

# FOSSIL FUELS ARE THEY DINOSAURS?

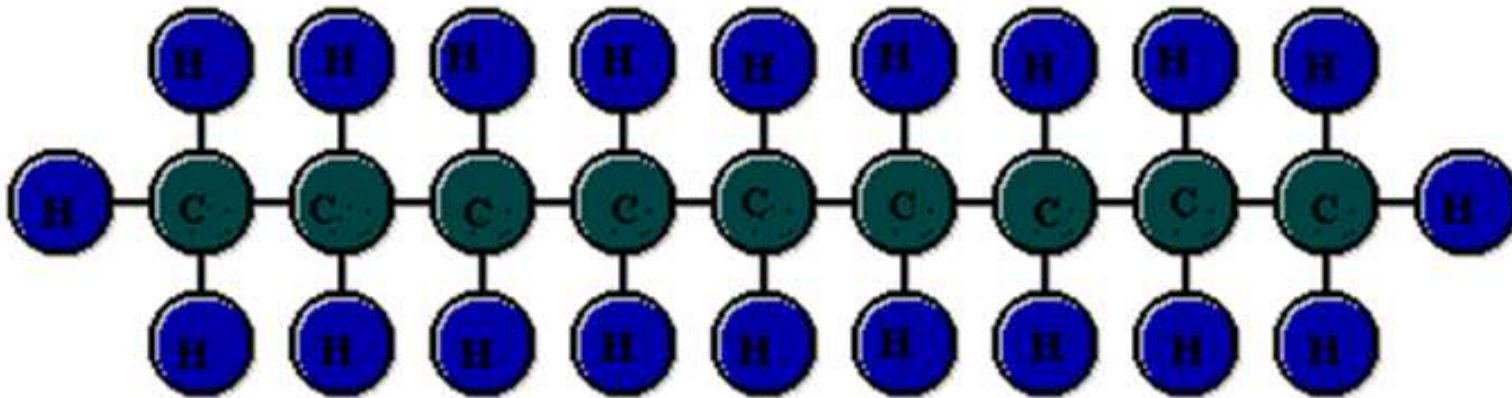
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University of the Witwatersrand

# COMBUSTION



# HYDROCARBONS

- Mainly Carbon and Hydrogen
- Also others like Oxygen and Sulphur



# HYDROCARBONS

## Periodic Table of Elements

|   | 1                                   | 2                                  | 3                                  | 4                                 | 5                                  | 6                                | 7                                   | 8                                | 9                                | 10                               | 11                              | 12                              | 13                                  | 14                               | 15                                  | 16                              | 17                                | 18                              |                                 |
|---|-------------------------------------|------------------------------------|------------------------------------|-----------------------------------|------------------------------------|----------------------------------|-------------------------------------|----------------------------------|----------------------------------|----------------------------------|---------------------------------|---------------------------------|-------------------------------------|----------------------------------|-------------------------------------|---------------------------------|-----------------------------------|---------------------------------|---------------------------------|
| 1 | <b>H</b><br>Hydrogen<br>1.00794     |                                    |                                    |                                   |                                    |                                  |                                     |                                  |                                  |                                  |                                 |                                 |                                     |                                  |                                     |                                 |                                   |                                 | <b>He</b><br>Helium<br>4.002602 |
| 2 | <b>Li</b><br>Lithium<br>6.941       | <b>Be</b><br>Beryllium<br>9.012182 |                                    |                                   |                                    |                                  |                                     |                                  |                                  |                                  |                                 |                                 | <b>B</b><br>Boron<br>10.811         | <b>C</b><br>Carbon<br>12.011     | <b>N</b><br>Nitrogen<br>14.0064     | <b>O</b><br>Oxygen<br>15.999    | <b>F</b><br>Fluorine<br>18.998403 | <b>Ne</b><br>Neon<br>20.1797    |                                 |
| 3 | <b>Na</b><br>Sodium<br>22.98976928  | <b>Mg</b><br>Magnesium<br>24.304   |                                    |                                   |                                    |                                  |                                     |                                  |                                  |                                  |                                 |                                 | <b>Al</b><br>Aluminum<br>26.9815386 | <b>Si</b><br>Silicon<br>28.0855  | <b>P</b><br>Phosphorus<br>30.973762 | <b>S</b><br>Sulfur<br>32.06     | <b>Cl</b><br>Chlorine<br>35.453   | <b>Ar</b><br>Argon<br>39.948    |                                 |
| 4 | <b>K</b><br>Potassium<br>39.0983    | <b>Ca</b><br>Calcium<br>40.078     | <b>Sc</b><br>Scandium<br>44.955912 | <b>Ti</b><br>Titanium<br>47.88    | <b>V</b><br>Vanadium<br>50.9415    | <b>Cr</b><br>Chromium<br>51.9961 | <b>Mn</b><br>Manganese<br>54.938045 | <b>Fe</b><br>Iron<br>55.845      | <b>Co</b><br>Cobalt<br>58.933195 | <b>Ni</b><br>Nickel<br>58.6934   | <b>Cu</b><br>Copper<br>63.546   | <b>Zn</b><br>Zinc<br>65.38      | <b>Ga</b><br>Gallium<br>69.723      | <b>Ge</b><br>Germanium<br>72.64  | <b>As</b><br>Arsenic<br>74.9216     | <b>Se</b><br>Selenium<br>78.96  | <b>Br</b><br>Bromine<br>79.904    | <b>Kr</b><br>Krypton<br>83.799  |                                 |
| 5 | <b>Rb</b><br>Rubidium<br>85.4678    | <b>Sr</b><br>Strontium<br>87.62    | <b>Y</b><br>Yttrium<br>88.90584    | <b>Zr</b><br>Zirconium<br>91.224  | <b>Nb</b><br>Niobium<br>92.90638   | <b>Mo</b><br>Molybdenum<br>95.94 | <b>Tc</b><br>Technetium<br>98.9062  | <b>Ru</b><br>Ruthenium<br>101.07 | <b>Rh</b><br>Rhodium<br>102.9055 | <b>Pd</b><br>Palladium<br>106.42 | <b>Ag</b><br>Silver<br>107.8682 | <b>Cd</b><br>Cadmium<br>112.411 | <b>In</b><br>Indium<br>114.818      | <b>Sn</b><br>Tin<br>118.710      | <b>Sb</b><br>Antimony<br>121.757    | <b>Te</b><br>Tellurium<br>127.6 | <b>I</b><br>Iodine<br>126.905     | <b>Xe</b><br>Xenon<br>131.29    |                                 |
| 6 | <b>Cs</b><br>Cesium<br>132.90545196 | <b>Ba</b><br>Barium<br>137.327     | 57-71                              | <b>Hf</b><br>Hafnium<br>178.49    | <b>Ta</b><br>Tantalum<br>180.94788 | <b>W</b><br>Tungsten<br>183.84   | <b>Re</b><br>Rhenium<br>186.207     | <b>Os</b><br>Osmium<br>190.23    | <b>Ir</b><br>Iridium<br>192.222  | <b>Pt</b><br>Platinum<br>195.084 | <b>Au</b><br>Gold<br>196.966569 | <b>Hg</b><br>Mercury<br>200.59  | <b>Tl</b><br>Thallium<br>204.3833   | <b>Pb</b><br>Lead<br>207.2       | <b>Bi</b><br>Bismuth<br>208.9804    | <b>Po</b><br>Polonium<br>209    | <b>At</b><br>Astatine<br>210      | <b>Rn</b><br>Radon<br>222.01753 |                                 |
| 7 | <b>Fr</b><br>Francium<br>223        | <b>Ra</b><br>Radium<br>226         | 89-103                             | <b>Rf</b><br>Rutherfordium<br>261 | <b>Db</b><br>Dubnium<br>262        | <b>Sg</b><br>Seaborgium<br>266   | <b>Bh</b><br>Bohrium<br>264         | <b>Hs</b><br>Hassium<br>277      | <b>Mt</b><br>Meitnerium<br>268   | <b>Ds</b><br>Darmstadtium<br>271 | <b>Rg</b><br>Roentgenium<br>272 | <b>Uub</b><br>Ununbium<br>285   | <b>Uut</b><br>Ununtrium<br>286      | <b>Uuq</b><br>Ununquadium<br>289 | <b>Uup</b><br>Ununpentium<br>288    | <b>Uuh</b><br>Ununhexium<br>291 | <b>Uus</b><br>Ununseptium<br>294  | <b>Uuo</b><br>Ununoctium<br>294 |                                 |

