The Age of Oil

Student Objective
The student:
- can explain the biological, chemical and geological conditions necessary for oil to form
- can explain how petrochemicals are part of most items used today
- can explain what is meant by Peak Oil
- can explain how a decrease in oil production could effect our society.

Key Words:
anoxic
carbon dioxide
energy density
finite
peak oil
petrochemical
photosynthesis
phytoplankton
sequestered

Materials:
- *Crude: The Incredible Journey of Oil* internet download (see Internet Sites below)
- Laboratory Manual

Time:
(2) class times of 45 minutes to 1 hour

Background Information

Oil is a finite resource. It was formed millions of years ago under certain geological conditions from the remains of vast numbers of microscopic sea creatures. Geologists have become adept at spotting rock formations that might contain oil, with the result that most (if not all) of the big fields have already been found. In fact, the majority of the world's oil supply flows from a relatively small number of regional oil fields, and over 20% of the world's petroleum comes from just 14 large oil regions. These large fields are on an average 45+ years old, and according to some geologists, many are past their "peak."

The Hubbert Peak Theory, also known as peak oil, looks at the long-term rate of extraction and depletion in conventional petroleum and other fossil fuels. Peak Oil is the moment when oil production reaches a maximum output and then goes into decline. It is named after American geophysicist Marion King Hubbert, who created a model of known oil reserves. He proposed, in 1956, that production of oil from conventional sources would peak in the continental United States between 1965 and 1970, and worldwide within "about half a century", and that after the peak, production would decline, graphically following a bell-shaped curve. His prediction of U.S. oil "peak" turned out to be so accurate that his methods are being used to try to predict the time of peak oil worldwide.

It is important to note that the point of maximum production tends to coincide with the midpoint of depletion of the resource. This means that when we reach the Hubbert Peak, **we will have used half of all the recoverable oil that ever existed on our planet.** The majority of geologists estimate the original total of petroleum resources at two trillion barrels of conventional oil (not including oil contained in tar sands). Consuming the first trillion barrels of oil took approximately 150 years. If we were to continue to deplete our oil supply at today's rate, the other half of our reserves would be consumed in roughly thirty-two years. However, this doesn't take into account the annual increase in world oil consumption, and the increased energy demand from countries (such as China and India) who are experiencing rapid growth in transportation and industry.

Oil companies have understandably extracted the easier-to-reach, cheap oil first. The oil pumped first was on land, near the surface, under pressure, light and "sweet" (meaning low sulfur content) and therefore easy to refine into gasoline. This oil had an **energy density** of 100:1 meaning it contained 100 times more energy than it took to extract it. The remaining oil, sometimes off shore, far from markets, in smaller fields, or of lesser quality, takes more money and energy to extract and refine. Some of the deep-sea, far offshore wells have an energy density of only 4:1. Under these more difficult and costly conditions, the rate of extraction declines. Furthermore, individual oil fields eventually reach a point where they become economically, and energetically, no longer viable.

Although world crude oil production from traditional methods, remained relatively flat in the first part of this century, new sources of unconventional oil were starting to be exploited–most notably fracking of "tight oil" from deep rock formations, and extracting a useable product (shale oil) from oil shale rock by pyrolysis (heating the rock to a very high temperature). These processes are even more costly than deep sea drilling, and are also associated with the risk of high environmental costs. However, by 2015, five million barrels a day of "light tight oil" was being produced by fracking. This additional production technique had many proclaiming an end to the concern that Peak Oil was imminent. However, the costs associated with these new oil recovery technologies are so high they are only cost effective when the barrel cost of oil is high.

Many economists speculate that when the cost of oil increases, it affects the worldwide economy so that it dampens the demand for oil–thereby forcing the price down and making the more expensive oil production techniques cost prohibitive. So, this sets up a "yo-yo" effect. When the cost of oil is high, unconventional oil production makes sense, but the increased energy price slows the economy, people conserve and change habits, decreasing demand. With a lowered demand, the oil price drops, expensive oil extraction procedures decrease, the economy picks up, people "forget" their conservation and revert back to using more oil, increasing demand, and the price of oil goes up again.

