Greenhouse Effect – Natural and Enhanced

What is the cause of Global Warming?

The natural greenhouse effect

The greenhouse effect is the process whereby some of the infrared radiation emitted by the Earth's surface is 'trapped' by greenhouse gases. This helps moderate the temperatures at the Earth's surface.

When we say 'trapped', we mean that the molecules of greenhouse gases absorb some of the infrared radiation. They then emit some of this infrared radiation back to the Earth. This makes the temperatures at the surface warmer than they otherwise would be.

The greenhouse effect has occurred naturally on Earth for millions of years, as our atmosphere has contained greenhouse gases ever since it first formed. For this reason this process, now known as the natural greenhouse effect, has enabled life to evolve on this planet. Without it, the temperatures experienced on Earth would be like those on the Moon, which is the same distance from the Sun as we are. This means it would be far too hot by day and far too cold by night for life as we know it to survive.

The Moon has no atmosphere and hence no greenhouse gases to help moderate the temperatures at its surface. The average ground temperature on the Moon is -17 ºC. The Earth, which does have an atmosphere containing greenhouse gases, the average temperature is 16 ºC, which is 33 ºC higher than the Moon.

Figure 1: Earthrise, Seen From the Moon
(NASA, Moon, 6/16/09) by NASA's Marshall Space Flight Center

The enhanced greenhouse effect

The enhanced greenhouse effect is the term used to describe the extra warming of the Earth's atmosphere, land and oceans that is caused by an increase in the amounts of greenhouse gases in the Earth's atmosphere.

The increase in greenhouse gases in our atmosphere is caused by human activities particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing.

Scientific modelling by atmospheric scientists and meteorologists, using data they have collected from ice core studies and measurements of atmospheric temperatures and gas concentrations in the atmosphere, indicates that the increase in concentration of the greenhouse gases in the atmosphere above their natural levels is the prime cause of global warming.

Greenhouse gases

Greenhouse gases include carbon dioxide, and water vapour. A number of other gases in the atmosphere also act as greenhouse gases, although the percentage of them in the lower atmosphere is much less than that of carbon dioxide and water. These gases include methane and nitrous oxide.

Greenhouse gases all have one thing in common: their molecules contain 3 or more atoms. This is shown in the following table.

Gas	**Approximate percentage in the air** (if water vapour is removed)**	**Chemical formula**	**Total number of atoms in each molecule**	**Is this a greenhouse gas?**
Oxygen	20.9	O_2	2	No
Nitrogen	78.1	N_2	2	No
Argon	0.9	Ar	1*	No
Carbon dioxide	0.04	CO_2	3	Yes
Methane	0.0002	CH_4	5	Yes
Nitrous oxide	0.00003	N_2O	3	Yes

* Argon is classified as a noble gas. Noble gases exist in Nature as individual atoms, so these are not called molecules.

** The percentage of water vapour in the air varies from place to place and at different times, but on average is about 1-4%. Its chemical formula is H_2O. It also is a greenhouse gas.

The larger **number** of atoms in the molecules of greenhouse gases enables them to absorb infrared radiation radiated by the Earth's surface, and then emit some back to the surface. This warms the Earth even more.

