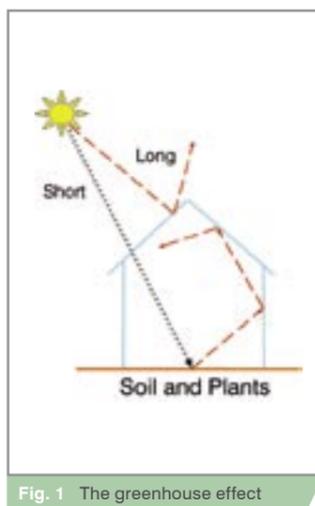


*Climate change* on Earth is not a new phenomenon; there have been many ice ages and warm periods. Based on our understanding of this natural variation, we might expect to be entering a cooler period. However, this is not the case. This is attributed to the *enhanced greenhouse effect*.

## What is the Greenhouse Effect?

As the name implies, the atmosphere around the Earth acts rather like the glass in a greenhouse, ensuring energy balance and conservation. The purpose of a greenhouse is to create favourable conditions that allow delicate plants to grow and this is what the atmosphere does for us.



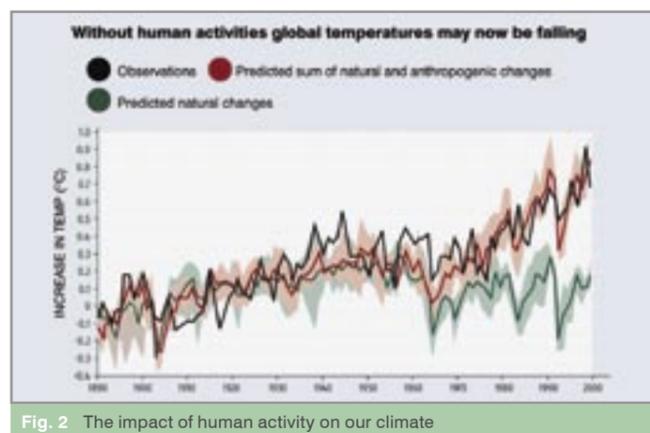
- The Sun produces light across a wide spectrum including short wavelengths.
- The atmosphere is not equally transparent to all wavelengths.
- Visible light reaches the surface of the earth and much of it is absorbed by the soil and vegetation. The absorbed energy produces heating.
- As a result the energy is emitted from soil and vegetation as thermal radiation i.e. long wavelength light
- Most of the thermal radiation is absorbed by certain gases in the atmosphere. These gases are known as the Greenhouse Gases, of which CO<sub>2</sub> is the most important.
- The total amount of energy within the atmosphere increases – leading to an increase in temperature.
- An equilibrium temperature is reached when the loss of heat energy at the top of the atmosphere equals the incoming energy received from the Sun.

The *greenhouse effect* is essential to life on Earth. It is necessary to maintain a climate that permits water to exist in a liquid state. Without the greenhouse effect we would freeze. The average global temperature would be approximately 30°C lower and would not be favourable to life as we know it.

The problem is the enhanced greenhouse effect; too much energy is being trapped, leading to climate change. If this were to continue it would cause major changes to our country and indeed our planet.

The majority of scientists believe that human activity is a significant contributor to an increase in climate variability. This includes the burning of *fossil fuels*, destruction of *rain forests*, exploitation of new croplands and overgrazing of grassland – causing extra CO<sub>2</sub> to be released. As a result our climate is becoming warmer and more variable, with Ireland, for example, experiencing more severe storms.

Carbon dioxide is present naturally in the atmosphere. It is vital for the growth of plants. However human activities are generating additional CO<sub>2</sub> in the atmosphere. The rate of CO<sub>2</sub> increase has accelerated in the last few decades.



## Factors affecting climate change.

Besides the enhanced greenhouse effect there are many other factors that aggravate climate change. For example, the melting of the polar ice results in less of the sun's energy being reflected back to space; this in turn raises the temperature and causes even more ice to melt. This is an example of *positive feedback*.

Another example of positive feedback can be seen in our oceans. The oceans act as a large reservoir for CO<sub>2</sub> and determine the atmospheric concentration to a large extent. CO<sub>2</sub> solubility decreases as the temperature rises.

## What other gases contribute to the greenhouse effect?

*Greenhouse gases* are gases in the atmosphere that trap radiant energy. There are many of them but the most important are:

*Water vapour* is responsible for most of the greenhouse effect. However, the amount of water vapour in the atmosphere is in response to climate rather than the driver of climate change.

