The End of Cheap Oil

Student Objective
The student:
- will be able to explain the biological, chemical and geological conditions necessary for oil to form
- will be able to explain how petrochemicals are part of most items used today
- will be able to explain how a decrease in oil production could affect our society
- will be able to explain why switching our transportation away from petroleum based fuels will be beneficial to our future.

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

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

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

Background Information

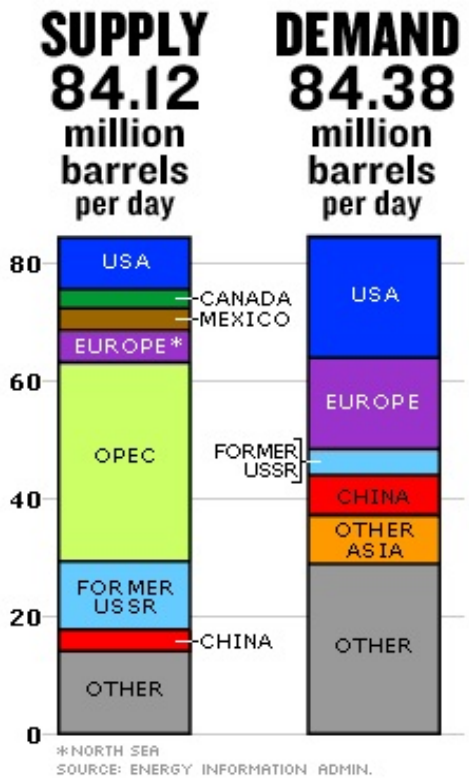
Oil is a finite resource. It was formed millions of years ago under certain geological conditions from the remains of vast numbers of microscopic sea creatures. Geologists have become adept at spotting rock formations that might contain oil, with the result that most (if not all) of the big fields have 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 crude 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. The Energy Information Administration (EIA) predicts that worldwide oil consumption *would* increase from 28.4 billion barrels a year in 2002 to 43 billion barrels per year by 2025–that is, *if it were possible*–if there in fact is that much oil that can be extracted. However, even at current supply and demand levels, we are not quite keeping up (see chart below). It is interesting to note however, that currently the price of gasoline has not sky-rocketed in the U.S. as might be expected in a situation with decreasing supply. This can be attributed to the increase in natural gas currently being recovered by fracking technology, which has diverted some of the demand for crude oil products in non-transportation applications to natural gas. While lower gasoline prices can be seen as a positive thing for the consumer, it does mask the underlying problem with crude oil supply.

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.



However, because of differences in reserve reporting and the secrecy of many countries when it comes to money and resources, it is very difficult to tell when worldwide peak oil will occur--or even if it may have recently happened. World oil production has been essentially flat since the beginning of 2005. Of the 65 largest oil producing countries in the world, up to 54 have past their peak of production and are now in decline.

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 occurring in the Sun, as the 'origin' answer
2. **Explore:** Show part 1 of the video, *Crude: The Incredible Journey of Oil*. 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 Laboratory Manual.
4. **Explain:** 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) for which 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:** Begin the class with this scenario:

   Imagine that you live in a world that has a finite food supply–when it is consumed, it cannot be grown or replaced. In the past, this world has had enough food, and you and your family have had as much food as you wanted to eat. The scientists tell you that your children will probably have enough food also--but sometime after that, it will become very scarce.. What should the people of this world do? Should everyone on this world get the same amount of food every day, or should it change depending on what is needed by the individual? Or would it depend on who had the most money and could afford to buy the food–or who had the most power? And who should decide how the food would be rationed out?
2. **Explore:** 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. **Explain:** 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 of food 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 ('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 how many 'food miles' your school lunch items traveled. What is the average distance traveled of your lunch?
2. 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.

3. Investigate how fracking has helped to keep gas prices low. Are these lower prices sustainable? Investigate the impact that gas prices have on the public's car buying behavior.

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
Social Studies Standards		SS.912.C.2.10																			

Standard 1: The Practice of Science

- SC.912.N.1.1- Define a problem based on a specific body of knowledge, 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; 7) pose answers, explanations, or descriptions of events; 8) generate explanations that explicate or describe natural phenomena; 9) use appropriate evidence and reasoning to justify these explanations to others; 10) communicate results of scientific investigations; 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.

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.

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.

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.

Social Studies Standards

Civics and Government

- SS.912.C.2.10 - Monitor current public issues in Florida.

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.

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-ESS2-6 - 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?