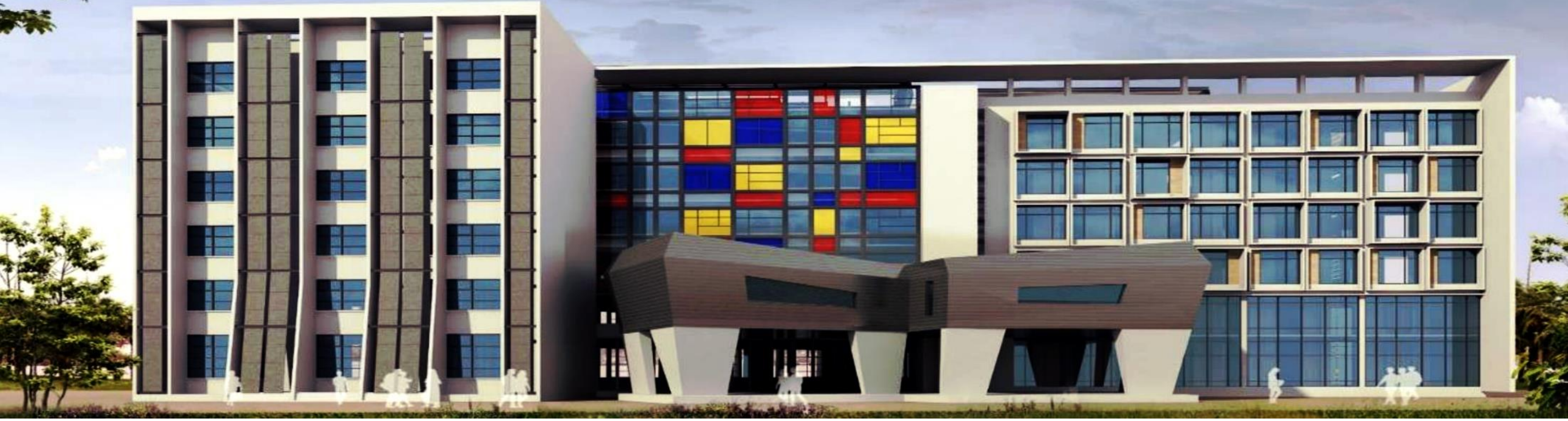


Environmental Chemistry Theory

CY1018

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Department of Chemistry

Sustainability, Energy resources & Recycling

Foundations of human well-being

Human well-being is supported by three pillars:

- <u>economic conditions and processes</u>

  employment, income & wealth (magnitude & distribution), markets, trade…

- <u>sociopolitical conditions and processes</u>

  law & order, national & homeland security, governance, liberty, justice, equity, education, health care, science, culture & the arts…

- <u>environmental conditions and processes</u>

  air, water, soils, mineral resources, the biota, nutrient cycles, climatic processes…

“Development” and “sustainability”

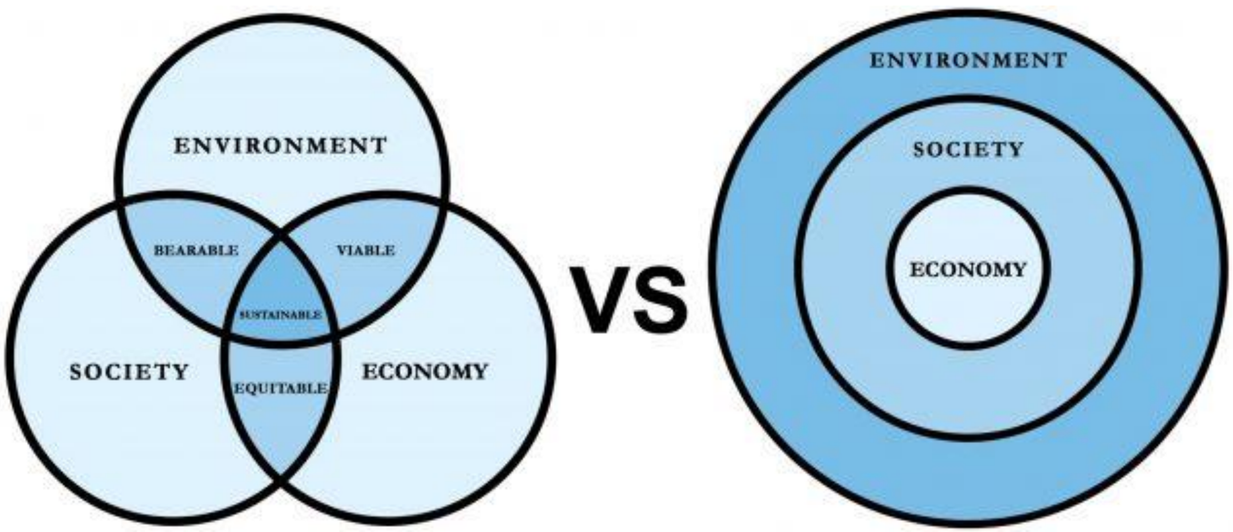
- Development should mean improving human well-being in all 3 dimensions — economic, sociopolitical, and environmental.

- "Sustainable development is development that meets the needs of the present, without compromising the ability of future generations to meet their own needs."

Sustainability - Definition

"Everything that we need for our survival and well-being depends either directly or indirectly on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, [conditions] that permit fulfilling the social, economic and other requirements of present and future generations."

"Sustainability is the process of living within the limits of available physical, natural and social resources in ways that allow the living systems in which humans are embedded to thrive in perpetuity."





What Is Recycling?

We all make rubbish each day. Rubbish is not good for the planet we live on and if we don't do something to reduce the amount of rubbish in our world it could damage it.

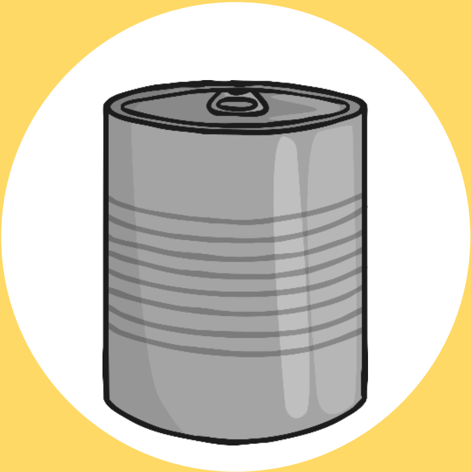
To lower the amount of rubbish in the world we can recycle.

Recycling means taking objects and using the materials they are made from to make something new.

What is Recycling? –Small effort brings big change

Examples of Recycling:

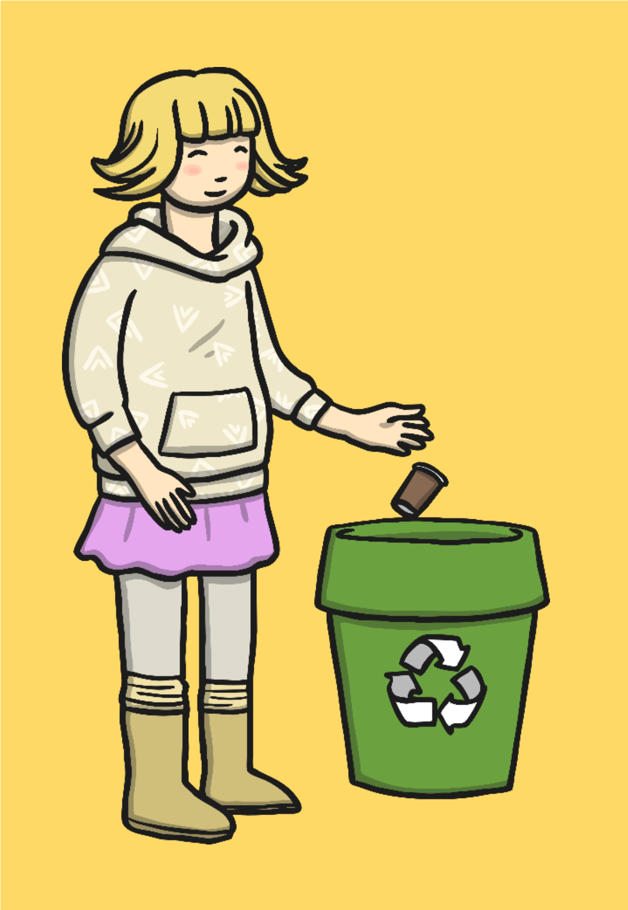
Paper can be recycled to make new paper or a toilet roll.