It is important to understand that abundant inexpensive oil has not been just about cheap gasoline and diesel fuel for transportation. Oil is a particularly efficient source of large amounts of energy, and as such has enabled our population to increase and thrive. Additionally, our industrial societies and our financial systems were built on the assumption of continual growth – growth based on ever more readily available cheap fossil fuels. Oil is so important that its peak will have vast implications across the realms of geopolitics, lifestyles, agriculture and economic stability. Significantly, for every one joule of food consumed in the United States, around 10 joules of fossil fuel energy have been used to produce it.

Procedure - Day 1 (Oil's Origin)

1. **Engage:** Ask the class where the energy in oil and gasoline came from. The answers will vary--in the ground, from dinosaurs, etc. Keep asking related questions until the students arrive at the Sun, or the reactions occuring in the Sun, as an answer.
2. Show part 1 of the video. If you use the direct link, the video is already broken into three parts, if you are using the mirror sites (YouTube), end the video at 27min 54 seconds (the last words are... "And there it stayed, trapped until humans came along; the sludgy remains of tiny brainless plants waiting to hold dramatic sway over the future of the most intelligent life form the planet has ever seen.")
3. Allow 10 - 15 minutes for the students to complete the Science Journal.
4. **Explore:** Lead a class discussion about the video. Some topics to discuss might include:
   - How slow the formation of oil was, and how long ago the process began.
   - How specific the condition had to be for oil to be formed; not all of the Earth produced oil.
   - How precious oil is–we shouldn't be wasting it and using it up so fast or using it for things (like transportation) that we have viable alternatives that can be used instead.
   - What do you think is meant in the last statement by oil "holding a dramatic sway" over our future? What has oil given us (both good and bad)?

Procedure - Day 2 (Peak Oil)

1. **Engage:** Ask the students how they have used petroleum products today. Lead a discussion about their energy usage. (You may wish to write their answers on the board.) Make sure the students include: the oil needed to grow, transport, and cook their food; their clothing; their electrical usage at home and school; plastics, pharmaceuticals, etc.
2. Show Part 2 of the video. (Starting at 27min 54 seconds if using the full video link from You Tube, and ending at 59min 04 sec. The last words are..."Hidden in the black magic of an oil reservoir, is a climate demon from the distant past, and we unleash it at our peril")
3. Allow 5 - 10 minutes for the students to complete the Laboratory Manual.
4. **Explore:** Lead a class discussion about the issues in the video. Some topics to discuss might include:
   - Are you addicted to oil? Could you do without it completely? How have you used oil so far today?
   - How would your day-to-day life change if oil became too expensive for most people to buy more than a couple gallons a week?
   - How will your diet change if long distance transportation is cost prohibitive? What foods will be available in your area to eat? Will there be times during the year when your food choices will be severely limited?
   - What alternative sources of energy can we currently implement easily into our existing society and infrastructure? What new technologies should we be pursuing?
   - Do you think we've passed the point of Peak Oil? What evidence do you see for your answer? If your students seem unconvinced because of the current rhetoric

in the news (i.e "There's plenty of oil when you count oil shale and new technologies"), you may want to show them the short Post Carbon Institute video *Don't Worry, Drive On*, listed in the Internet Sites section below.

- what changes can we make now as individuals to help offset upcoming problems? As a community? As a country?
- What plans can you personally make to prepare?

Key Words & Definitions

- **anoxic –** lacking oxygen
- **carbon dioxide (CO_2)** – a colorless, odorless, incombustible gas composed of one carbon and two oxygen atoms.
- **energy density –** the amount of energy stored per unit volume
- **finite** – limited, having an end
- **peak oil –** the moment when oil production reaches a maximum output before going into decline
- **petrochemical** – a chemical obtained from petroleum or natural gas
- **photosynthesis** – the synthesis of organic compounds from carbon dioxide and water (with the release of oxygen) using light energy absorbed by chlorophyll
- **phytoplankton** – small, free floating organisms that use carbon dioxide, release oxygen and convert minerals to a form animals can use
- **sequestered** – locked up, bound up or set apart. Carbon is sequestered below ground in the rocks, oil and natural gas.

Related Research

1. Research the history of electric cars and new transportation research and inventions. How can these new inventions help transition to a world with less fossil fuels?
2. Research how many "food miles" your school lunch items traveled. What is the average distance traveled of your lunch?
3. Hold a classroom debate on the pros and cons of obtaining and using shale oil. Divide the class into two research teams. Students may either choose which side they want to represent, or they can be assigned. After completing their research, the groups choose who will represent them during the classroom debate.