*Methane* is produced by many processes including digestion of *cellulose* by *bacteria* in wetlands, in rice fields and in the intestines of *ruminants* and *termites*. Methane is often released during the extraction of crude oil. *Nitrous oxide* is a by-product of some industrial processes. It is also produced by bacterial action on nitrogen compounds in the soil; this effect is greatly increased by the use of fertilisers whether natural or manufactured. Ireland has high emissions of methane and nitrous oxide per head of population compared to other developed countries.

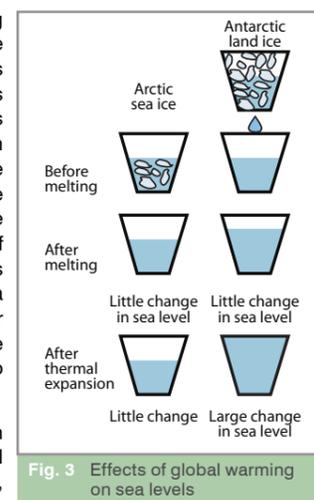
Other greenhouse gases include *ozone* (O<sub>3</sub>), *CFCs* and *HFCs*. Ozone is formed in the upper atmosphere by the action of ultraviolet radiation on oxygen.

Many of these gases are not easily removed from the atmosphere and therefore have long *residence times*. For example, CO<sub>2</sub> can persist, and continues to influence climate, for hundreds of years.

## Effects on sea level.

There are four major reservoirs of freshwater ice on Earth: *Arctic ice* which is sea based and *Antarctic ice*, the *Greenland Ice shelf* and *Permafrost/Glaciers* which are all land based. Melting Arctic sea ice makes little difference to sea level as this ice is floating. Melting land

based ice however makes a big difference. Evidence suggests the land ice in the polar regions is melting and adding large volumes of fresh water to the ocean; this causes a rise in sea levels with consequent effects on the environment. The *IPCC* – The Intergovernmental Panel on Climate Change – estimates a rise of between 18 and 59 cm in sea levels during this century, and that sea levels will continue to rise for hundreds of years due to the time scales required for the energy to reach the deep oceans.



Global Climate Models forecast an increase of 1.8 to 4.0°C in global temperatures over the next century, compared to 0.6°C in the last century. These models represent our most advanced estimates of future events.

In many cases, it is the rate of environmental change that is the real issue. Species are generally very resilient to slow changes and can adapt over time. However, climate change is happening at such a rapid rate that species may not have sufficient time to react and adapt.

Tree species are slow to adapt. They take time to re-establish themselves in areas with more suitable conditions. Some animal/bird species are more adaptable than others. For example, cod and other fish species have moved further north in search of cooler waters during the last twenty five years or so.

*Marine species* such as coral are even more sensitive to temperature changes. Corals grow very slowly, but are easily bleached by warmer water, excessive ultraviolet radiation, pollution or changes in salinity. If coral polyps and their associated plankton are killed by adverse conditions then the calcium carbonate structures that they build around themselves become pale in colour.

## Our effect on global warming.

How can we measure our effect on the Earth's climate? One way is to calculate our *Carbon Footprint* – this is a measure of the amount of carbon dioxide we produce per year. In 2005, the average carbon footprint per Irish person was 16,850 kg, compared to that in the UK where it was around 11,000 kg per person. Secondly we can look at the *Food miles/kilometres* associated with our food. Strawberries and other foods produced in Ireland do not require nearly as much energy to get to our tables as those imported from abroad. Consumer demands for such products out of season greatly increases the energy used in transport. The mode of transport is also a significant factor.

## What can we do about it?

The answer is simple: we need to reduce our demand for fossil fuels; this requires major and difficult changes in our lifestyle. We also need to make more use of energy sources that are renewable such as wind, wave, *hydroelectric*, *geothermal* and *biofuels* which can supply some of our needs. We also need to conserve energy more efficiently by using lower energy products at home and in work or school. We all have to reduce our CO<sub>2</sub> emissions in order to protect our planet.

The Environmental Protection Agency (EPA) is an independent public body established under the Environmental Protection Agency Act, 1992. The EPA regulates and polices activities that might otherwise cause pollution. It ensures there is solid information on environmental trends so that necessary actions are taken. The EPA's priorities are protecting the Irish environment and ensuring that development is sustainable. It employs over 290 people who work in ten locations throughout the country.

The other main instruments from which it derives its mandate are the Waste Management Act, 1996, and the Protection of the Environment Act, 2003. The EPA has a wide range of functions to protect the environment. Its primary activities include:

- Environmental licensing
- Enforcement of environmental law
- Environmental planning and guidance
- Monitoring and reporting on environmental quality – air, water, waste, noise, land and soil
- Environmental research

The EPA's function is to protect and improve the natural environment for present and future generations, taking into account the environmental, social and economic principles of sustainable development.