A tin can could be recycled to make chocolate wrapping and new drinks or food cans.

Glass can be recycled to make new bottles and jars.

What Happens to Things When They Are Recycled?



After you have placed your object for recycling in the recycling bin it will be taken away to a recycling factory, shredded into very small pieces and melted down (metals, glass and plastic) into a liquid or pulp before being used to create something new.

“Recycling doesn't just save materials: it saves energy too”

RRR

R

Reduce

Think about things you are about to throw away. Could they be used again or do a different job? If we can use things again it reduces the amount of rubbish we create.

R

Reuse

Could the items you no longer need be used by someone else who might like them? You could give them to friends or family or take them to a charity shop.

R

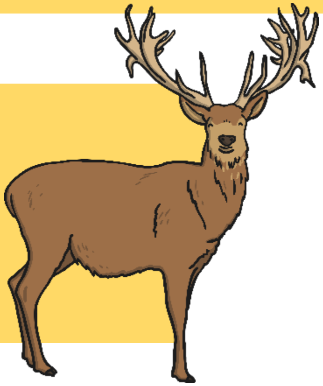
Recycle

If you cannot reduce or reuse your rubbish, then recycle it. Take them to your nearest recycling bank or add to your recycling bin and it will be made into something completely new.

Why Is Recycling Important?

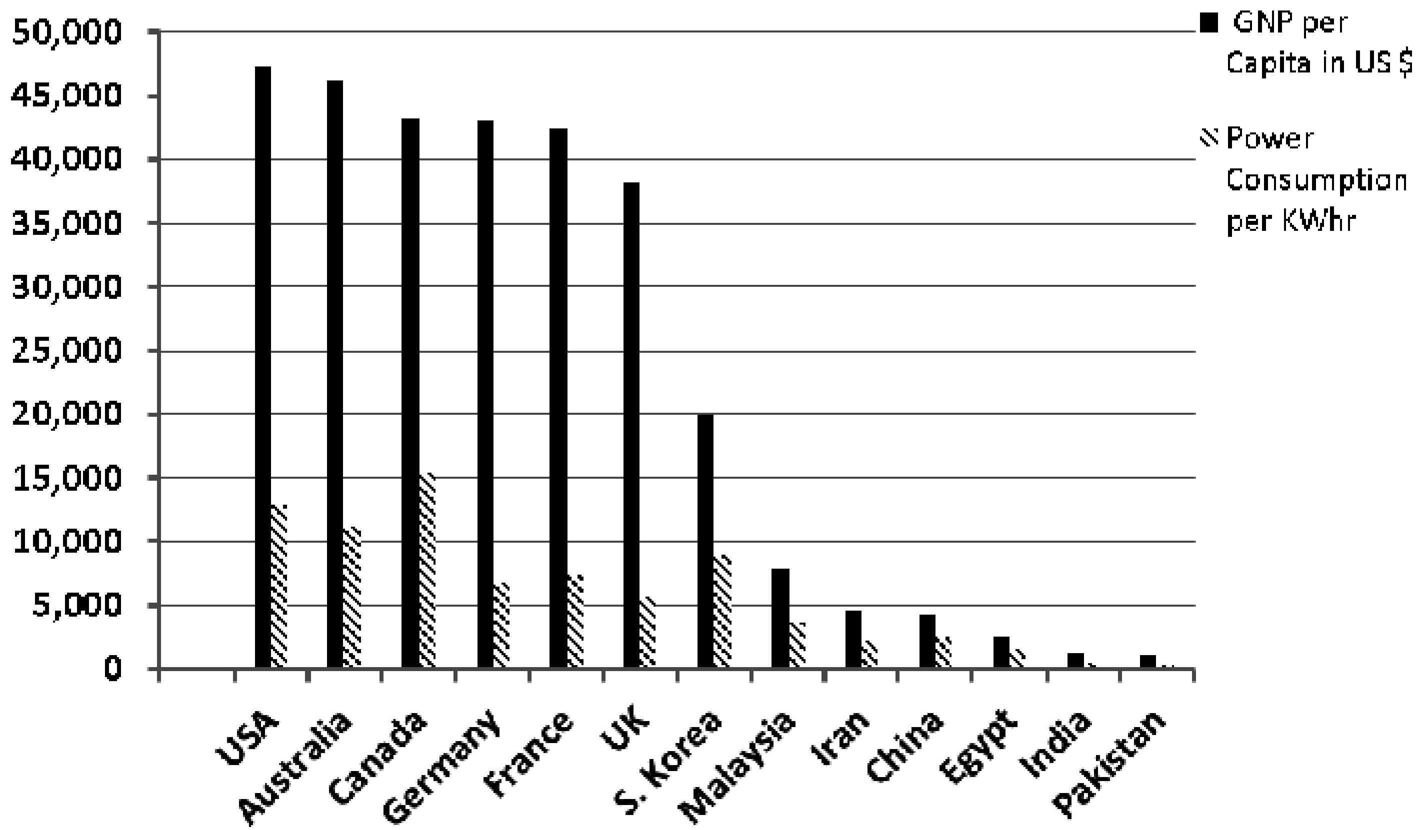
If materials are recycled it saves natural resources having to be taken from the earth to make new things.

Recycling saves energy and stops pollution like gases which can harm animals and plants.



Land which is used to store rubbish can be used for other things and poisonous liquids which could leak from rubbish are destroyed.

Per capita energy use and GNP



GNP = Gross National Product
KWhr= Kilowatt - hour

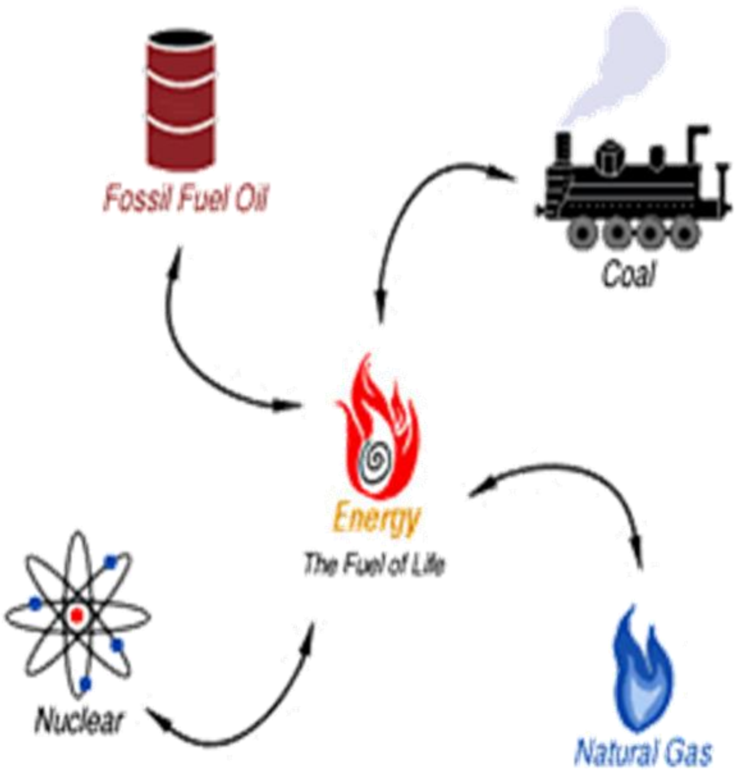
Energy Resources

Energy Resources

A non-renewable resource is a natural resource that cannot be readily replaced by natural means at a quick enough pace to keep up with consumption.

