## Fossil Fuels, Chemistry of Fuels

## *Energy sources*

- Wood—chemical energy stored by plants
- Kinetic energy—
  - Water power to grind grain
  - Wind to pump water
- Fossil fuels

http://www.adamandlyn.co.uk/country/greecewindmill.shtml

## *Sun's Energy*

- Radiant energy
  - Released by fusion
  - Hydrogen fused into Helium
- $1.73 \times 10^{17}$ watts received by Earth from Sun
- 99+% of Earth's energy
- Converted by plants into chemical energy

## *Photosynthesis*

$6\ CO_2 + 6\ H_2O + \text{sun energy} \rightarrow C_6H_{12}O_6 + 3\ O_2$

- Converts $CO_2$ and $H_2O$ to sugar and $O_2$
- Created the level of oxygen present in today's atmosphere
- Ancient algae in Archean and Proterozoic oceans released $O_2$ by photosynthesis

## *Energy and Chemical Reactions*

- Heat released or consumed in chemical reactions
- Measured in calories
  - Food 'calorie' is a kilocalorie (kcal)
  - 1 Joule = 0.24 calories
- Energy shown in equation
- $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O + 526$ kcal

## *Reaction energy*

***EXOTHERMIC***

***heats up environment***

***ENDOTHERMIC***

***absorbs heat from environment***

## Conservation of Energy

- Energy is not created or destroyed
- First Law of Thermodynamics

## Heat Flow

- From objects with higher temperature to those with lower temperature
- Second law of thermodynamics

## Implications of laws

- Change form from high quality to lower quality
  - Chemical energy to heat energy
  - Friction: mechanical to heat
- Energy wasted as frictional heat
- Need to put energy in to 'make' cold

## *Fossil fuels*

- Burn readily
- Reaction is oxidation
- Release heat energy

## *Fossil fuels*

- Coal
- Petroleum
- Natural Gas

## *First law of thermodynamics*

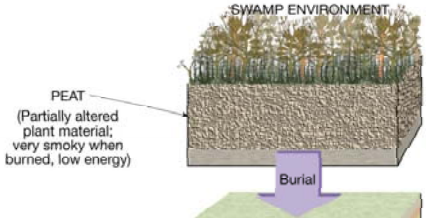
- Conservation of energy
- Cannot create or destroy energy
- (But we can convert to less-useful form)

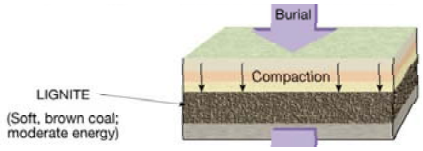
## *Fossil fuels*

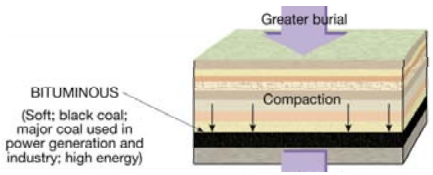
- Non renewable
- From ancient organisms
- Extracted from Earth

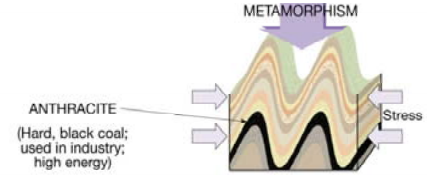
## Carboniferous Period Forest

http://palaeos.com/Paleozoic/Carboniferous/Carboniferous.htm



## *Coal*

$C + O_2 \rightarrow CO_2$

- Anthracite
- Bitumen
- Lignite

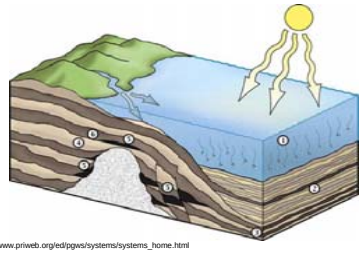
## *Coal*

- Incompletely decayed plants
- Burial pressure releases $O_2$ and $H_2$
- Carbon remains
- Paleozoic—Pennsylvanian coal, Carboniferous Period