## Syllabus Reference

### Leaving Certificate Chemistry

Option 1B: Atmospheric Chemistry

### Leaving Certificate Biology

Unit 1.4: General principles of Ecology

### Junior Certificate Science

Section 1C7: Ecology  
Section 2B2: Carbon dioxide  
Section 2C5: Hydrocarbons, acid rain

## Learning Outcomes

On completing this section, the student will be able to:

- Recognise the effects of climate change on our environment.
- Relate the activities of humans to the changes in our climate.
- Understand the Greenhouse Effect and appreciate that it is vital for life to exist on Earth.
- Appreciate the need to account for individual production of CO<sub>2</sub> and the responsibility we each can have on reducing global warming.

## General Learning Points

- The Greenhouse Effect is essential for life on Earth.
- The Enhanced Greenhouse Effect increases the energy in the atmosphere and causes changes in global climate. It is of concern because it is driven by human activity.
- Greenhouse gases are gases present in the atmosphere which trap the Sun's energy.
- There are many of these gases and the most prominent, in terms of climate change, are CO<sub>2</sub> and CH<sub>4</sub> (carbon dioxide and methane).
- The effects of climate change include an increase in extreme weather conditions such as droughts, storms and monsoons.
- Individual contributions to the Enhanced Greenhouse Effect can be expressed as a Carbon Footprint – a measure of our annual CO<sub>2</sub> production.
- The calculation of food miles/kilometres can also highlight the environmental impact of our lifestyle. It is the amount of energy associated with producing and transporting the food we eat.

## Student Activity

Calculate your own carbon footprint. List the ways you can reduce your carbon footprint. For a carbon footprint calculator check [www.sta.ie](http://www.sta.ie)

List the contents of your school lunch and calculate the food miles associated with getting it from its source to your lunch box.

## True/False Questions

Indicate whether the following are true (T) or false (F) by drawing a circle around T or F.

- (a) Human activity is a significant contributor to the enhanced greenhouse effect. **T F**
- (b) Methane is produced in bacterial breakdown of cellulose. **T F**
- (c) Oxygen in the air acts as greenhouse gas. **T F**
- (d) Carbon dioxide is naturally present in the atmosphere. **T F**
- (e) Plants and animals adapt readily to climate change. **T F**
- (f) Per head of population, Ireland is one of the lowest emitters of greenhouse gases in the world. **T F**
- (g) The enhanced greenhouse effect only causes temperatures to rise. **T F**
- (h) Nitrous oxide is the most significant greenhouse gas. **T F**

Check your answers to these questions on [www.sta.ie](http://www.sta.ie)

## Examination Questions

### 2007 Leaving Certificate Chemistry Ordinary Level

A number of gases present in the lower atmosphere are responsible for the greenhouse effect.

This effect is generally beneficial, but it has been increasing in recent times, and this increased greenhouse effect is believed to be responsible for various kinds of damage to the environment.

- What is the *greenhouse effect*?
- Name two of the gases responsible for causing the greenhouse effect.
- Why is the greenhouse effect largely beneficial?
- Give two kinds of environmental damage that may result from the increased greenhouse effect.

### 2007 Leaving Certificate Chemistry Higher Level

Environmentalists are concerned about the increasing abundance of carbon dioxide in the atmosphere.

- State one important way carbon dioxide is constantly added to the atmosphere.
- Carbon dioxide is a greenhouse gas. It has been assigned a greenhouse factor of 1.

What use is made of the "greenhouse factor" of a gas?

- Name two other greenhouse gases.
- Carbon dioxide is removed from the atmosphere when it dissolves in rainwater, seas, lakes, etc.

What three chemical species arise in water as a result of carbon dioxide gas dissolving in it?

### 2006 Chemistry Leaving Certificate Ordinary Level

Hydrocarbons are widely used as fuels.

- What are hydrocarbons? Give one major source of hydrocarbons.
- Increasing levels of methane (CH<sub>4</sub>) in the lower atmosphere are a concern to environmentalists at present. Explain why this is so.

### 2004 Leaving Certificate Chemistry Higher Level

The greenhouse effect is a natural phenomenon but its effects have been enhanced by human activity over the past 200 years.

