Video: Crude - The Incredible Journey of Oil
Teacher Notes

Documentary: Crude – The Incredible Journey of Oil
Duration: 89 minutes

Overview of the Documentary

At a time of peaking fuel prices, Dr Richard Smith explores the history of one of our most contentious commodities. "Crude" is internationally acclaimed and has won more than 12 film awards, including the coveted Earth Sciences category at Jackson Hole and the Walter Sullivan Medal for Science Journalism for the American Geophysical Union, the world's largest professional association of Earth scientists.

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Questions

1. **Identify** the source of oil.
   Ancient marine photosynthetic plankton captured light energy and converted it into carbon that was stored and then concentrated to form oil in sedimentary basins.

2. **Describe** the importance of carbon to life.
   Bones and bodies, plants and microbes would not exist without carbon and carbon chemistry that links all living things. Carbon is found in all living things and was formed in stars.

3. **Identify** how much carbon is locked up in living organisms.
   One trillion tonnes of carbon is bound up in living organisms.

4. **Identify** the large geological sinks of carbon locked away deep underground.
   The fossil fuels coal, oil and gas and in the rocks of the Earth.

5. **Explain** the release of large volumes of carbon dioxide in the mid Jurassic.
   The tectonic plates were moving and sustained volcanism pumped huge volumes of carbon dioxide into the atmosphere.

6. **Explain** how carbon dioxide acts to regulate the Earth's temperature.
   Too little carbon dioxide in the atmosphere and the planet will be too cold for life to exist, too much and it will be too hot.

7. **Describe** the Earth during the mid Jurassic.
   Half the Earth would have been blue and covered with clouds, the other half brown and green. The continents would have been bunched together on one side of the planet. The land to the north and south was separated by a warm ancient ocean called the Tethys. There was no ice at the poles and there is thought to have been no substantial ice on the planet. It would have been a warm greenhouse world with elevated levels of carbon dioxide. It would have been like the Bahamas over the entire area that is now the Middle East. It would have had a shallow carbonate environment like the Barrier Reef today.

8. **Describe** the journey and timeline of a carbon dioxide molecule from how long it is in the atmosphere to when it enters a Gingko tree until it is released back into the atmosphere.
   100 years in the atmosphere
   1 season in the leaf of a Gingko tree
   50 years in the body of the dinosaur that ate it before being exhaled back into the

atmosphere as carbon dioxide

9. **Identify** the process that phytoplankton uses to harvest carbon dioxide.
   Carbon dioxide is absorbed by phytoplankton and in the presence of sunlight the phytoplankton converts it into an energy-rich sugar (glucose) through the process of photosynthesis.

10. **Describe** the result of nitrogen and phosphorus pollution from the Mississippi River in the Gulf of Mexico.
    Excess nitrogen and phosphorus from the Mississippi River lead to algal blooms in the Gulf of Mexico.

11. **Describe** how anoxic stagnant dead zones in the ocean lead to black ooze and future oil deposits.
    The decay of excess living things uses up oxygen in the water and leads to stagnant anoxic zones where many organisms can't live. These have been named 'dead zones'. A steady rain of uneaten dead organisms falls through these anoxic waters to the seafloor and builds up, in layers. These layers, containing plankton cells, build up form a black ooze which may become a future oil deposit.

12. **Describe** the geology of the Dorset 'Jurassic' coast of Southern England and its formation.
    Mountains of black rock formed from a plankton graveyard. Black shale mudstone made up of the remains of dead plankton and clay that accumulated on the seafloor. Finely laminated sediments which indicate no animals churned them up. So, the layers are the same as when they were deposited in the Jurassic. These conditions were perfect for preserving large numbers of fossils.

13. **Describe** the conditions required to produce oil and natural gas deposits.
    Black shales and claystones need to be buried deep underground where they are altered by the increased pressures and temperatures. The original carbon can be converted to crude oil. The temperatures reached are critical, if it is too hot the original material is converted into natural gas. If it is too shallow (and therefore temperatures are lower) the material remains as a greasy oil shale.

14. **Identify** the special conditions that are needed for large oil reservoirs to form.
    Source rocks that are very rich in carbon and have reached the ideal temperature and pressure conditions (via burial).
    Excellent reservoir rocks so that the oil can migrate and be trapped within them.

Sound cap rocks that are impermeable, assisting to trap the oil in place.
Gentle traps, such as fold structures (anticlines) in which the oil can accumulate.

15. **Identify** what drove the first global demand for oil.
    A shortage of sperm whale oil drove the first demand of fossil fuel oil for lighting.

16. **Identify** the main use for gasoline, a kerosene production waste product.
    The internal combustion engine uses gasoline (petroleum, petrol), the waste product of kerosene production.

17. **Identify** the products refined from crude oil.
    Transport – car petrol, aviation fuel and diesel.
    Petrochemical industry – 10% of all oil is converted into a wide range of products from plastics to paints, pesticides and pain killers.
    Household items – food, clothes, medicine and toothpaste.
    Farms - fertilisers
    Fisheries - nets

18. **Describe** the Gwahar Oil Field and what makes it unique.
    It is the largest oil field ever found on Earth. It is 35 km wide and 175 km long.

19. **Identify** when Peak Oil was reached in the USA.
    Early 1970s was predicted by Hubbert and it was reached in 1970 in the USA.

20. **Identify** when global Peak Oil was predicted to be reached by Hubbert.
    Peak oil predicted by Hubbert to be in the year 2000.

