MAX DE BOO



***Above:*** *The first horse chestnut leaves, bluebells, and wood anemone flowers are all signs of spring — but are they appearing earlier?*

# Effects of climate change

**GCSE key skills and concepts**

- Considering ideas and evidence
- The power and limitations of science, uncertainties in scientific knowledge
- Patterns and relationships in data
- The impact of humans on the environment
- Interrelationships of organisms

*Do your grandparents ever complain, 'You don't have to suffer the really cold winters we had when we were young'? If so, they are right. Records began 350 years ago, and nine of the warmest years recorded have been since 1990. You might think warmer temperatures are a good thing, but climate change has far-reaching implications. You need to know about the impacts we have on our global environment for your GCSE course. This article explores climate change in detail.*

Climate is defined as the prevailing conditions of factors such as temperature, humidity, rainfall and wind in a region. The UK is in the **temperate** zone, one that does not exhibit extremes of heat or cold.

Animals and plants have annual cycles of growth and reproduction. **Phenology** is the study of the times each year that certain life-cycle events occur. It involves recording things like when you heard the first cuckoo or saw the first frogspawn, hawthorn trees in blossom, blackberries fruiting or leaves changing colour. If the climate is changing, the timing of these events might change as well.

## CLIMATE IS CHANGING

The debate among scientists now is not *whether* climate change will happen but *how fast* it will occur. The United Nations' IPCC (Intergovernmental Panel for Climate Change) predicts warming of 2.4–5.8°C over the next century. Nine of the ten warmest years since temperature records began in Britain, in 1659, occurred in the 1990s. The warmest year on record was 1998, the second warmest was 2001 and the Meteorological Office predicts a 75% probability that 2002 will be warmer than 2001. January 2002 was the warmest January for 9 years (the average temperature of 5.8°C was even warmer than the average of 5.2°C in 1998), February 2002 was 3.2°C warmer than the 30-year average, and March was 1.8°C above the average.

## RECORDING CHANGE

Over the centuries both scientists and non-scientists have kept records of natural events. In 1736, Robert Marsham began recording 27 indications of spring in the UK and we have recently found a few even older records dating back to 1703. When correlated with temperature these phenological records show how nature is responding to a changing climate. The Marsham family continued recording until 1958. A nationally coordinated scheme ran from 1875 to 1947 and the UK Phenology Network (UKPN) began in 1998.

In autumn 2000 UKPN had 350 recorders. Two years on there are more than 14,000 recorders spread across the UK, mostly working over the internet. Although recordings of natural events by the public are sometimes dismissed as unscientific, the UKPN records are producing some important results which are statistically significant. When a large number of people are recording, the data as a whole become credible because anomalous records can be spotted.

Phenology is taken very seriously. The IPCC sees it as legitimate research into climate change and phenological events are now part of the UK government's Climate Change Indicators.

## INDICATORS OF CHANGE

Chemical reactions, including those of respiration and growth, speed up with increased temperature. The UK Phenology Network has found that for each 1°C rise in temperature, events happen on average 6–8 days earlier in spring!

Earlier this year we predicted, based on temperatures and phenological data, that spring 2002 would be 2–2.5 weeks earlier than the norm and that seasonal changes in autumn 2002 would be delayed or prolonged.

## IMPLICATIONS FOR WILDLIFE

Let's consider a woodland. Organisms in woodland communities are interdependent, not only in the way represented in food webs, but also in the timings of their life cycles. For example, herbivorous insects need to hatch from eggs when their food plant is available. If this breaks down as climate patterns change, feeding relationships will be disrupted.

At present, insects seem to be responding to temperature changes at the same rate as their food plants. Orange tip butterflies are active and egg-laying earlier; but garlic mustard, their food plant, is growing sooner. The same is happening with winter moths and oak trees. However, there is evidence that the hatching of blue tits may no longer coincide with the peak of caterpillar numbers in a wood in Oxfordshire, and the arrival dates of some summer migrant birds are already lagging behind the rest of the woodland community.

Climate change may also affect woodland composition. Trees such as sycamore and oak are responding more quickly to climate change than, for example, beech and ash. Bluebells and snowdrops may lose the competitive advantage gained by starting growth

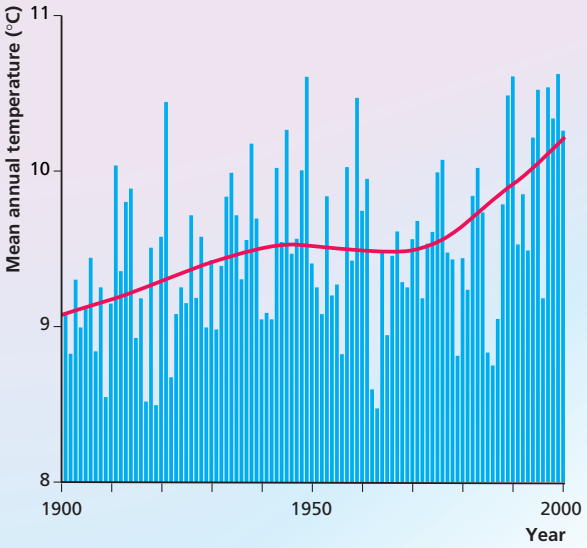


*Figure 1* *Graph showing temperature change over the last 100 years. Predict the rise in temperature over the next 20 years if the same trend continues.*