|                   |               |                       |             |                   |             |                  |             |  |
|-------------------|---------------|-----------------------|-------------|-------------------|-------------|------------------|-------------|--|
| <b>C</b> Solid    | <b>Metals</b> |                       |             |                   |             | <b>Nonmetals</b> |             |  |
| <b>Hg</b> Liquid  | Alkali metals | Alkaline earth metals | Lanthanoids | Transition metals | Poor metals | Other nonmetals  | Noble gases |  |
| <b>H</b> Gas      |               |                       |             |                   |             |                  |             |  |
| <b>Rf</b> Unknown |               |                       |             |                   |             |                  |             |  |

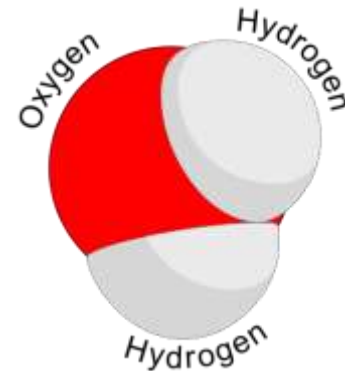
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

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|                                       |                                     |   |                                      |                                     |                                    |                                     |                                      |                                      |  |                                      |                                   |                                      |                                       |                                     |
|---------------------------------------|-------------------------------------|---|--------------------------------------|-------------------------------------|------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|--|--------------------------------------|-----------------------------------|--------------------------------------|---------------------------------------|-------------------------------------|
| 57 <b>La</b><br>Lanthanum<br>138.9047 | 58 <b>Ce</b><br>Cerium<br>140.119   | 59 <b>Pr</b><br>Praseodymium<br>140.90766 | 60 <b>Nd</b><br>Neodymium<br>144.242 | 61 <b>Pm</b><br>Promethium<br>(145) | 62 <b>Sm</b><br>Samarium<br>150.36 | 63 <b>Eu</b><br>Europium<br>151.964 | 64 <b>Gd</b><br>Gadolinium<br>157.25 | 65 <b>Tb</b><br>Terbium<br>158.92535 | 66 <b>Dy</b><br>Dysprosium<br>162.5003 | 67 <b>Ho</b><br>Holmium<br>164.93032 | 68 <b>Er</b><br>Erbium<br>167.259 | 69 <b>Tm</b><br>Thulium<br>168.93041 | 70 <b>Yb</b><br>Ytterbium<br>173.0546 | 71 <b>Lu</b><br>Lutetium<br>174.967 |
| 89 <b>Ac</b><br>Actinium<br>227       | 90 <b>Th</b><br>Thorium<br>232.0377 | 91 <b>Pa</b><br>Protactinium<br>231.03688 | 92 <b>U</b><br>Uranium<br>238.02891  | 93 <b>Np</b><br>Neptunium<br>237    | 94 <b>Pu</b><br>Plutonium<br>244   | 95 <b>Am</b><br>Americium<br>243    | 96 <b>Cm</b><br>Curium<br>247        | 97 <b>Bk</b><br>Berkelium<br>247     | 98 <b>Cf</b><br>Californium<br>251     | 99 <b>Es</b><br>Einsteinium<br>252   | 100 <b>Fm</b><br>Fermium<br>257   | 101 <b>Md</b><br>Mendelevium<br>258  | 102 <b>No</b><br>Nobelium<br>259      | 103 <b>Lr</b><br>Lawrencium<br>260  |

# HYDROGEN



# HINDENBURG



# CARBON



# IDENTIFY THE HYDROCARBONS

- ◉ A Used engine oil
- ◉ B New engine oil
- ◉ C Peat
- ◉ D Tar
- ◉ E Charcoal
- ◉ F Coke
- ◉ G Anthracite
- ◉ H Coal