## *Coal*

- Must be mined
- Pollutants in coal
  - Sulfur leads to acid rain
  - Also contains mercury, arsenic, nitrates

## *Hydrocarbon System*



- http://www.priweb.org/ed/pgws/systems/systems_home.html

## *SOURCES*

- Shale with organic material
- Gooey sludge on ocean floor

## *Zooplankton*

- Planktonic organisms
- Probable source of petroleum

http://www.priweb.org/ed/pgws/systems/source/source.html

- http://en.wikipedia.org/wiki/Image:Haeckel_Stephoidea.jpg

## *COOKING*

- Just right temperature
- Just right pressure
- Just right time

## *RESERVOIR*

- Porous
- Permeable
- Usually a sedimentary rock

## *POROUS*

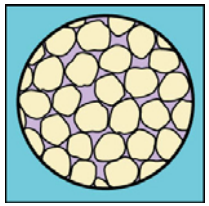
- Has open space
- Sponge

## *PERMEABLE*

- Permits fluid throughflow
- Nylon scrubbie

## *RESERVOIR*

- Permeable
- and Porous



http://www.priweb.org/ed/pgws/systems/reservoir/reservoir.html

## *TRAP*

Almost no permeability or pore space

- Shale (Usually not source shale)

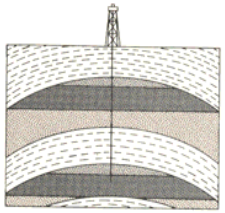
http://www.priweb.org/ed/pgws/systems/seal/seal.html

## *STYLES OF TRAPS*

- Structural
- Stratigraphic

## *STRUCTURAL TRAP*

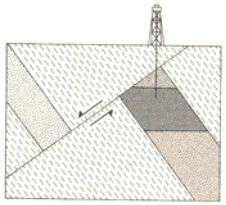
- Reservoir sand
- Capping shale
- Arched fold



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

## *STRUCTURAL TRAP*

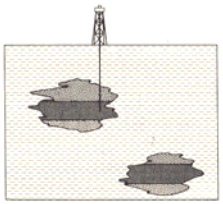
- Reservoir exists
- Fault creates trap



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

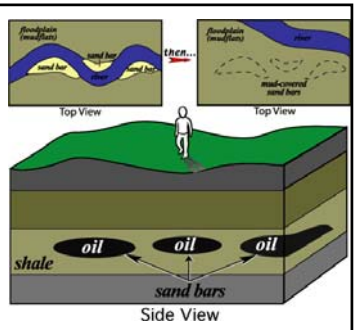
## *STRATIGRAPHIC TRAP*

- Channel sand
- Shifting channel of river
- Shale above caps reservoir



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

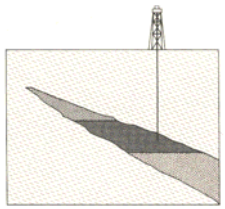
Sand lens Traps from meandering streams




http://www.priweb.org/ed/pgws/systems/traps/strat/strat_traps.html

## *STRATIGRAPHIC TRAP*

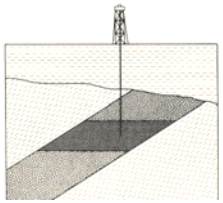
- Deposition of sand
- Shale deposited above sand
  - Deltas
  - Invading seas



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

## *UNCONFORMITY TRAP*

- Reservoir rock tilted and eroded
- Impermeable rock deposited above erosion surface



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

## ***Natural Gas***

- Mostly methane

  $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ + heat
- Excellent, clean-burning fuel
- Raw material for plastics and other chemicals

## ***Petroleum***

- Replaced coal by about 1950
- Complex hydrocarbon molecules
- Derived from fats
- Combustion products are carbon dioxide and water