Internet Sites

Video for this lesson

http://www.abc.net.au/science/crude/

Crude: The Incredible Journey of Oil, ABC Television (Australia), Science Series.

https://www.youtube.com/watch?v=IC40mZHu2ZQ

Mirror site - same video as above.

Related sites

https://www.youtube.com/watch?v=cJ-J91SwP8w&feature=kp

300 years of fossil fuels in 300 seconds by the Post Carbon Institute.

https://www.youtube.com/watch?v=4uKgU7krWzE
Don't Worry, Drive On: Fossil Fools & Fracking Lies by the Post Carbon Institute.
http://periodicvideos.com/videos/006.htm
Periodic Videos, Carbon.
http://www.nationmaster.com/country-info/stats/Energy/Oil
NationMaster. Worldwide statistics of oil production and use.
http://www.eia.gov/kids/energy.cfm?page=oil_home-basics
Department of Energy student pages on oil.

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Florida NGSS Standards & Related Subject Common Core

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Nature of Science																					
Standard 1	**SC.912.N.1.**	X			X		X														
Standard 4	**SC.912.N.4**		X																		
Earth and Space																					
Standard 6	**SC.912.E.6.**	X					X														
Life Science																					
Standard 17	**SC.912.L.17.**											X	X	X	X	X	X	X	X	X	X

Science–Standard 1: The Practice of Science

- SC.912.N.1.1- Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: 3) examine books and other sources of information to see what is already known, 4) review what is known in light of empirical evidence, 5) plan investigations, 7) pose answers, explanations, or descriptions of events 8) generate explanations that explicate or describe natural phenomena (inferences), 9) use appropriate evidence and reasoning to justify these explanations to others 10) communicate results of scientific investigations, and 11) evaluate the merits of the explanations produced by others.
- SC912.N.1.4 - Identify sources of information and assess their reliability according to the strict standards of scientific investigation.
- SC912.N.1.6 - Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

Science–Standard 4: Science and Society

- SC912.N.4.2 - Weigh the merits of alternative strategies for solving a specific societal problem by comparing a number of different costs and benefits, such as human, economic, and environmental.

Science–Standard 6: Earth Structures

- SC.912.E.6.1 - Describe and differentiate the layers of Earth and the interaction among them.
- SC.912.E.6.6 - Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

Science–Standard 17: Interdependence

- SC.912.L.17.11 - Evaluate the costs and benefits of renewable and nonrenewable resources, such as water, energy, fossil fuels, wildlife and forests.
- SC.912.L.17.12 - Discuss the political, social, and environmental consequences of sustainable use of land.
- SC.912.L.17.13 - Discuss the need for adequate monitoring of environmental parameters when making policy decisions.
- SC.912.L.17.14 - Assess the need for adequate waste management strategies.
- SC.912.L.17.15 - Discuss the effects of technology on environmental quality.
- SC.912.L.17.16 - Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.
- SC.912.L.17.17 - Assess the effectiveness of innovative methods of protecting the environment.
- SC.912.L.17.18 - Describe how human population size and resource use relate to environmental quality.
- SC.912.L.17.19 - Describe how different natural resources are produced and how their rates of use and renewal limit availability.
- SC.912.L.17.20 - Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability.

National Next Generation Science Standards

From Molecules to Organisms: Structures and Processes

- HS-LS1-5 - Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Ecosystems: Interactions, Energy, and Dynamics

- HS-LS2-5 - Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
- HS-LS2-7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Earth’s Systems

- HS-ESS2-2 - Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth’s systems.
- HS-ESS2-4 - Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.
- HS-ESS2-6 - Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

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Day 1 - Oil's Origin

1. Describe how oil is formed. Be specific. Use diagrams as necessary.

2. Explain as if you were talking to someone who hadn't watched the video, why it can be said we are living in the Age of Oil.

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Day 2 - Peak Oil

1. We should be concerned about peak oil because..........

2. With the real possibility of a reduction in petroleum products occurring simultaneously with an increase in demand (from a growing population, and the industrialization of countries that have previously been agricultural or undeveloped), I think we should........

3. If you knew for sure that gasoline prices would increase tenfold in ten years, what do you think should be done to prepare...

...by your family?

...in your neighborhood?

...by our country?