
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> *Plants and certain bacteria use sunlight to convert carbon dioxide into sugar. This stored chemical energy is passed along the food chain, and a few "crumbs" wind up getting buried underground.*

So it's the "crumbs," which get buried deep underground, providing all the oil which people use in the 21st century? Once again ... the answer is "yes."

> *Once there, this organic material is transformed by heat and pressure into a complex mixture called kerogen. Depending on the initial ingredients and the geologic conditions, kerogen can produce either coal (a solid carbon-rich fuel derived mostly from woody plants) or hydrocarbons (a relatively hydrogen-rich substance that comes from algae and various lipid-containing plant parts).*
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> *Hydrocarbons are typically long chains of carbon and hydrogen atoms. The smaller hydrocarbon molecules (such as methane, propane and butane) are found in natural gas. The larger hydrocarbons (such as hexane and octane) make up petroleum.*

So if it's the crumbs falling to the ocean floor, which starts the whole process of turning organic material into oil, what percentage of the crumbs actually become oil? The answer is: "not much."

> *"It's a very inefficient process," Katz said. "Less than 1 percent of the organic material growing in the ocean becomes hydrocarbons."*

Wow ... it's surprising that we get oil at all, isn't it?

Once the "less than 1 percent of the organic material growing in the ocean becomes hydrocarbons," how much of it can humans actually retrieve to use in our daily lives?

> *Even when oil does form, it does not always last. Some of it migrates up to the surface, where oil-eating microbes consume the better parts of it (creating so-called tar sands). To prevent this from happening, there needs to be a geologic formation that can trap the petroleum in a reservoir.*

When oil drillers search for oil in places like the Gulf of Mexico, or the North Sea, they are looking for oil-containing reservoirs.

This whole transformation process—from tiny plants and animals to oil—takes an incredibly long time. That raises another question: How old is the petroleum that we put into our cars (which fuels us for a *very* short time)?

> *"Charging" this oil battery can take anywhere from 1 million to 1 billion years, with most petroleum we use being around 100 million years old.*

Yikes! Think about that! It took around 100 million years to create something which benefits us for a very short time.

We use petroleum products to heat our homes and to fuel our cars, planes, boats, trucks, lawnmowers, snowmobiles and a host of other things. Petroleum, to us, is *energy* which helps us to do our work and live our lives.

Is petroleum—which is a non-renewable source of energy—high-energy or low-energy when it's buried deep in the Earth?

> *Energy drain*
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> *The chemically stored solar energy is whittled away by the long and intricate process of petroleum formation.*
>
> *"Petroleum in the ground is at a low energy state," Shock told LiveScience. "It only becomes energetic when we bring it up to the surface and introduce it to an oxygen atmosphere."*

If petroleum is low-energy, when it's in the ground, how are those newly discovered microbes thriving in the deep Earth? And ... what are they *doing* there?

> *The reduced energy potential of buried organic material begs the question: what are deep-dwelling microbes surviving on?*
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> *"We don't know what they do," Shock said. "We just met them."*
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> *One possibility is that they are eating small organic byproducts that get expelled from the kerogen at the same time as the hydrocarbons. The other possibility is that these hearty bugs are actively helping to catalyze the reactions that create oil and siphoning off a bit of the remaining energy for themselves.*

Wouldn't it be interesting to go deep into the Earth and investigate this whole process ourselves? It would, but we can't—so—can we simulate all of this in a lab?

Simulating at high speed

Shock's team plans to create petroleum in the lab to see if there is any aspect of the process that might support bacteria.

This won't be the first time that scientists have simulated natural petroleum formation. To speed up the cooking process, researchers generally turn the temperature up to several 100 degrees Celsius.

"No one wants to wait around 10 million years for an experiment to finish," Shock said.

The assumption is that the same reactions occur at both high and low temperatures, but no one can say for sure that this is the case.

"It's rather remarkable that we are so dependent on oil, and yet we really don't understand how it is made in all its gory details," Shock said.

To which we all respond: "That's an understatement!"

Maybe the newly discovered bacteria, living deep within the Earth, will help scientists to better understand how it all comes together.

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