## ***Petroleum***

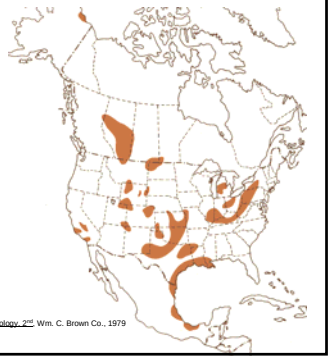
$2C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$

- Also contains some sulfur compounds
- Fuel oil is fairly clean
- Burning gasoline results in smog
  - Internal combustion engines inefficient

## *Petroleum Requirements*

- Source
- Cooking
- Reservoir
- Trap

**MAJOR OIL FIELDS IN NORTH AMERICA**



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

## *TITUSVILLE, PA*

- Oil Creek Valley in the 1860s
- Phillips well (rt) 4000 bbl/day
- Woodford well (lt) 1500 bbl/day

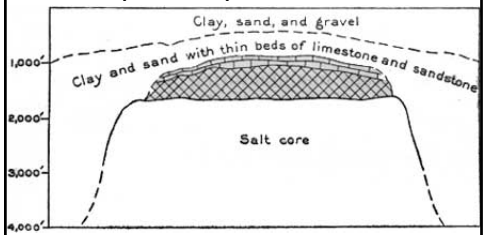
http://www.priweb.org/ed/pgws/history/pennsylvania/tarr_farm.html

## *Texas Oil*

- Lucas Gusher, 1901
- Initial production 100,000 bbl/day
- Salt dome traps

http://www.priweb.org/ed/pgws/history/spindletop/spindletop.html

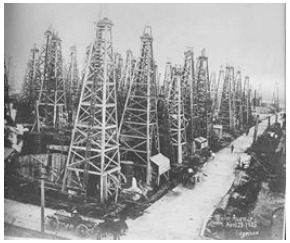
## Spindletop Salt Dome




http://www.nps.gov/history/history/online_books/geology/publications/bul/845/contents.htm

## *Boiler Avenue*

On Spindletop salt dome at Beaumont, Texas



http://www.priweb.org/ed/pgws/history/spindletop/spindletop.html

## *Signal Hill, Long Beach, CA*

1932

http://www.priweb.org/ed/pgws/history/signal_hill/signal_hill2.html

## *Drilling on the North Slope*

Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

## *Drilling in the North Sea*

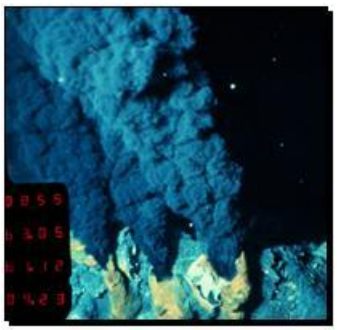
Rocks and Fossils, Busbey, Doennaads, Willis and Roots, Fog City Press, 1997

## *Top 10 Countries— Oil Statistics*

- Reserves
- http://www.nationmaster.com/graph-T/ene_oil_res&int=10
- Comsumption
- http://www.nationmaster.com/graph-T/ene_oil_con&int=10

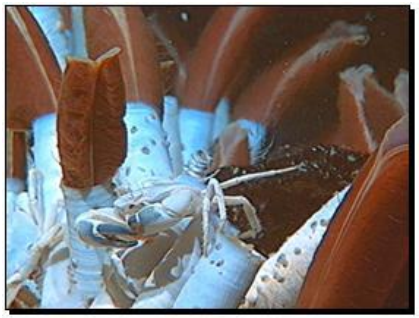
## ***Source of energy not from Sun***

- Rare deep sea vent communities
- Sulfurous hotsprings supports bacteria
- Other organisms subsist on bacteria
- Larger creatures can survive on the bacteria-eating organisms



http://www.punaridge.org/doc/factoids/Biology/

http://www.punaridge.org/doc/factoids/Biology/



http://www.punaridge.org/doc/factoids/Biology/