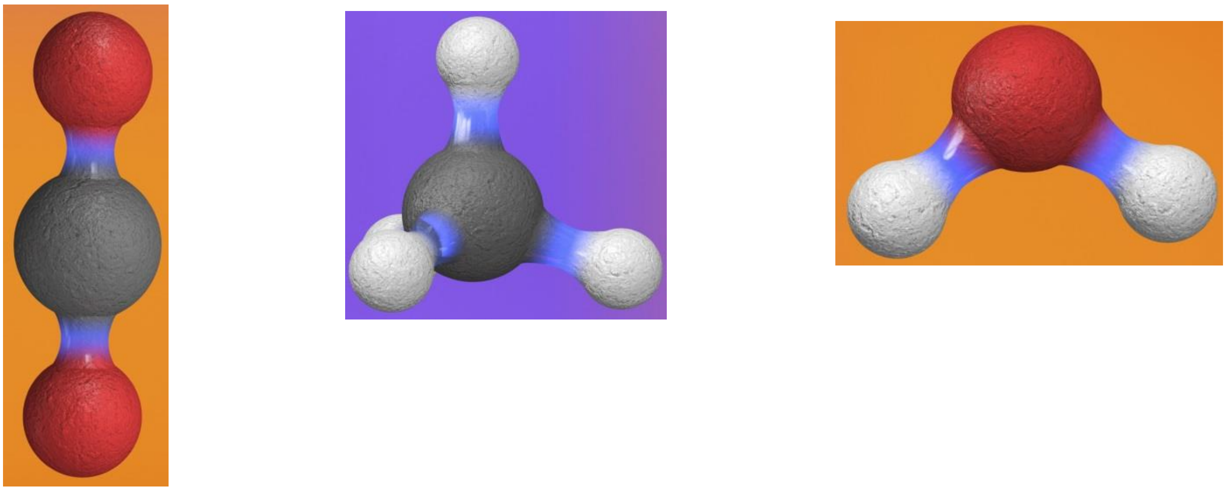

Figure 2: Models of greenhouse gas molecules carbon dioxide, methane and water vapour

What happens when the Sun’s radiation reaches Earth

Figure 3 shows what happens to the Sun’s radiation as it reaches the Earth.

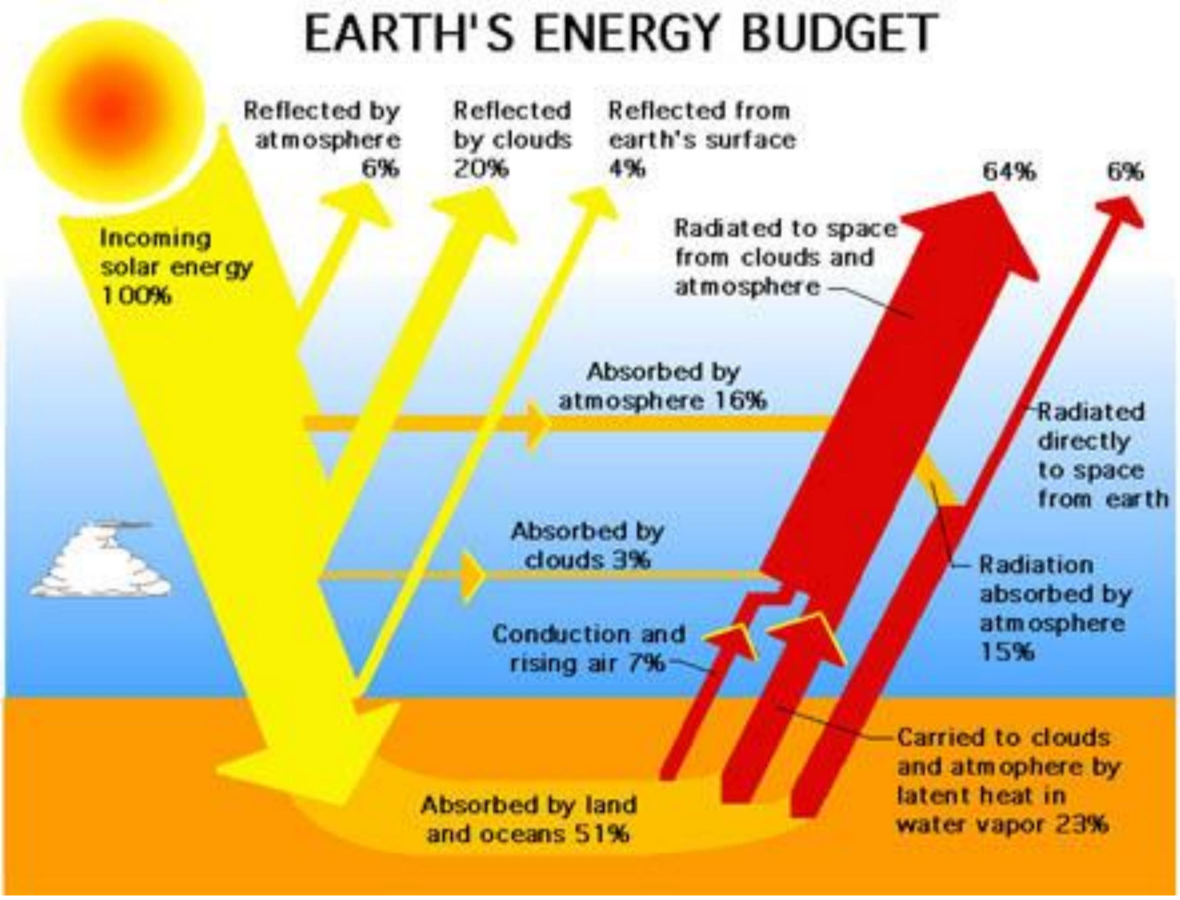

Figure 3: Where the Sun’s energy goes – courtesy of NASA

When the system is in balance, the total energy going out from Earth into space equals the total energy coming in.