Non- renewable energy resources:

- **Oil**
- **Natural gas**
- **Coal**
- **Nuclear energy.**



Oil

❖**Petroleum, or crude oil (oil as it comes out of the ground)**, is a black, gooey liquid consisting of hundreds of different combustible hydrocarbons along with small amounts of sulfur, oxygen, and nitrogen impurities.

❖Oil supplies about **one-third of the world's commercial Energy**.

❖We use oil to grow most of **our food, transport people and goods**, and make most of the things we use every day.

❖The products of crude oil distillation, called **petrochemicals, are used as raw materials in industries.**

❖Conventional oil is currently abundant, has a high net energy yield, and is relatively inexpensive, but using it causes **air and water pollution** and releases greenhouse gases to the atmosphere.

❖Heavy oils from **tar sand and oil shale** exist in potentially large supplies but have low net energy yields and higher environmental impacts than conventional oil has.

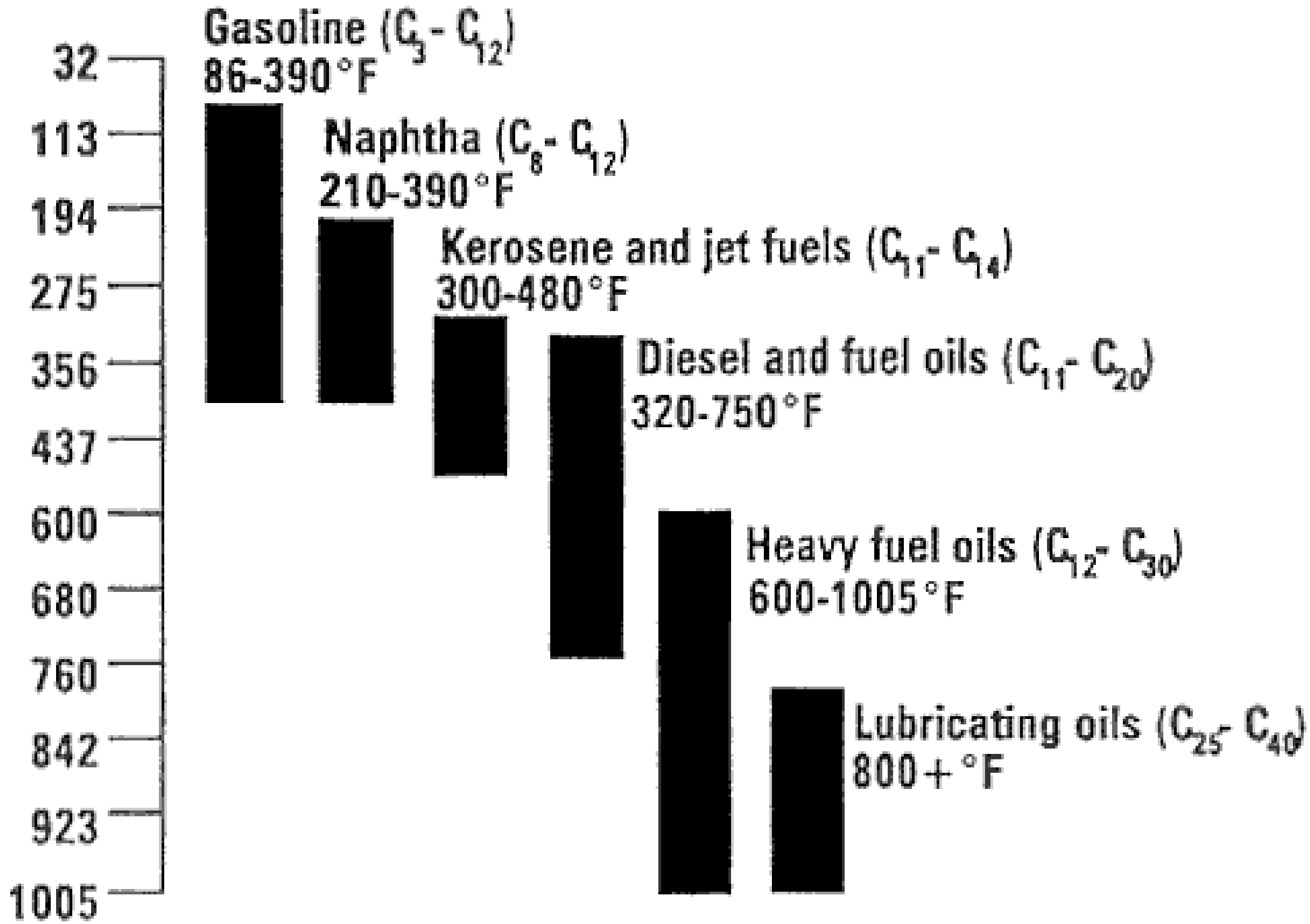


Fig. A-1 Hydrocarbon composition and boiling ranges for major refined products

Liquefied Petroleum Gas (LPG)

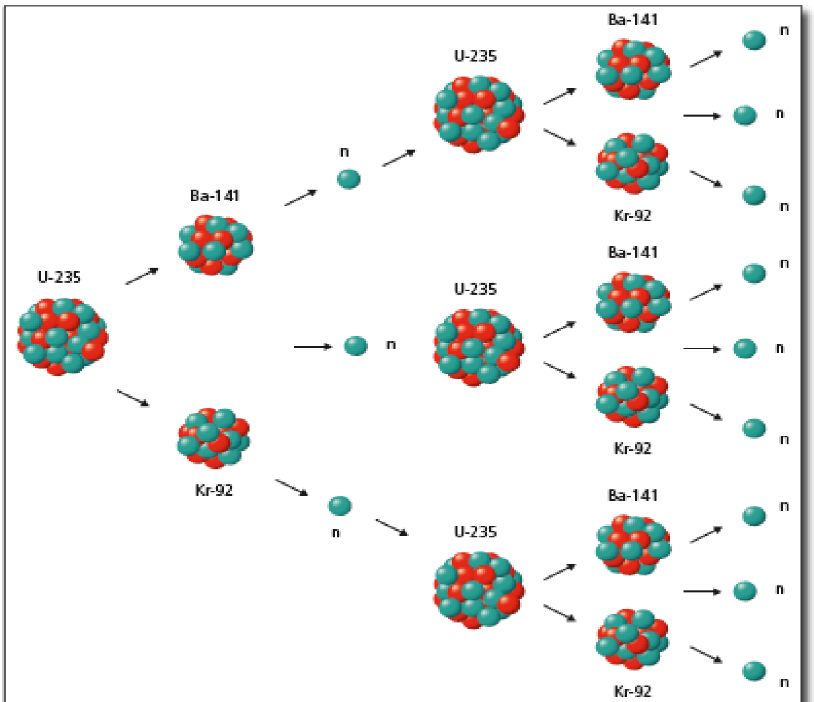
- The main component of petrol is **butane**, the other being propane and ethane
- Under pressure, petroleum is converted to LPG
- It is odourless
- In domestic gas cylinders ethyl mercaptan, a foul smelling gas, is added
- In India at Digboi (Assam), Gujarat plains, Bombay high, deltaic coasts of Godhavari, Krishna, Kaveri and Mahanadhi.

