CARBON DIOXIDE

using mathematics to understand
the greenhouse effect

CARBON DIOXIDE OCCUPIES ONLY 3 PARTS IN 10,000 OF
THE AIR WE BREATHE, YET IT IS A VITAL PART OF
EVERYTHING THAT LIVES ON EARTH. IT IS PRODUCED
WHEN ANIMALS BREATHE AND IS ALSO PRODUCED BY
ROTting VEGETATION. ALTHOUGH HUMANS AND
ANIMALs BREATHE OUT, IN TOTAL, QUITE LARGE
QUANTITIES OF CARBON DIOXIDE, IT IS PRODUCED IN
VERY MUCH LARGER QUANTITIES BY INDUSTRIES WHICH
BURN FOSSIL FUELS, IE IT IS PRODUCED WHEN OIL,
PETROL, COAL (THE FOSSIL FUELS), WOOD, OR ANY
SUBSTANCE CONTAINING CARBON BURNS TOGETHER
WITH LARGE AMOUNTS OF OXYGEN (WHEN FUELS BURN
WITHOUT OXYGEN THEY PRODUCE CARBON
MONOXIDE). FORTUNATELY THE AMOUNT OF CARBON
DIOXIDE IN OUR ATMOSPHERE IS CONTROLLED, TO
SOME EXTENT, BY GREEN PLANTS AND THE PLANKTON
IN THE SEA WHICH ABSORB IT. EVEN SO THE AMOUNT IS
STEADILY INCREASING. THERE IS NOW 25% MORE CO₂
IN OUR ATMOSPHERE THAN AT THE BEGINNING OF
THE INDUSTRIAL REVOLUTION.

CARBON DIOXIDE AND OTHER GASES IN OUR
ATMOSPHERE ACT LIKE THE GLASS IN A GREENHOUSE.
THEY LET THE SUN’S RAYS THROUGH AND TRAP SOME
OF THE HEAT, BY ABSORPTION, CAUSING THE AIR TO
WARM. IN EFFECT THEY KEEP SOME OF THE RADIANT
ENERGY RECEIVED BY THE EARTH FROM BEING
RETURNED TO SPACE. CARBON DIOXIDE
CONTRIBUTES ABOUT 5% OF THE GREENHOUSE
EFFECT. IF THE RESULTING INCREASE IN WARMING
CONTINUES, IT COULD HAVE SERIOUS EFFECTS
ON OUR PLANET.

THE EXERCISES WHICH FOLLOW USE TOPICS SUCH AS MULTIPLICATION,
DIVISION, AREA, PERCENTAGES, GRAPHS AND CHARTS TO EXPLORE FURTHER THE EFFECTS
OF FOSSIL FUEL POLLUTION.
Leaves are very important to plants and trees. They are responsible for providing food, in the form of sugars, for the entire tree. They absorb sunlight and carbon dioxide which, together with water, are used to make sugar using the process known as photosynthesis. Oxygen and water are released into the atmosphere in exchange. This process of absorbing carbon dioxide and giving out oxygen and water is a vital part of keeping our air cool and fresh.

Look at the square below. Its size is 10 cm x 10 cm and its area is therefore 1 square decimetre or 1 dm$^2$.

For every 1 dm$^2$ of its area, a leaf absorbs about 15 mg of CO$_2$ for every hour of sunlight it receives. Generally this is about 10 hours per day.

Scientists have suggested that for leaves that are shaped like the one below, a simple formula can be used to calculate their area:

$$\text{Area of leaf} = \frac{2}{3} \times \text{length} \times \text{breadth}$$
You can also get a good estimate of the area of a leaf by placing it on 1 cm² paper, drawing round it and counting the number of whole squares it covers. As long as half or more of the square is covered count it as one whole square. Ignore anything less.

1. Find the area, in cm², of a large leaf (bigger than the one in the diagram):
   (a) using the formula
   (b) by counting squares.