# EXAMPLES ARE!



Coal

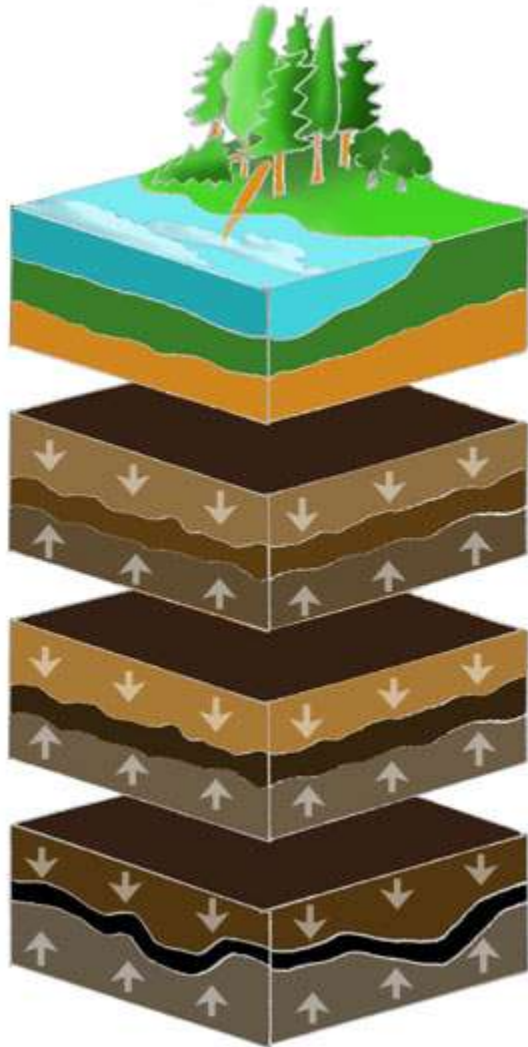


Natural Gas



Oil

# FORMATION OF COAL



HUGE FORESTS GREW AROUND  
300 MILLION YEARS AGO  
COVERING MOST OF THE EARTH

THE VEGETATION DIES AND  
FORMS PEAT

THE PEAT IS COMPRESSED BETWEEN  
SEDIMENT LAYERS TO FORM LIGNITE

FURTHER COMPRESSION  
FORMS BITUMINOUS AND  
SUBBITUMINOUS COAL

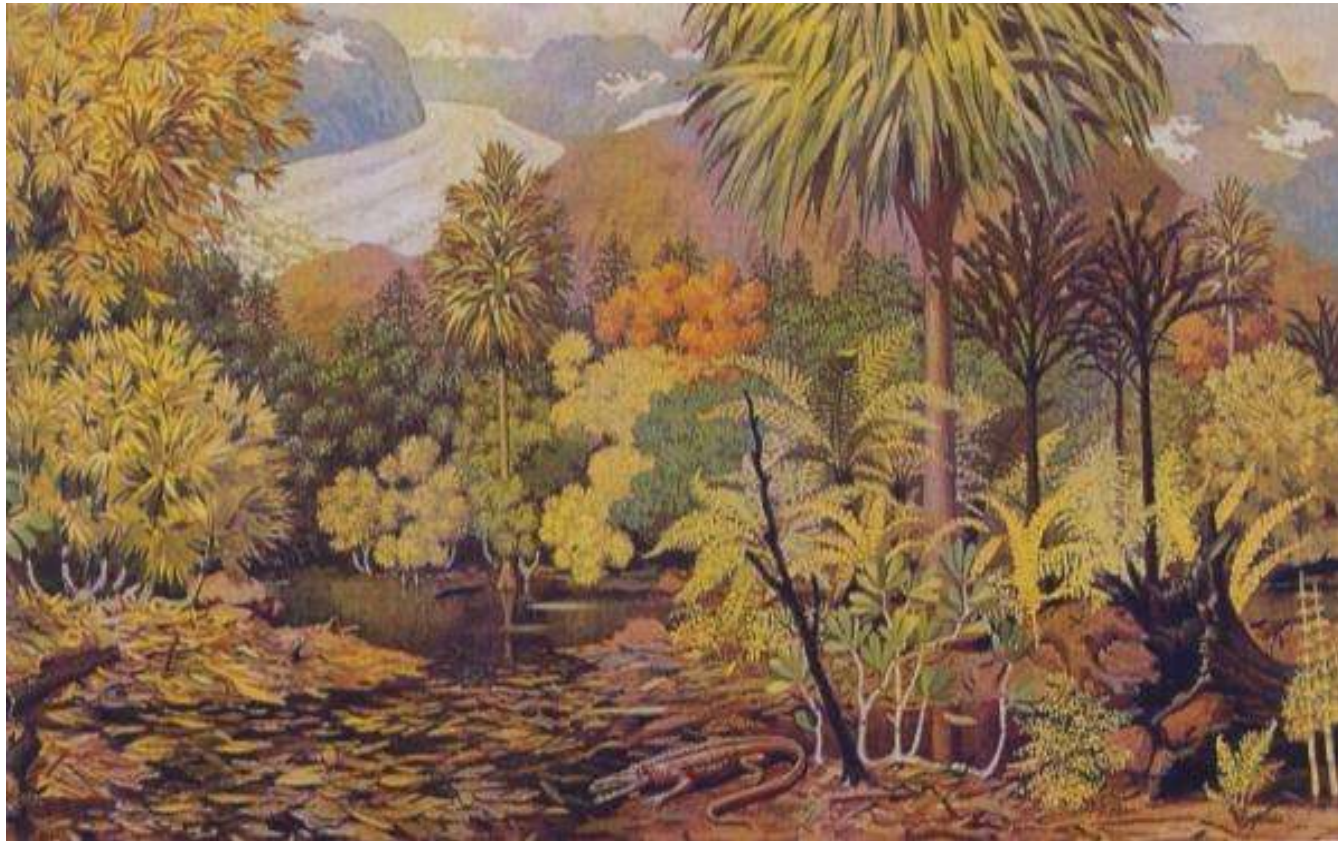
EVENTUALLY ANTHRACITE FORMS

## FOSSIL FUEL FACTS

- Rotting plant material becomes peat.
- Peat is buried and subject to high pressures and temperatures.
- Peat becomes lignite.
- Lignite becomes bituminous coal.
- Bituminous coal becomes anthracite.

# HOW IS COAL FORMED

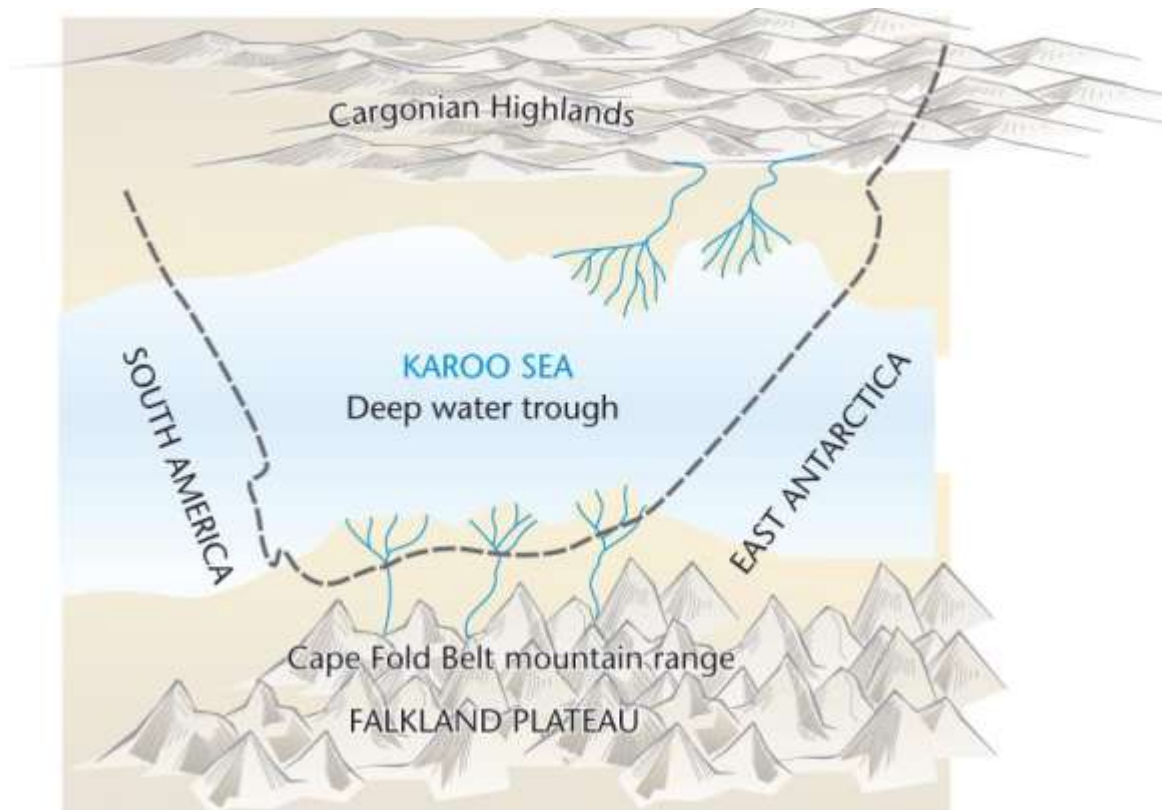
260 million years ago South Africa was covered with vast swamps



# MODERN SWAMPS



# WHERE WERE THEY FOUND?



# PRESERVED AS FOSSILS



Ferns



Glossopteris



Horse tails

# PEAT



*Swamp*



*Peat bog*



*Peat piled for burning*

## FOSSIL FUEL FACTS

- Over millions of years plants in the coal swamps died and were buried underwater with no oxygen.
- The dead plant material did not decompose forming peat.
- Burial of the peat created heat and pressure resulting in the peat being turned into coal.
- In South Africa peat is found in wetlands where it is protected.
- In the Northern Hemisphere peat is more common.
- Peat can be burned or used as a potting soil, it is also used to grow mushrooms.

# LIGNITE

*Lignite*



*Lignite Burning Power Station*



## FOSSIL FUEL FACTS

- ◉ Lignite or brown coal forms when peat is altered by relatively low temperatures and pressures over a long period of time.
- ◉ Lignite may still contain unaltered plant material.
- ◉ Fresh Lignite has a high moisture content (up to 66%) and a relatively low carbon content (20 – 35 %).
- ◉ Lignite contains many substances (volatiles) which turn into gas or smoke when burnt.
- ◉ We do not burn lignite in South Africa, but in other parts of the world it is burned in power stations.