COAL

- Coal was formed 350 million years ago in the hot, damp regions of the earth during the carboniferous age.
- Anthracite [hard coal, 90% carbon, 8700 kcal/kg)
- Bituminous [Soft coal, 80% carbon]
- Lignite [Brown coal, 70% carbon]
- The coal reserves are likely to last for about 200 years, if the use increased by 2% per year, then it will last for another 65 years
- India has 5% of world's coal and Indian coal is not very good in terms of heat capacity
- Major coal fields in India are
  - Raniganj, Jharia, Bokaro, Singrauli, Godavari valley
- The coal state of India are
  - Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andhra pradesh, Maharashtra

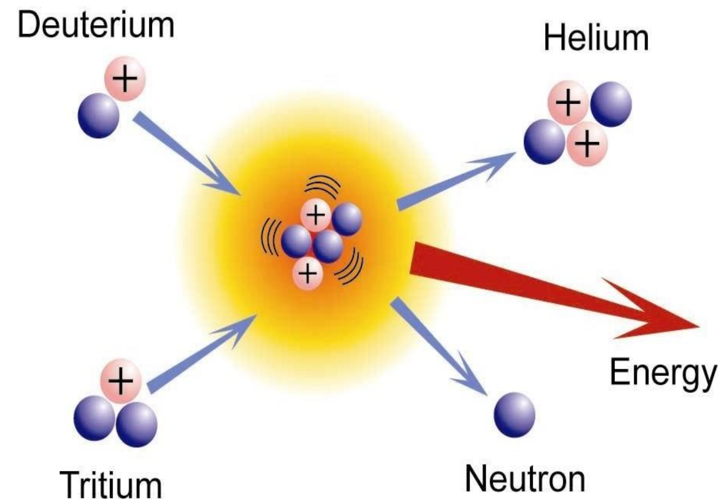
Nuclear Energy

Nuclear Fission



$$ {}^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3\ {}^{1}_{0}n + \text{Energy} $$

Nuclear Fusion



$$ {}_1H^2 + {}_1H^3 \longrightarrow {}_4He^2 + {}_0n^1 + \text{Energy} $$

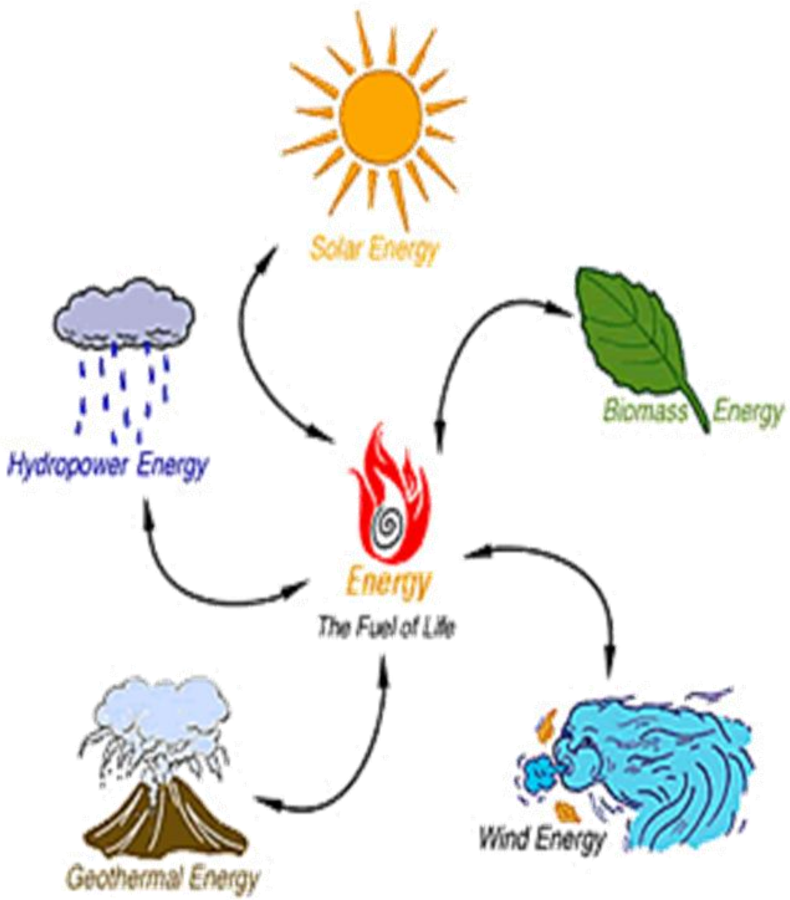
There are seven nuclear power stations with an installed capacity of 7480 MW
Tarapur (Maharashtra), Rana Pratap Sagar (Rajasthan), Kalpakkam (Tamilnadu), and Narora (U.P)

Renewable Energy Resources:

Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, including carbon neutral sources like sunlight, wind, rain, tides, waves, and geothermal heat.

Renewable Energy Resources:

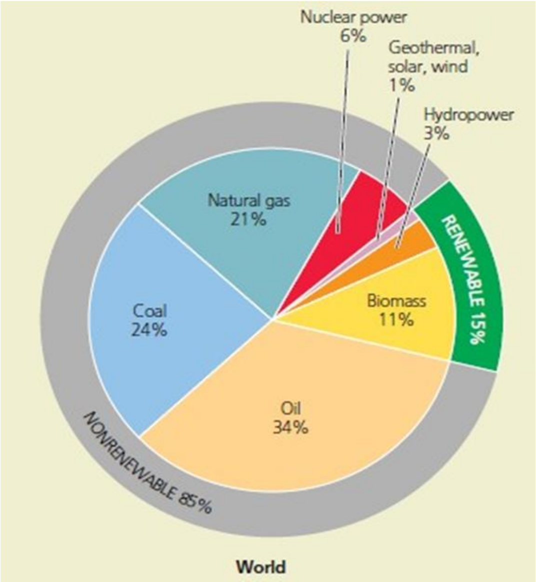
- **Solar energy**
- **Hydroelectric power**
- **Ocean thermal energy**
- **Wind Energy**
- **Geothermal energy**
- **Energy from biomass.**

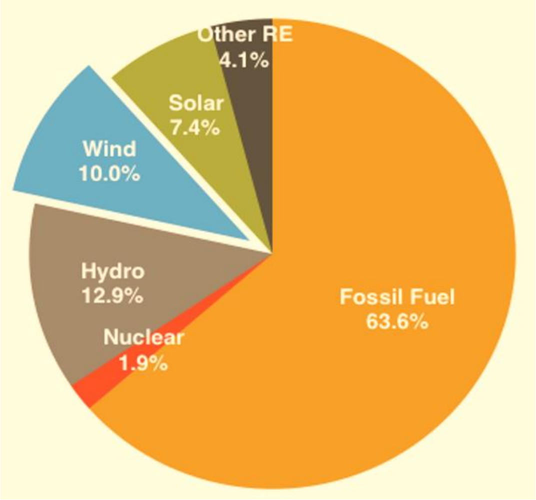


https://www.youtube.com/watch?v=KEeH4EniM3E

Energy Use – Net Energy

- We get most of our energy by burning carbon-containing fossil fuels .
- Note that oil is the most widely used form of commercial energy and that about 79% of the energy used in the world.
- Net energy is the amount of high-quality energy available from an energy resource minus the amount of energy needed to make it available.
- Net Energy Is the Only Energy That Really Counts.
- Energy Resources With Low or Negative Net Energy Yields Need Help to Compete in the Marketplace.
- Reducing Energy Waste Improves Net Energy Yields and Can Save Money.