21. **Describe** what it means to be on the other side of Peak Oil and what this means for oil prices in the future.
    As oil availability decreases the price will increase.

22. **Identify** how many barrels of oil are transported and burnt every day.
    84 million barrels of oil

23. **Identify** the consequences of burning fossil fuels, like oil.
    Greenhouse gases, such as carbon dioxide, are emitted into the atmosphere. World climates are warming.

24. **Identify** the conditions each super anoxic oceanic event has been linked to.
    Each super anoxic oceanic event has been linked to super Greenhouse conditions of unusual warmth, ice-free and high atmospheric carbon dioxide.

25. **Identify** what each period of super Greenhouse climate has been correlated to.
    Each period of super Greenhouse climate is correlated with excess volcanism. Huge outpourings of lava vented sulfur dioxide and carbon dioxide into the atmosphere.

26. **Identify** the relationship between the number of pores in fossil Gingko leaves and atmospheric levels of carbon dioxide.
    The greater the carbon dioxide in the atmosphere the fewer the number of pores in the leaves of Gingko.

27. **Describe** the effects of rising temperatures.
    The rate of evaporation and humidity increases, which leads to more rain, powerful tropical storms and flooding (particularly in coastal regions).

28. **Identify** how rain was different in the Jurassic to rain today and the effects it would have had.
    The rain would have been more acidic than it is today. It would have burnt vegetation and etched rocks and soils. This would lead to much higher amounts of nutrients being released from rocks into the oceans, acting as a fertiliser for phytoplankton.

29. **Describe** the effects of increased sediments and nutrients in the oceans.
    The nutrients as a fertiliser for phytoplankton, which are the source of carbon for oil shales. The numbers of phytoplankton would have increased, leading to algal bloom, possibly triggering an anoxic oceanic event.

30. **Describe** the conditions required to transfer oxygen into the deep sea.
    Cold water at the poles holds more oxygen and as ocean currents transfer water around the planet cold oxygen rich water sinks into the deep ocean.

31. **Identify** the toxic chemical released in anoxic ocean environments and the consequences.
    Hydrogen sulfide is the toxic chemical released in anoxic ocean environments, it causes the death of many organisms.

32. **Identify** the organisms that can survive in the anoxic conditions of Green Lake.
    Purple and green sulfur bacteria.

33. **Describe** how the Earth recovers from super Greenhouse conditions.
    Carbon dioxide gets incorporated into living things which die and get buried in the ocean. Their contained carbon is locked away in sediments. This reduces the carbon dioxide in the atmosphere and the climate cools.

34. **Identify** three effects of excess carbon burial and resetting the global thermostat.
    Sharp drop in sea temperature, drop in sea level and signs of ice reforming at the poles. Additionally, the buildup of carbon rich shales which may form oil or natural gas reservoirs in the future.

35. **Describe** how the loss of polar ice can amplify global warming.
    As temperatures rise there is less ice to reflect heat away which leaves the darker ocean to absorb heat. The faster the sea warms the faster the remaining ice melts. This can weaken ocean currents or stop them, amplifying global warming.

Complete the passage below based on your answers to the questions above.

Molecules of carbon dioxide were released in huge volumes by volcanic eruptions in the mid Jurassic. Carbon dioxide helps to regulate the Earth's temperature. Too little carbon dioxide in the atmosphere and the Earth cools, too much and the Earth warms. The time of the dinosaurs was one of the warmest in Geological history with Super Greenhouse conditions.
Carbon dioxide in the ocean is absorbed during photosynthesis by phytoplankton. When these organisms die, they transport the carbon locked in their tissues to the deep ocean. If conditions are anoxic then nothing decays, and large volumes of black ooze build up on the ocean floor. If conditions are favourable then this black ooze will form black shale and potentially oil. To form large oil reserves several special conditions are needed:

1. Rich source rocks high in carbon
2. Source rocks heated to the right temperature underground
3. Excellent reservoir rocks that are porous and permeable
4. Impermeable cap rocks that trap the oil
5. Anticline (or other structure) for the oil deposit to collect and sit in.

Oil is used for transportation and in the petrochemical industry which underpins almost everything in our modern lives. Burning oil releases carbon dioxide into the atmosphere. This leads to global warming and Greenhouse climate conditions.

In the Jurassic Super Greenhouse conditions would have led to more rainfall and extreme weather. The rain was more acidic than it is today. This led to increased weathering and erosion which released sediments and nutrients into the oceans. This led to phytoplankton blooms and the

depletion of oxygen in the ocean. This led to the production of hydrogen sulfide which is toxic to most lifeforms.

Oceanic anoxic events lead to high levels of purple and green sulfur bacteria and Archaea that use hydrogen sulfide. This leads to perfect conditions for large reservoirs of undecayed organisms to accumulate and extinction events. Burying the carbon contained in dead organisms creates a carbon sink, locking away the carbon in source rocks. This reduces the amount of carbon dioxide in the atmosphere and leads to global cooling. This leads to a drop in sea temperatures, sea levels and the formation of ice at the poles.

Increasing water temperatures in the oceans leads to the slowing or halting of oceanic currents. Increased temperatures also lead to sea level rises, melting of ice and increased surface temperatures. This leads to less dissolved oxygen and are of anoxic conditions in the deep oceans, which may trigger a Super Greenhouse event, like in the Jurassic, and the formation of new oil deposits in the future.