# BITUMINOUS COAL

**Bituminous coal**



**Arnot Power Station**



## FOSSIL FUEL FACTS

- ◎ Bituminous coal is formed when lignite is subject to high pressures and temperatures.
- ◎ Bitumen is a type a sticky black tar-like substance.
- ◎ Bituminous coal is 60% to 80% carbon, together with substances like water, hydrogen and sulphur.
- ◎ Bituminous coal is the most common type of coal in South Africa. It is used for heating, cooking and in power stations.
- ◎ The high sulphur content of this coal can cause acid rain. Power stations need to “scrub” their waste gases to get rid of the sulphur.

# ANTHRACITE

**Anthracite**



**Clean burning**



## FOSSIL FUEL FACTS

- Anthracite is formed when bituminous coal is subject to temperatures of between 150°C and 200°C .
- Anthracite is a type of metamorphic rock.
- It is harder and shinier than ordinary coal.
- Anthracite contains between 92 and 98% carbon. It produces hardly any smoke and can burn for days (unlike ordinary coal which burns out in hours).
- Anthracite is too expensive for power stations and is preferred for domestic heating and cooking because it is clean burning.

# COKE (FUEL)

**Coke**



**Iron Smelting**

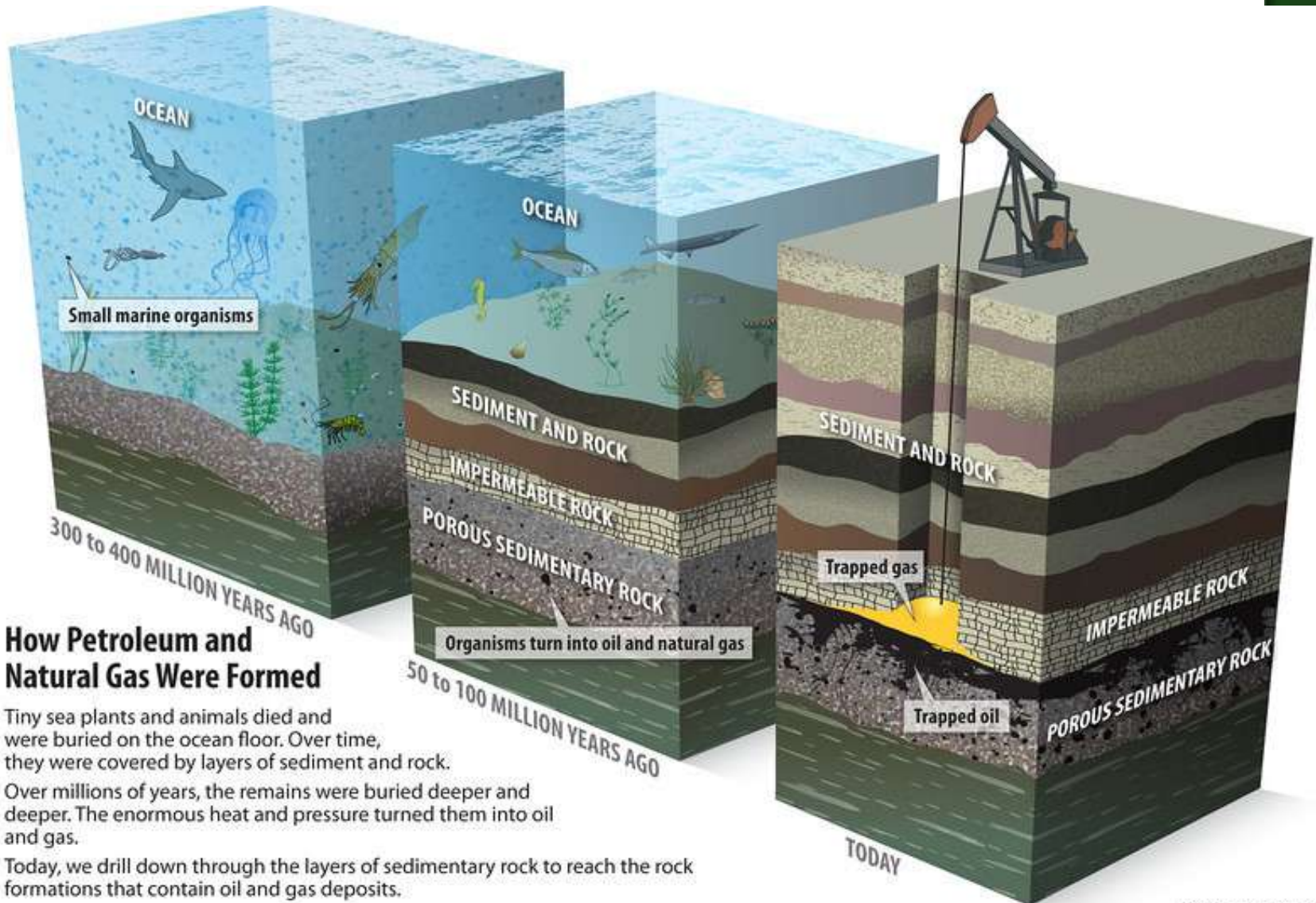


## FOSSIL FUEL FACTS

- Coke is formed by heating low Sulphur bituminous coal in the absence of air at a temperature as high as 2000°C
- Coke burns cleanly at high temperatures
- Coke is specially useful in furnaces in the iron industry where it is used to reduce iron ore ( $\text{Fe}_2\text{O}_3$ ) into iron.



# OIL AND GAS FORMATION



## How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sediment and rock.

Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

Today, we drill down through the layers of sedimentary rock to reach the rock formations that contain oil and gas deposits.

Note: not to scale

# OIL AND GAS

**The Ocean**



**Plankton**



**Diatoms**



## FOSSIL FUEL FACTS

- Oil is formed from fossilized plankton.
- A drop of Ocean water contain thousands upon thousands of tiny creatures called plankton which include:
  - Protists (e.g. copepods and algae including diatoms).
  - Larvae of jellyfish, starfish, sea-cucumbers and other animals.
- These tiny creatures die and form a thick sludge on the bottom of the ocean.
- Diatoms- can form a thick clay called diatomite which is used in toothpaste.
- The dead plankton sludge is buried and heated to form oil and gas.

# DRILLING FOR OIL AND GAS

**Drilling on land**



**Oil pump**



**A floating oil platform**

## FOSSIL FUEL FACTS

- Huge drilling rigs that can drill through thousands of metres of sediments are needed to drill for oil.
- The drill rigs can be found on land or on floating platforms at sea.
- Once the drillers have found oil they pump it out with special pumps

# CRUDE OIL

An oil gusher



## FOSSIL FUEL FACTS

- ⦿ Oil pumped straight out of the ground is called **crude oil**.
- ⦿ Crude oil is a smelly mixture of tar, oil, benzene and other substances including sulphur.
- ⦿ When an oil drill strikes oil the crude oil may come gushing out, this is called a blowout and can be very dangerous.