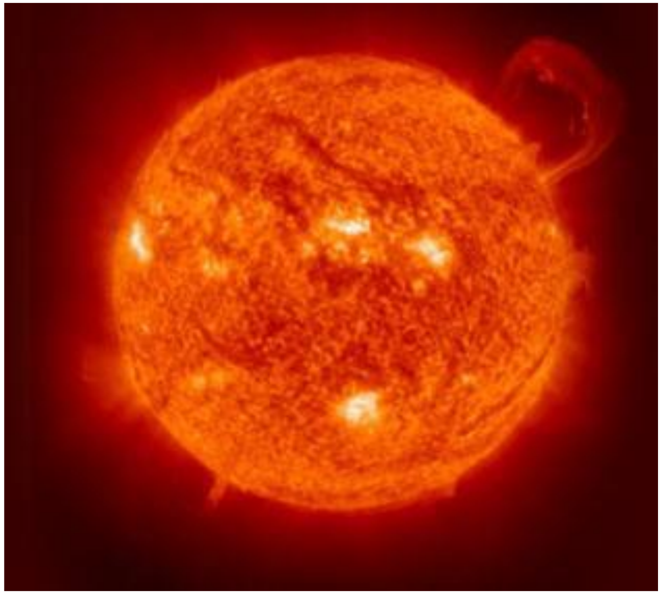




India

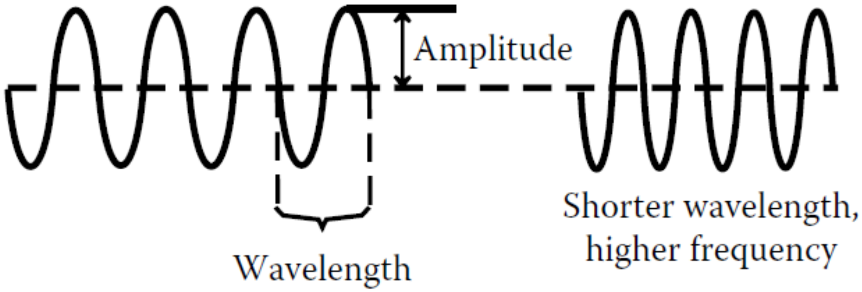
Sun light – The source of life

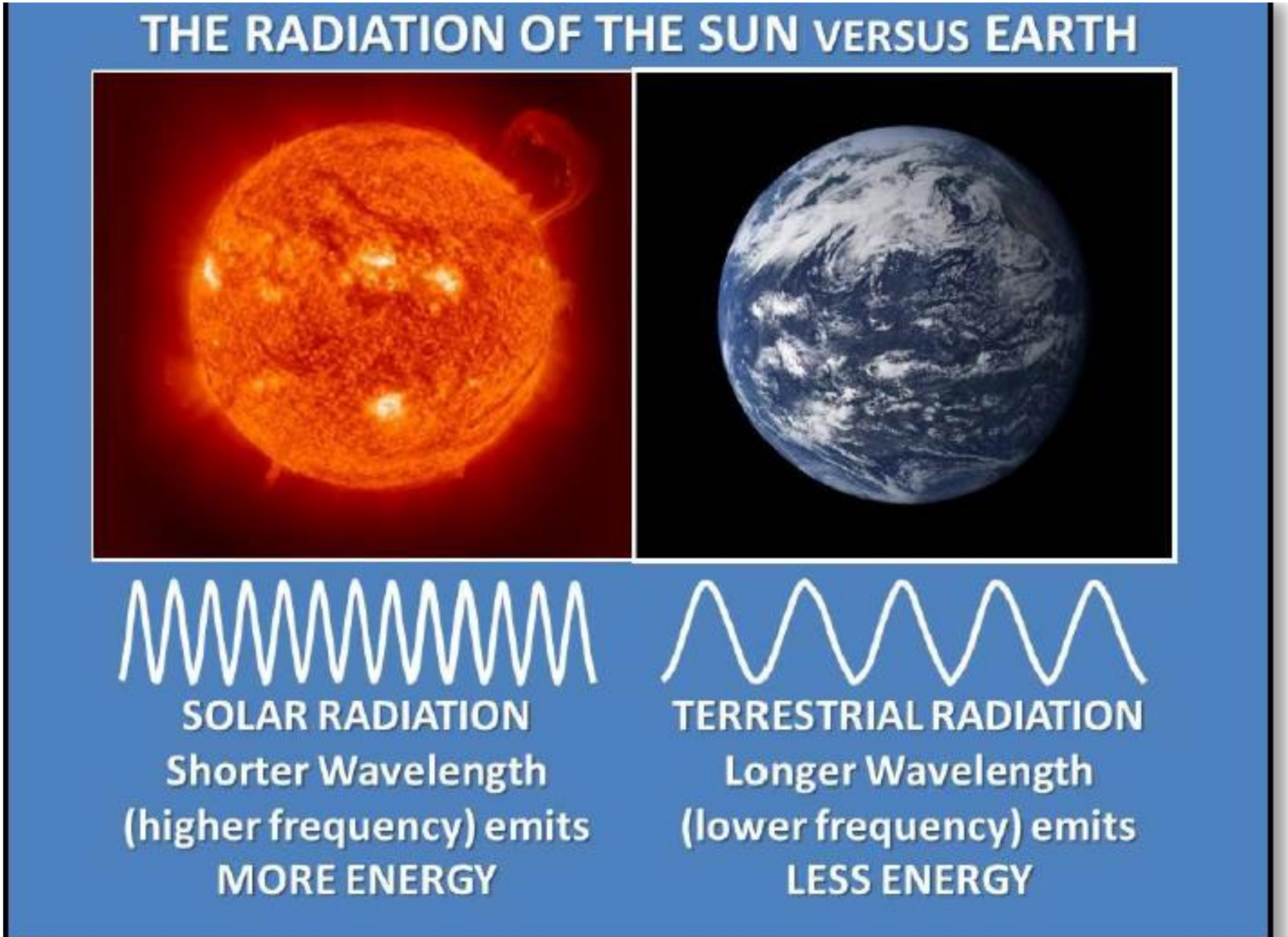
Biogeochemical cycles and virtually all other processes on the Earth are driven by energy from the sun.