   Which method do you think is most accurate? Give your reasons.

2. What is the area of your leaf in dm²? (Choose the area from either method.)

3. How much CO₂ does your leaf absorb:
   (a) per hour
   (b) per day
   (c) per year?

4. Estimate how many leaves are on the tree or bush (a rhododendron bush is ideal). Now work out how much CO₂ the tree or bush absorbs in one year.

5. A BMW 525i produces about 8 tonnes of CO₂ per year. Will your tree or bush be able to absorb that much? Show your working.
Plants and trees absorb carbon dioxide exhaled by humans and animals as well as much of that produced by fossil fuels. Humans and animals take in the oxygen given off by plants and trees. In this way the supply of oxygen and carbon dioxide, at present, stays fairly stable.

1. People breathe out carbon dioxide at the rate of about 600 g per person per day. What weight, in kilograms/tonnes, of CO$_2$ will the following produce in one year:

   (a) you  
   (b) all the pupils in your school  
   (c) all the people in the UK  
   (d) all the people in the world?

Remember to give your answers in appropriate units. Is your answer likely to be accurate? Explain why.

2. An athlete in training might easily breathe in 16,000 litres of air per day. Assuming s/he breathes out the same volume and that 4% of the expired air is carbon dioxide, calculate:

   (a) the volume of carbon dioxide s/he breathes out in one day  
   (b) the weight of carbon dioxide s/he breathes out in one day. Take the density of carbon dioxide to be 1.5 g per litre.
It has been calculated that for every person it can carry:
- an aircraft produces 684 g of CO₂ for each kilometre it travels
- a motor car produces 83 g of CO₂ per kilometre
- a fast electric train, such as the French Train à Grande Vitesse (TGV), produces 31 g of CO₂ per kilometre.

Which mode of travel is best for our atmosphere? Give your reasons.
- People breathe out carbon dioxide at the rate of about 600 g per person per day.

Carry out a mini-survey of your own to investigate the total contribution of CO₂ to the atmosphere by a family or group of four people going on holiday. Illustrate your work with tables, graphs and/or charts wherever you think these are appropriate.

You choose the holiday destination! What percentage of the total combination of CO₂ in each case is from the people?

Would you say you have chosen a 'green' holiday?
Carbon dioxide is a major contributor to global warming. By trapping the sun's heat in the atmosphere, the Earth's temperature will rise. Such warming is known as the 'greenhouse effect', and eventually could cause the sea to expand sufficiently to cause flooding in many parts of the world.

Carbon dioxide is created whenever we use energy, e.g. electricity generated from fossil fuels. In fact, carbon-based fossil fuels provide three-quarters of our present energy needs.

Each of us can make a personal contribution to a reduction in carbon dioxide production in our homes. It is estimated that we could cut our fuel bills and reduce the carbon dioxide produced by about 20% if we all used less energy by making changes such as those described below.

**Carry out a mini-environmental audit in your home**

- Taking a shower uses only 20% of the hot water used for a bath. It is cheaper and can save between 60 and 125 kg of CO₂ per year.
- Turning down your central heating thermostat by 1°C can save £15–£40 and 190–500 kg of CO₂ per year.
- A dripping tap can waste a bathful of water a day. Making sure taps are turned off and fixing dripping taps can save up to £5 a year.
- Fitting shelves above radiators can save £5–£10 and 60–125 kg of CO₂ per year.
- Insulating hot water pipes can save about £5–£10 and 60–125 kg of CO₂ per year.
- Draught proofing your windows and doors with simple plastic strips can save about £15–£40 and 190–500 kg of CO₂ per year.
- Closing your curtains when it is getting dark can save you £10–£15 and 125–190 kg of CO₂ per year.
- Insulating your hot water tank with a purpose-made jacket can save £10–£15 and 125–190 kg of CO₂ per year.
- Replacing an old central heating boiler with a new condensing boiler costs extra initially but can save about £100–£150 per year.