# NATURAL GAS



# METHANE



# OIL REFINERY

Oil refinery

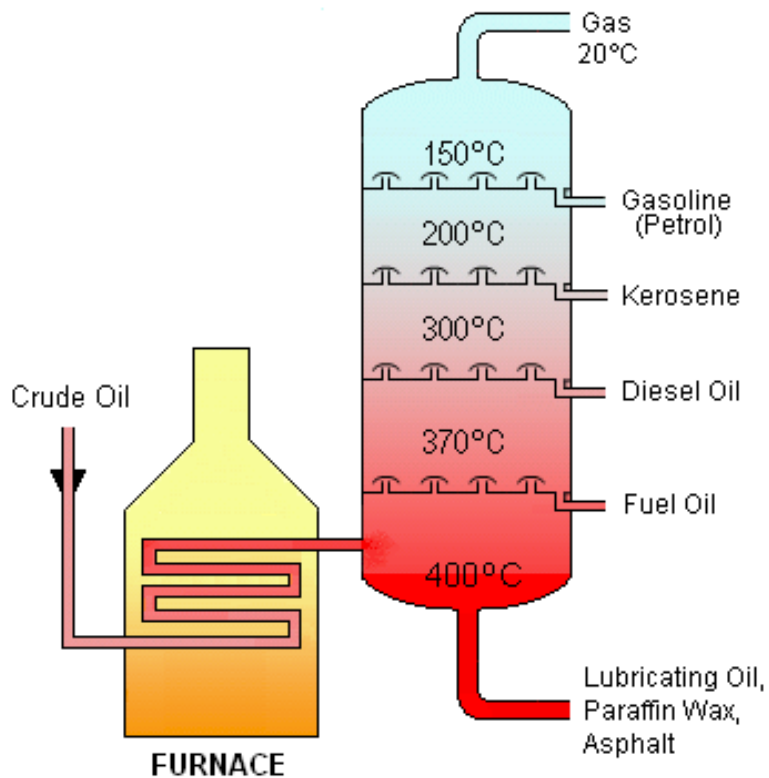


## FOSSIL FUEL FACTS

- ◉ An oil refinery is a huge factory where crude oil is converted into other products like:
  - Tar (Bitumen)
  - Wax
  - Diesel
  - Petrol
  - Motor car oil
  - Gas
- ◉ The crude oil here comes from the Engen refinery in Durban

# OIL REFINERY

## Fractional Distillation



## FOSSIL FUEL FACTS

● In an oil refinery a huge fractional distillation column is used to separate the crude oil into different parts:

- At lower temperatures (20°C) gas (LPG) separates.
- At 150°C petrol forms.
- Next at 200°C paraffin (kerosene) separates.
- At 300°C Diesel forms.
- At 370°C motor car oil separates.
- At 400°C Wax and road tar separate out.
- The products of crude oil can be turned in many types of chemicals and plastics.

# SASOL

**Sasol Plant**



## FOSSIL FUEL FACTS

- ◉ Since 1955 Sasol has had a factory that can turn coal into oil.
- ◉ Coal is heated with oxygen and steam under pressure to make carbon monoxide, hydrogen and methane gas.
- ◉ The gases are passed over an iron based catalyst to create:
  - LPG (Liquid Petroleum Gas), petrol, diesel, paraffin, motor car oil, waxes, alcohol and acetone
- ◉ Sasol can also turn natural gas into fuels.
- ◉ Using natural gas and coal as a starting point Sasol produces over 300 types of chemical and
- ◉ many types of plastic.

# IDENTIFY THE HYDROCARBONS

⦿ A

⦿ B

⦿ C

⦿ D

⦿ E

⦿ F

⦿ G

⦿ H

# NON-RENEWABLE RESOURCES



## NONRENEWABLE AND RENEWABLE RESOURCES

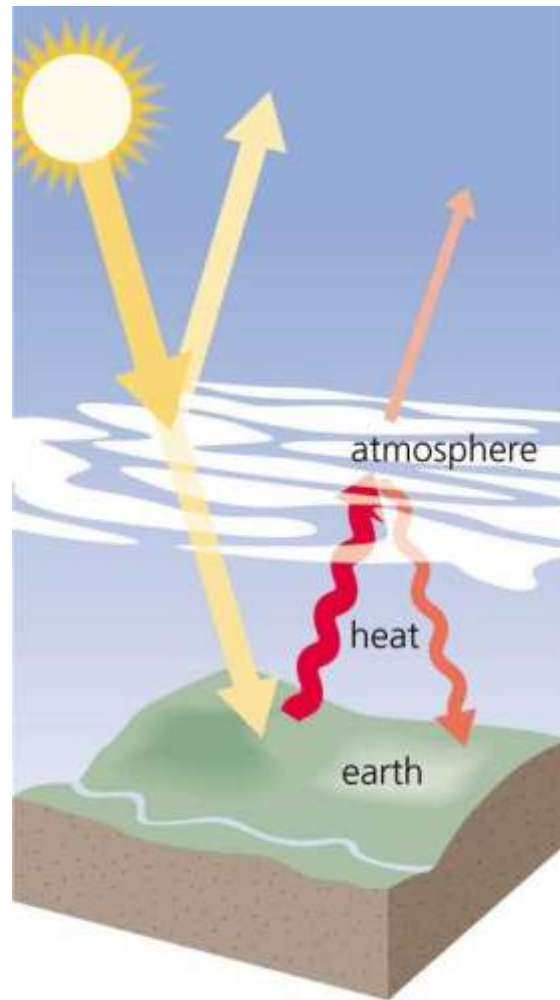
### FOSSIL FUEL FACTS

- Fossil fuels are non-renewable resources.
- They took millions of years to form and once we have used them up they will be gone.

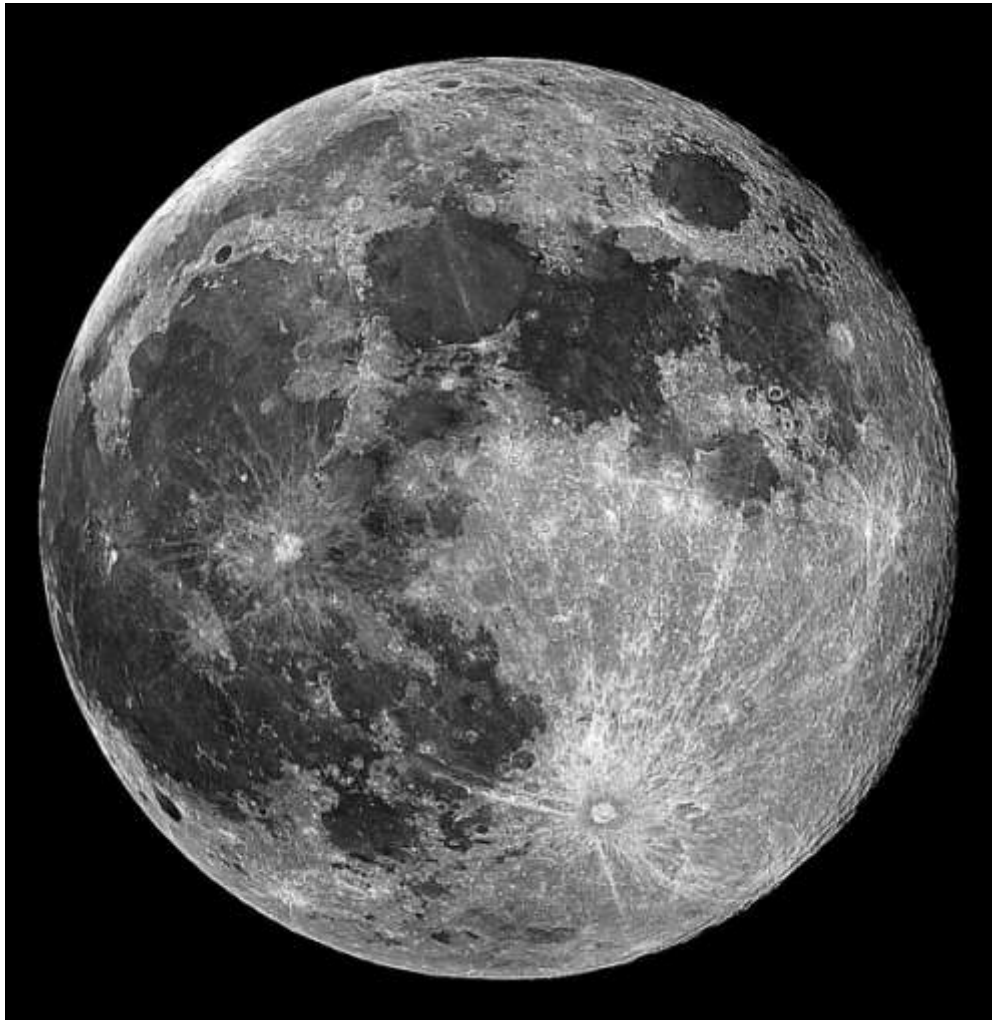
It has been estimated that we have 35 years of oil left, 37 years of gas left and 105 years of coal.