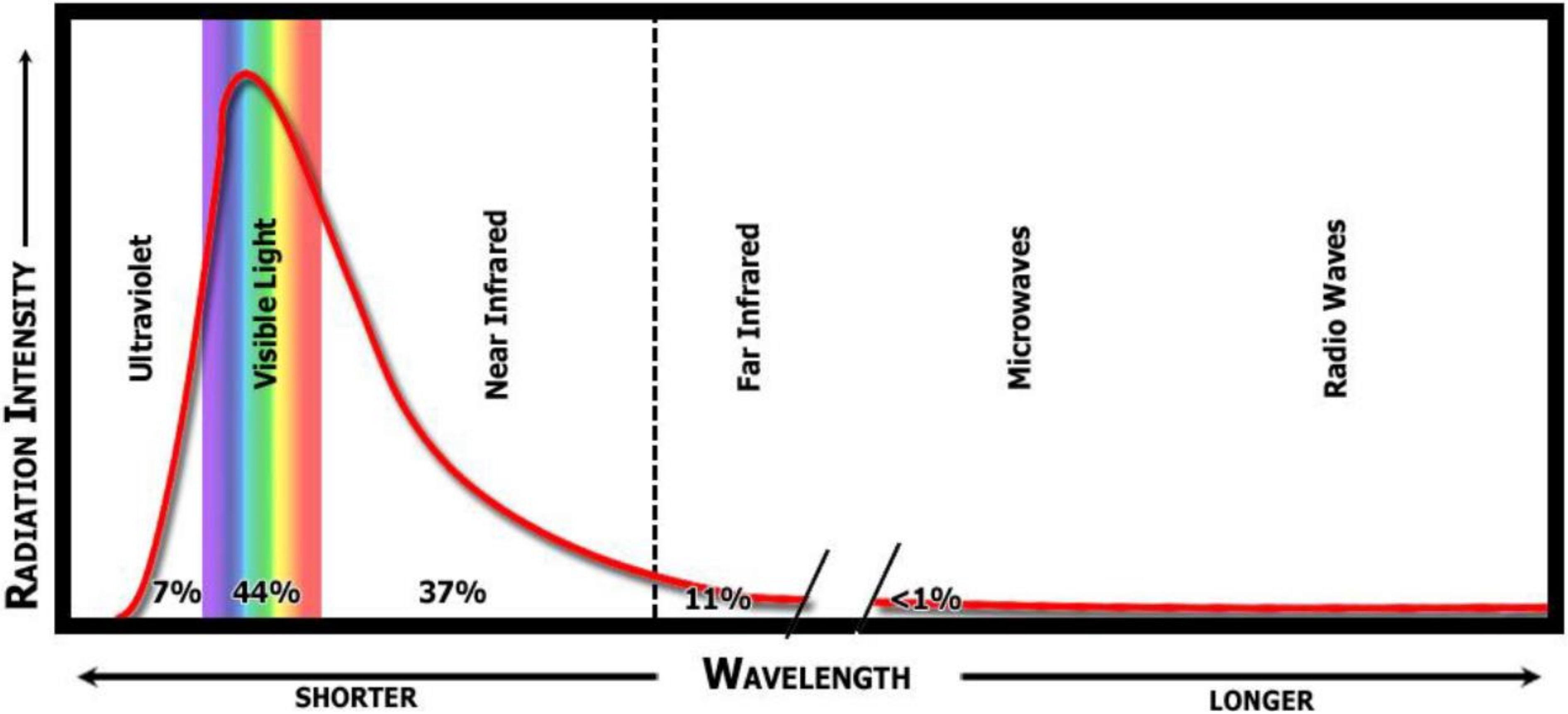
Energy can be carried through space at the speed of light (*c*), 3.00 x 10^8 meters per second (m/s) in a vacuum, by **electromagnetic radiation**, which includes visible light, ultraviolet radiation, infrared radiation, microwaves, radio waves, g-rays, and x-rays.

$$E = h\nu = \frac{hc}{\lambda}$$



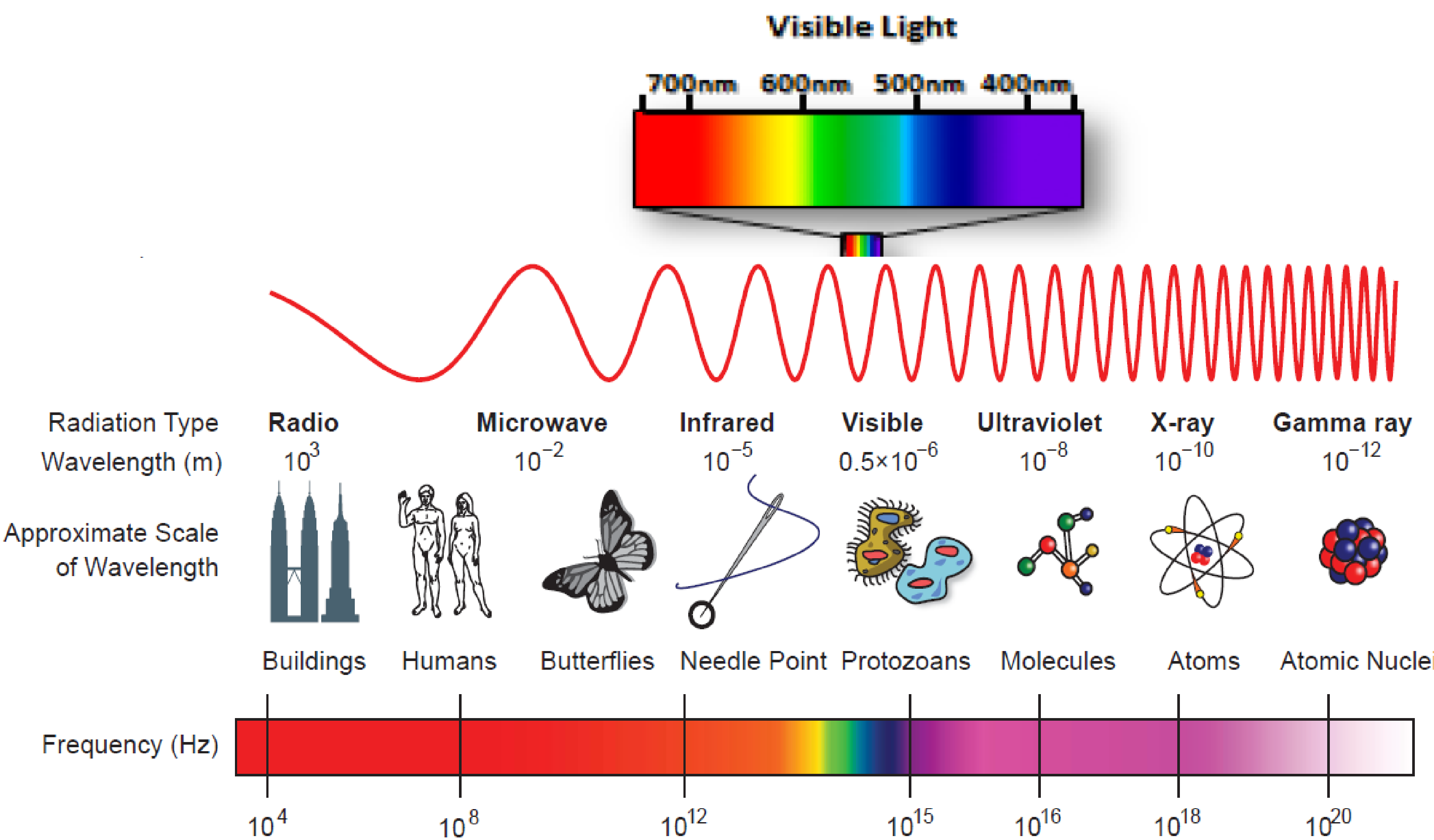

THE RADIATION OF THE SUN VERSUS EARTH
SOLAR RADIATION
Shorter Wavelength
(higher frequency) emits
MORE ENERGY
TERRESTRIAL RADIATION
Longer Wavelength
(lower frequency) emits
LESS ENERGY

Sun's Electromagnetic Spectrum



Electromagnetic Spectrum

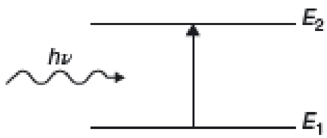
The electromagnetic spectrum represents the complete range of electromagnetic radiation. The region of the spectrum with a shorter wavelength than the color violet is referred as ultraviolet radiation, and the region of the spectrum with a longer wavelength than the color red is referred to as infrared radiation.