- Explain the term greenhouse effect.
- Identify one gas in the atmosphere which makes a significant contribution to the greenhouse effect.
- In relation to the gas you have identified in (ii), mention a type of human activity which has been a major contributor to the increased levels of this gas in the atmosphere.
- Identify one gas, found in the atmosphere, which is not a greenhouse gas.
- State three probable consequences of an increased greenhouse effect which have been suggested by environmental scientists.

### 2007 Leaving Certificate Biology Ordinary Level

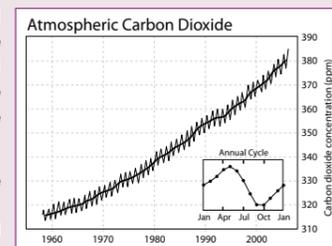
- What is the principal source of energy for the Earth's ecosystems?
- Name the process that converts this energy into chemical energy in plants.

### 2007 Junior Certificate Science Higher Level

The increase in carbon dioxide concentration in the Earth's atmosphere is currently causing concern. The *use of fossil fuels* and *deforestation* have been identified as major contributors to this increase in carbon dioxide concentration. The graph shows a continual increase in the carbon dioxide concentration for the last fifty years. The data was collected at a site in Europe.

- Explain how *either* the use of fossil fuels or deforestation could have contributed to the increase in atmospheric carbon dioxide.  
Explain \_\_\_\_\_
- Suggest one possible *effect* of continued increase in carbon dioxide concentration in the Earth's atmosphere.  
Effect \_\_\_\_\_

Though there is an overall increase in carbon dioxide concentration there is an annual *rise and fall* in carbon dioxide concentration as shown in the box in the diagram.



- Suggest one *reason* why the carbon dioxide concentration decreases between April and October each year.  
Reason \_\_\_\_\_
- How could the reason that you have given in (iii) be used in a *practical way* to slow down and even reverse the overall increase in carbon dioxide levels in the atmosphere?  
How? \_\_\_\_\_

### 2004 Junior Certificate Science Higher Level

Burning fossil fuels releases gases into the atmosphere that can damage our planet. Name one of these gases and state a damaging effect that it has on our environment.

Gas \_\_\_\_\_  
Damaging effect \_\_\_\_\_

For further examples of past paper questions check [www.sta.ie](http://www.sta.ie)

## Did You Know?

*Anthropogenic* is the term used to describe the effects of human activity on our environment. Originates from Greek *anthropos* meaning human and *gen* meaning produced.

CFCs are powerful greenhouse gases. They are also involved in the destruction of the ozone layer in the upper atmosphere. The production of CFCs was controlled by the Montreal Protocol and as a result their concentration is now decreasing in the atmosphere.

Ireland is required under the Kyoto Protocol to maintain our greenhouse gas emissions to 13% above our 1990 levels. At present we are 25% over that level so more work needs to be done to reduce our emissions.

A Carbon Footprint is a measure of the impact human activities have on the environment. It is measured in terms of the amount of CO<sub>2</sub> produced (greenhouse gases).

In Ireland the CO<sub>2</sub> emission per person in 2003 was 10,300 kg compared to 19,800 kg in the USA, 9,400 kg in the UK and 100 kg in Ethiopia.

### There are many ways of reducing your carbon footprint, including

- Using public transport to get to school / work.
- Turning off electrical appliances – not just leaving them on standby.
- Encouraging the use of local produce rather than imported produce where possible.

### Travelling by aeroplane increases your carbon footprint.

- Short haul (Europe) - 600 kg
- Medium haul (East coast America, Africa, India) -1,300 kg
- Long haul (Far East, Australia, South America) -1,600 kg

## Biographical Notes

### John Tyndall (1820–1893)

The Irish scientist John Tyndall was one of the first to develop a theory about the Earth's natural greenhouse effect and to identify the relative radiative forcing of various greenhouse gases. He explained how trace gases in the atmosphere affect our climate.

He was born in Leighlinbridge, Co. Carlow on August 2, 1820.

Read more about other famous scientists on [www.sta.ie](http://www.sta.ie)

## Revise The Terms

Can you recall the meaning of the following terms? Reviewing the terminology is a powerful aid for recall and retention.

Climate change; enhanced greenhouse effect; greenhouse effect; fossil fuels; rain forests; positive feedback; greenhouse gases; water vapour; carbon dioxide; methane; bacteria; cellulose; ruminants; termites; nitrous oxide; ozone; CFCs; HFCs; residence times; Arctic; Antarctic; Greenland Ice Sheet; permafrost; glacier; IPCC; carbon footprint; food miles; renewable; hydroelectric; geothermal; biofuels.

Check the Glossary of Terms for this lesson at [www.sta.ie](http://www.sta.ie)