Calculating how long it will take to use up reserves of fossil fuel is complex because new reserves are being found as are new ways of extracting it

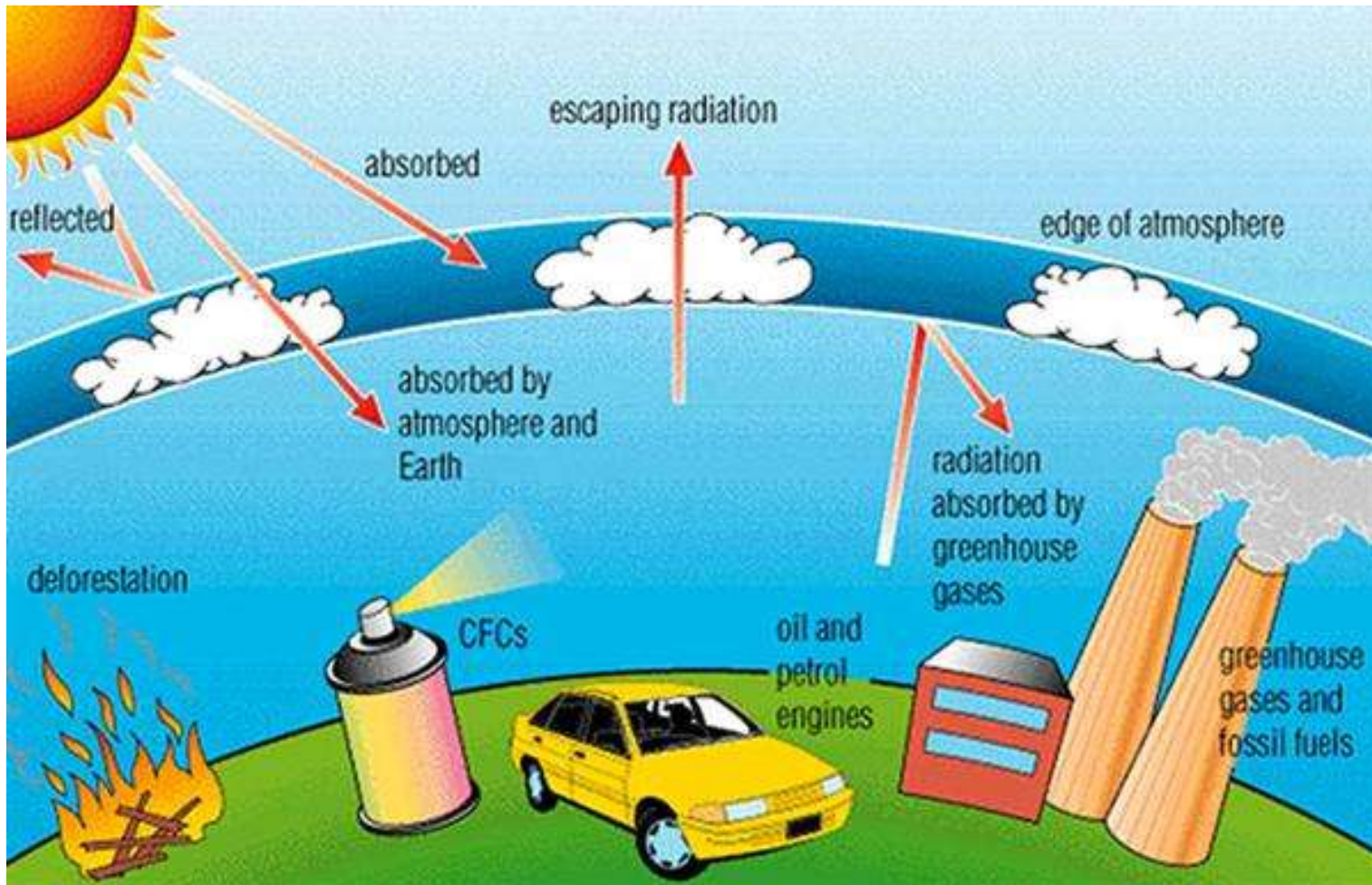
# THE GREENHOUSE EFFECT



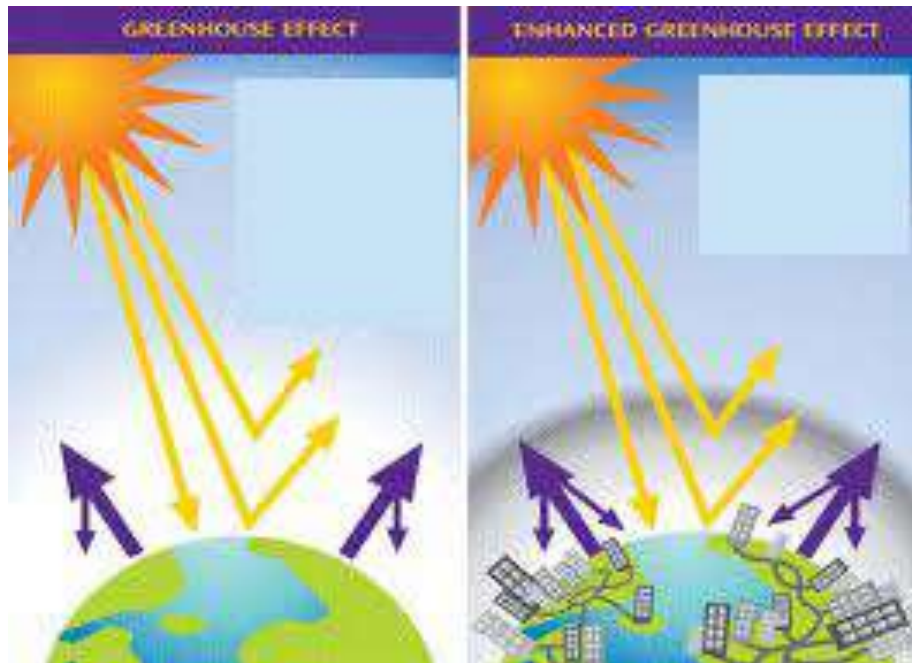
# THE MOON



# EFFECT OF METHANE AND CO<sub>2</sub>



# FOSSIL FUELS AND THE ENVIRONMENT



## FOSSIL FUEL FACTS

- In 2006 humans produced **29,195.42** million metric tons of carbon dioxide from use of fossil fuels.
- It took millions of years for nature to take carbon dioxide out of the air and to store it in the Earth in the form of fossil fuels.
- Humans are releasing it back into the air in only a few hundred years.
- Increased concentrations of carbon dioxide together with other gases like methane are responsible for enhancing global warming.
- Burning of fossil fuels produces many other pollutants.