When radiation from the Sun reaches the Earth:
About 30% of the Sun’s radiation is reflected back into Space by the particles in the atmosphere, clouds and the Earth’s surface.

Some is absorbed by the water vapour in the atmosphere and by clouds. Some (about 3%) is absorbed by the ozone layer. This adds up to about 19 %.

The remaining 51% of the Sun’s energy is absorbed by the Earth’s surface (land and oceans). If it kept being absorbed and none was ever given back out, the Earth would get hotter and hotter. The oceans would have boiled away long ago, and all our water would have evaporated!

Fortunately for us, this does not happen, because the Earth radiates heat energy in the form of infrared radiation back into the atmosphere. And ultimately the atmosphere radiates heat energy back into Space. What happens to this infrared radiation in the atmosphere is of crucial importance to life on Earth.

What is infrared radiation and why is it important?

The light energy that is radiated out into Space by the Sun is not just the light you can see. Besides visible light, the Sun also radiates out ultraviolet light (UV) and infrared light (IR). These cannot be seen with the unaided human eye. The whole range of radiation is known as the electromagnetic spectrum.

Figure 4 shows the electromagnetic spectrum. The Sun's radiation travels through Space in waves. For this reason the different parts of the spectrum are distinguished by the frequency of the waves, or their wavelength.

The highest energy radiation is at the left of the diagram – that is, x rays (and gamma rays).

UV light has more energy than visible light, which is why it can be damaging if we are exposed to it too much. IR light has less energy than visible light, but is responsible for the warmth we feel. (Infrared lamps are used to warm bathrooms and to heat food.) Radio waves have very low energy.

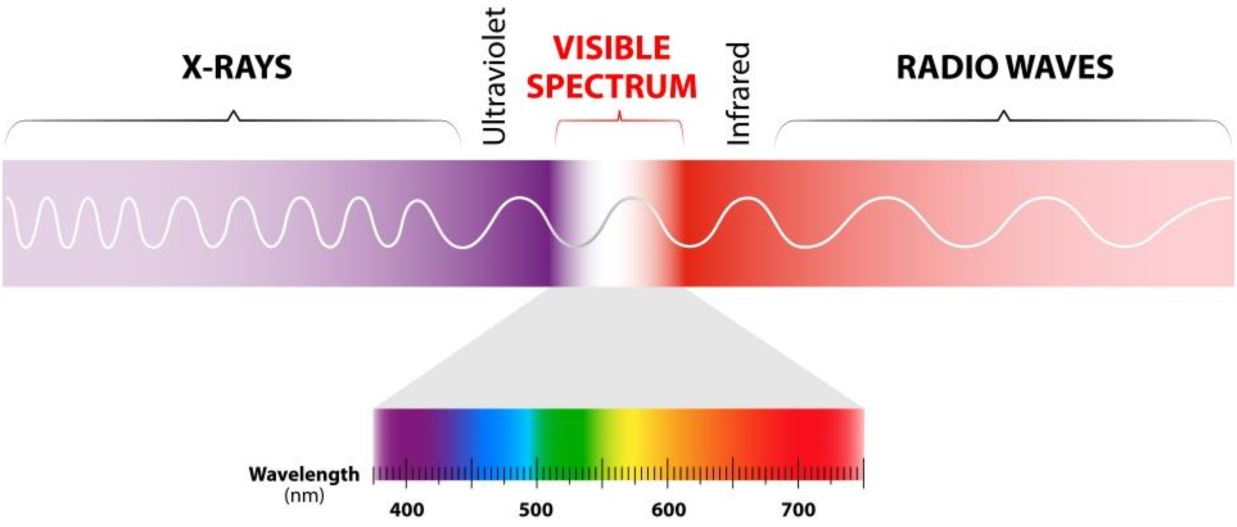

Figure 4: A schematic diagram of the electromagnetic spectrum

Note in Figure 4 that the band of wavelengths that match visible light has been expanded to show the colours that together make up the visible light. There is actually a continual range of colours, not just the seven distinct colours listed in the well-known “ROYGBIV” (Red, Orange, Yellow, Green, Blue, Indigo and Violet).