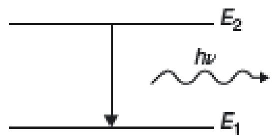
Interaction of EMR with matter

ΔE = E difference between energy levels

$$\Delta E = E_2 - E_1 \qquad E = h\nu = \frac{hc}{\lambda}$$



Absorption



Emission

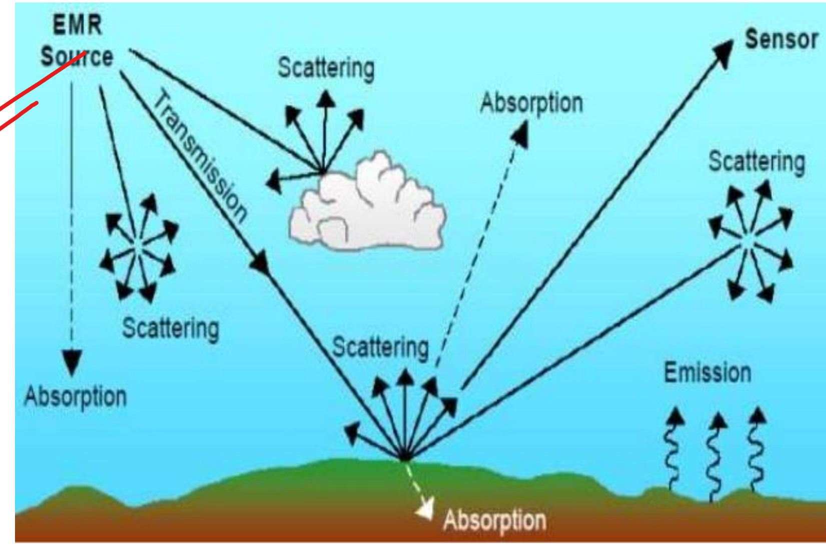


Table 1.1 Electromagnetic spectrum.[a)]

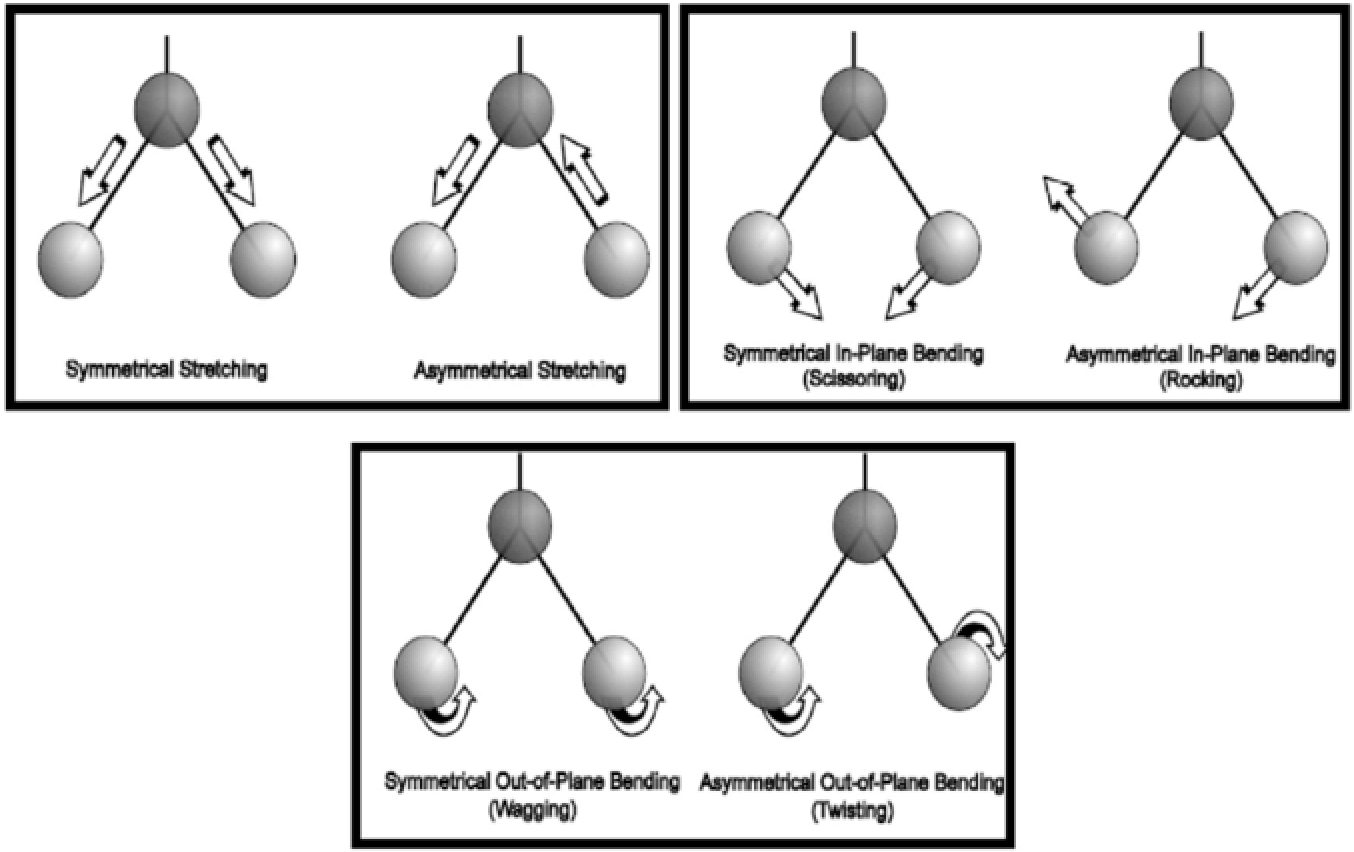
Region	Frequency (s^{-1})	Wavelength	Wavenumber (cm^{-1})	Energy (eV)	Spectroscopy
Radio	$10^6 \rightarrow 3\times10^9$	300 m → 10 cm	$3\times10^{-5} \rightarrow 0.1$	$4.1\times10^{-9} \rightarrow 1.2\times10^{-5}$	Nuclear magnetic resonance
Microwave	$3\times10^9 \rightarrow 3\times10^{12}$	10 cm → 0.1 mm	$0.1 \rightarrow 100$	$1.2\times10^{-5} \rightarrow 0.012$	Electron spin resonance and rotational spectroscopy
Infrared	$3\times10^{12} \rightarrow 3\times10^{14}$	0.1 mm → 1 μm	$100 \rightarrow 10000$	$0.012 \rightarrow 1.2$	Rotational spectroscopy and vibrational spectroscopy
Visible	$4.3\times10^{14} \rightarrow 7.5\times10^{14}$	700 nm → 400 nm	$14300 \rightarrow 25000$	$1.7 \rightarrow 3.1$	UV–visible
Ultraviolet	$7.5\times10^{14} \rightarrow 3\times10^{16}$	400 nm → 10 nm	$25000 \rightarrow 10^6$	$3.1 \rightarrow 120$	UV–visible
X-rays	$3\times10^{16} \rightarrow 10^{19}$	100 Å → 0.3 Å	$10^6 \rightarrow 3\times10^8$	$120 \rightarrow 4\times10^4$	Electronic transition (internal electrons)
γ-rays	$10^{19} \rightarrow 10^{22}$	0.3 Å → 0.003 Å	$3\times10^8 \rightarrow 3\times10^{10}$	$10^4 \rightarrow 10^9$	Nuclear transitions

a) Most commonly used spectroscopic units:
Radio frequency radiation: MHz = 10^6 Hz (Hz = s^{-1}). Microwave radiation: GHz = 10^9 Hz.
Infrared radiation: cm^{-1} (wavenumbers). Visible and ultraviolet radiation: nm = 10^{-9} m.
X-ray and γ-ray radiation: nm = 10^{-9} m and Å = 10^{-10} m.