# BEFORE GLOBAL WARMING

CO<sub>2</sub>

CO<sub>2</sub>

15.5 °C

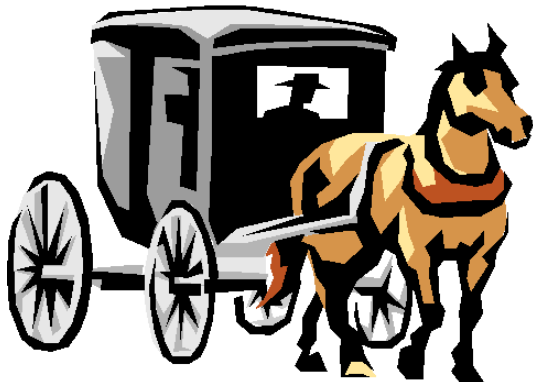
CO<sub>2</sub>

Cool

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>



# WITH GLOBAL WARMING

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

CO<sub>2</sub>

16.5 °C

CO<sub>2</sub>

Warm

CO<sub>2</sub>

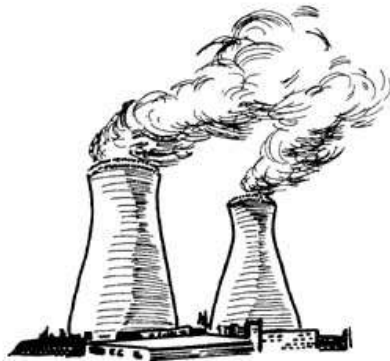
CO<sub>2</sub>

CO<sub>2</sub>

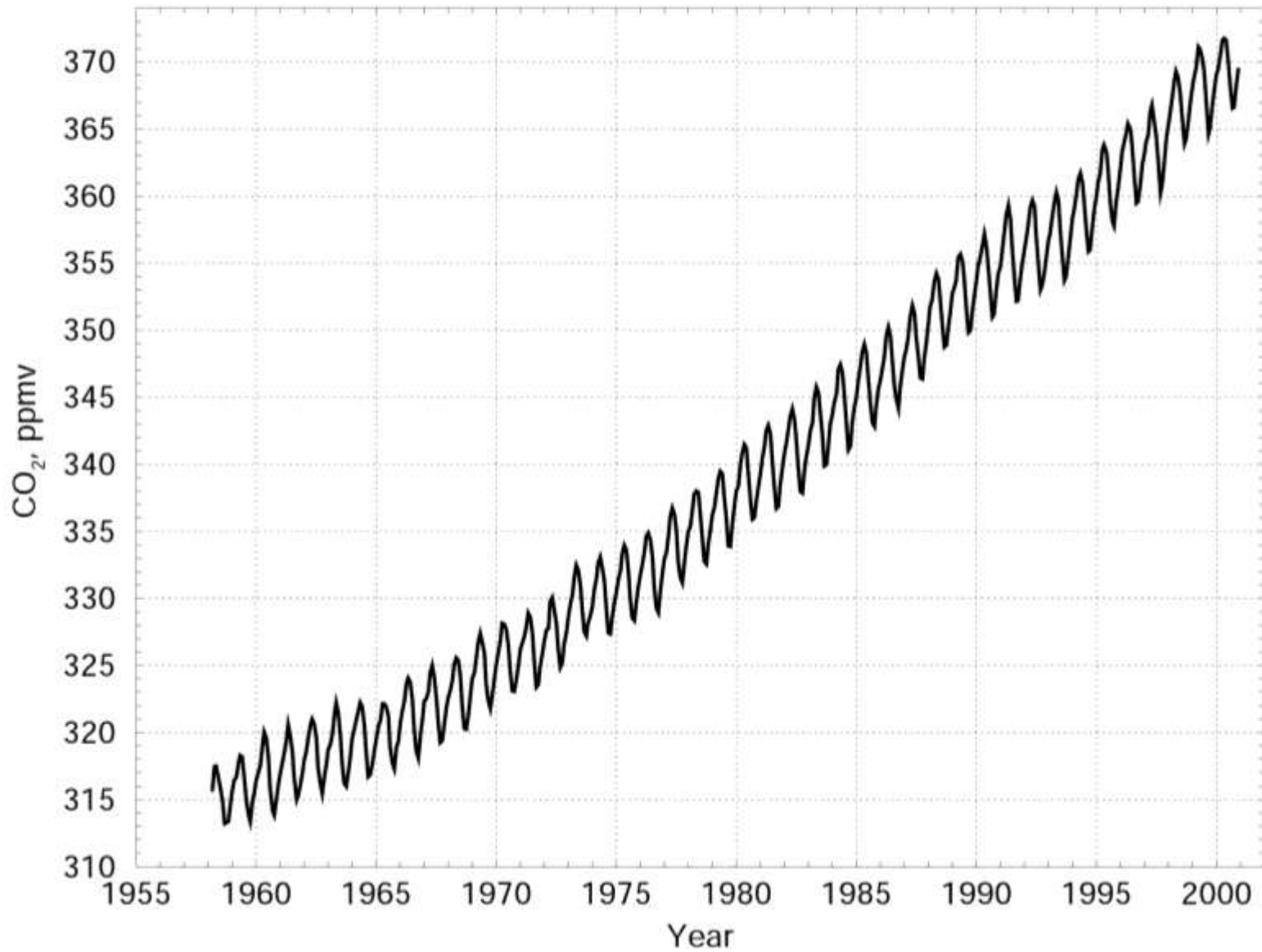
CO<sub>2</sub>

CO<sub>2</sub>

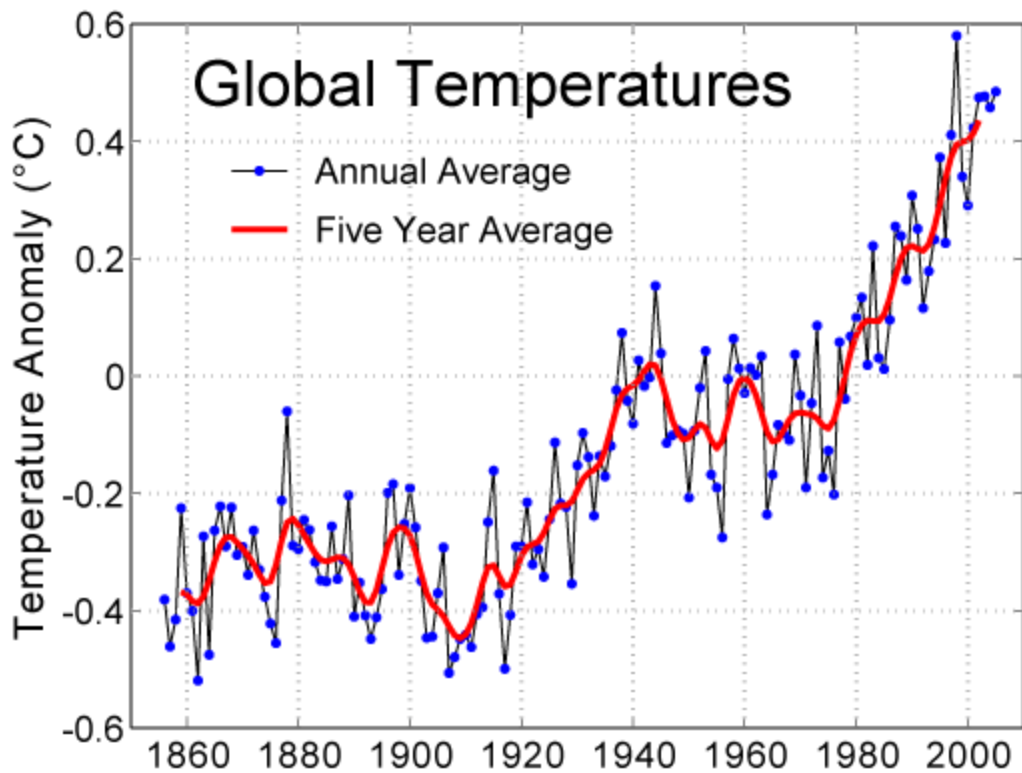
CO<sub>2</sub>



## Carbon Dioxide at Mauna Loa, Hawaii



# INCREASE IN TEMPERATURE



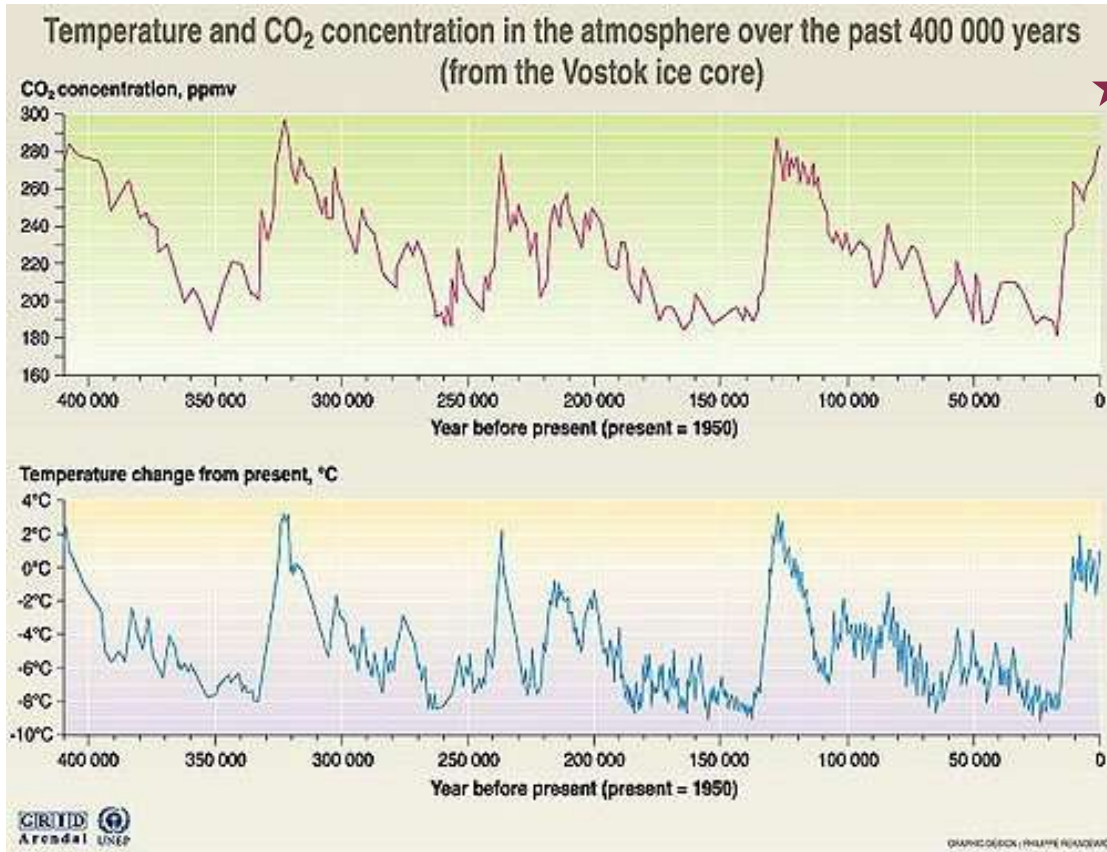
# DRILLING IN THE ICE



# VOSTOK ICE CORE



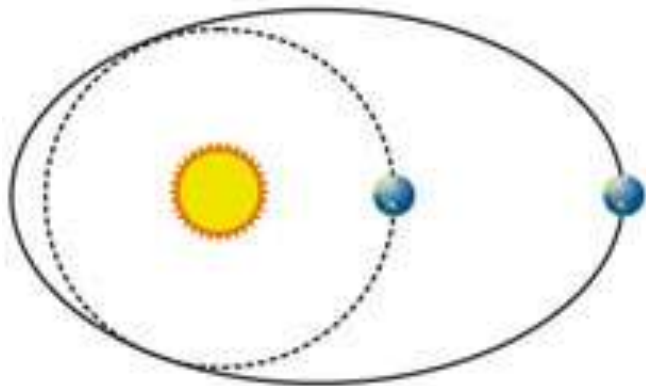
# CO2 AND TEMP 400 000 YEARS



Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, *Nature* 399 (33June), pp 429-436, 1999.

# MELANKOVITCH CYCLES

## Milankovitch Cycles



Eccentricity

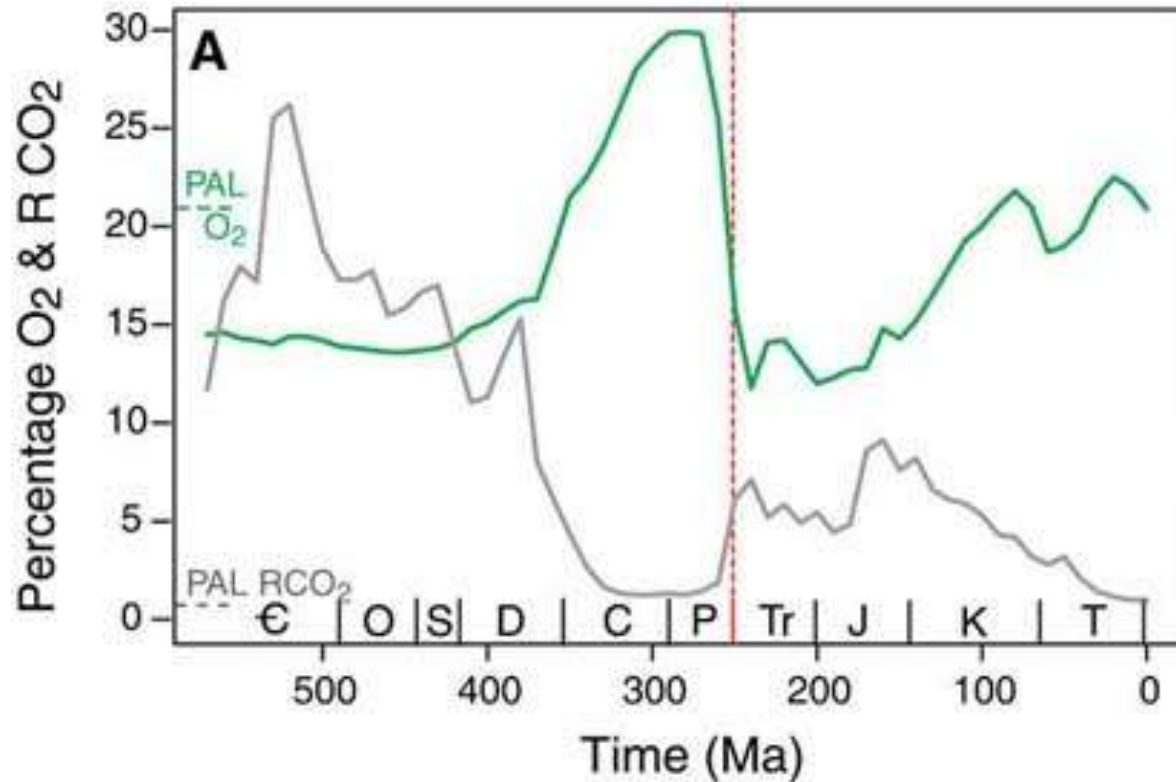


Obliquity



Precession

# % OF O<sub>2</sub> AND CO<sub>2</sub> OVER TIME



# EFFECTS OF CLIMATE CHANGE

Melting Ice  
Caps  
High Sea levels  
More extreme  
weather:

- Hurricanes
- Droughts
- Storms



Sustainable/small carbon footprint

Practical

Not Practical

Not sustainable/ big carbon footprint





**anward**  
WARM YOUR LIFE

