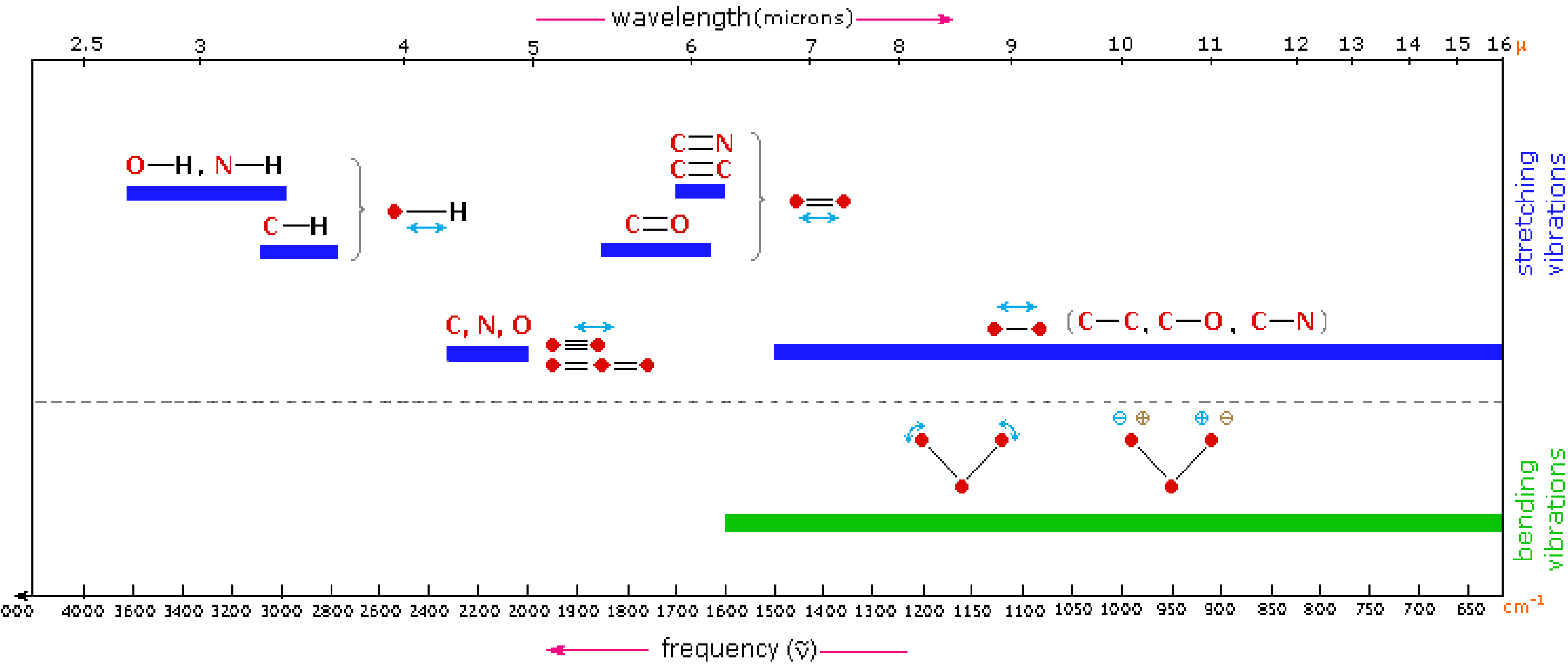
Vibrational (Infrared) Spectroscopy

Photon energies associated with the infrared regime (from 1 to 15 kcal/mole) are not large enough to excite electrons (which need UV-vis region), but may induce **vibrational excitation** of covalently bonded atoms and groups.

A molecule composed of n-atoms has 3n degrees of freedom, six of which are translations and rotations of the molecule itself. This leaves 3n-6 degrees of vibrational freedom (3n-5 if the molecule is linear).



Vibrational (Infrared) Spectroscopy



	Stretching Vibrations			Bending Vibrations		
Functional Class	**Range (cm^{-1})**	**Intensity**	**Assignment**	**Range (cm^{-1})**	**Intensity**	**Assignment**
Alkanes	2850-3000	str	CH_3, CH_2 & CH 2 or 3 bands	1350-1470 1370-1390 720-725	med med wk	CH_2 & CH_3 deformation CH_3 deformation CH_2 rocking
Alkenes	3020-3100 1630-1680 1900-2000	med var str	=C-H & =CH_2 (usually sharp) C=C (symmetry reduces intensity) C=C asymmetric stretch	880-995 780-850 675-730	str med med	=C-H & =CH_2 (out-of-plane bending) cis-RCH=CHR
Alkynes	3300 2100-2250	str var	C-H (usually sharp) C≡C (symmetry reduces intensity)	600-700	str	C-H deformation
Arenes	3030 1600 & 1500	var med-wk	C-H (may be several bands) C=C (in ring) (2 bands) (3 if conjugated)	690-900	str-med	C-H bending & ring puckering
Alcohols & Phenols	3580-3650 3200-3550 970-1250	var str str	O-H (free), usually sharp O-H (H-bonded), usually broad C-O	1330-1430 650-770	med var-wk	O-H bending (in-plane) O-H bend (out-of-plane)
Amines	3400-3500 (dil. soln.) 3300-3400 (dil. soln.) 1000-1250	wk wk med	N-H (1°-amines), 2 bands N-H (2°-amines) C-N	1550-1650 660-900	med-str var	NH_2 scissoring (1°-amines) NH_2 & N-H wagging (shifts on H-bonding)
Aldehydes & Ketones	2690-2840(2 bands) 1720-1740 1710-1720 1690 1675 1745 1780	med str str str str str str	C-H (aldehyde C-H) C=O (saturated aldehyde) C=O (saturated ketone) aryl ketone α, β-unsaturation cyclopentanone cyclobutanone	 1350-1360 1400-1450 1100	 str str med	 α-CH_3 bending α-CH_2 bending C-C-C bending
Carboxylic Acids & Derivatives	2500-3300 (acids) overlap C-H 1705-1720 (acids) 1210-1320 (acids) 1785-1815 (acyl halides) 1750 & 1820 (anhydrides) 1040-1100 1735-1750 (esters) 1000-1300 1630-1695(amides)	str str med-str str str str str str str	O-H (very broad) C=O (H-bonded) O-C (sometimes 2-peaks) C=O C=O (2-bands) O-C C=O O-C (2-bands) C=O (amide I band)	1395-1440 1590-1650 1500-1560	med med med	C-O-H bending N-H (1¡-amide) II band N-H (2¡-amide) II band
Nitriles	2240-2260	med	C≡N (sharp)			
Isocyanates,Isothiocyanates, Diimides, Azides & Ketenes	2100-2270	med	-N=C=O, -N=C=S -N=C=N-, -N_3, C=C=O			

Example: Water

(3n-6 = 3)
degrees of vibrational freedom