**At the end of 2001, observers noted very intense autumn colours on trees. Warmer weather and a longer growing season increase the concentration of sugars in the leaves. At the end of the season, the chlorophyll breaks down, revealing the other pigments, particularly carotene and anthocyanin, both of which are more intense with increased sugar concentrations.**

### BOX 1 REGISTERING AS A RECORDER

Wherever you live in the UK you can join the Woodland Trust's network of recorders. Connect to Nature's Calendar at **http://www.phenology.org.uk**. You will get help online and offline to identify species for observation. It is easy to record some natural events — for example the first snowdrops, the first leaves on oak trees, and autumn events such as blackberry fruits and leaf fall.

### BOX 2 CAUSES OF CLIMATE CHANGE

Some variation in climate is natural, but the primary cause of climate change is the increase in carbon dioxide concentration in the atmosphere. Levels of this gas were relatively stable for thousands of years but have increased by 31% since 1750. Burning of fossil fuels (industry, domestic use, vehicles on the road) has contributed 75% of this increase, while deforestation accounts for most of the remainder.

Carbon dioxide is quantitatively the most significant contributor to global warming but some other gases play a part. These include methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride ($SF_6$).

The USA releases most of the global carbon dioxide (85% of all emissions).

Ian Beamer/Ardea

***Above:*** *First sightings of frogspawn around the British Isles are recorded by the UK Phenology Network each year.*

in the previous autumn, as leaf growth of many other plants now begins earlier in the spring.

Ancient woodland is by far the richest habitat for wildlife in the UK. Such woods are often small and isolated — surrounded by intensively-managed land. A rise in annual temperatures will mean that those species that can will spread north to a more suitable climate. Many of the species found in ancient woodland, such as lichens, fungi and invertebrates, are very immobile, rare and threatened. Effectively they will be locked into these small wildlife 'islands'.

## IMPLICATIONS FOR PEOPLE

Winters will be warmer, wetter and increasingly frost-free. A longer growing season can be useful for farmers, although other factors, such as flooding, the survival of pests through the winter and the chance for them to produce more generations in one year, might counteract these benefits. Temperate plants often rely on winter chills to break dormancy. Research is being done on this at the moment, for example investigating the potential impact on yields of fruits such as blackcurrants. Longer growing seasons might even mean longer pollen seasons and more hay fever.

## BOX 3 ACTIVITIES

(1) Try this at home. Can you find out how much electricity is used per week by:
- a computer used for 6 hours per day?
- all the LEDs (cooker, VCR, televison) left on permanently in your home?

(2) Predict the increases/decreases in the animal and plant populations if blue tits hatch later than caterpillars:
- to the caterpillars.
- to the birds.
- to green plants.
- to other wildlife.

(3) Can you find out which country abandoned its commitment to the Kyoto Protocol? Clue: It is the country producing the most carbon dioxide emissions.

## WHAT CAN WE DO?

All the major carbon dioxide emitting countries (EU states, Japan and the US), signed the Kyoto Protocol of 1997. This committed them to reducing overall emissions of greenhouse gases by at least 5% of the 1990 levels by 2005. When the protocol was due to be ratified in 2001, one country withdrew its agreement to cut back emissions (see Box 3).

In Britain, from April 2002, businesses will be liable to the Climate Change Levy (adding 15% to typical energy bills) but discounts will be awarded to those who cut their energy use.

There are ways that we as individuals can reduce carbon dioxide emissions:
- use the car less — walk, cycle or use public transport instead;
- make sure our homes are well insulated;
- install energy-saving devices;
- avoid using energy-consuming equipment like air conditioning unnecessarily — open a window instead.

And why not contribute to research on the local effects of global warming by joining the UK Phenology Network (Box 1)?

## WEBSITES

The UK Phenology Network **http://www.phenology.org.uk**

Eco Schools **http://www.eco-schools.org.uk** promotes school and community involvement in improving the environment, citizenship and healthy lifestyles.

**http://www.greencode.org.uk** for schools wishing to include education for sustainable development in the curriculum.

The Met Office **http://www.meto.gov.uk/research/hadleycentre/index.html**

Friends of the Earth **http://www.foe.co.uk**

Green Energy Options **http://www.greenenergy.org.uk**

Government energy projections for the UK **http://www.carboncalculator.org/faq.html**

*Max de Boo has taught science for many years, in primary and secondary schools and in teacher education.* *She is grateful to Nick Collinson (Conservation Policy Advisor, The Woodland Trust/UK Phenology Network), Tim Sparks (Centre for Ecology and Hydrology/UK Phenology Network) and Jill Attenborough (Phenology Project Manager, The Woodland Trust UK).*

# Spheres in space

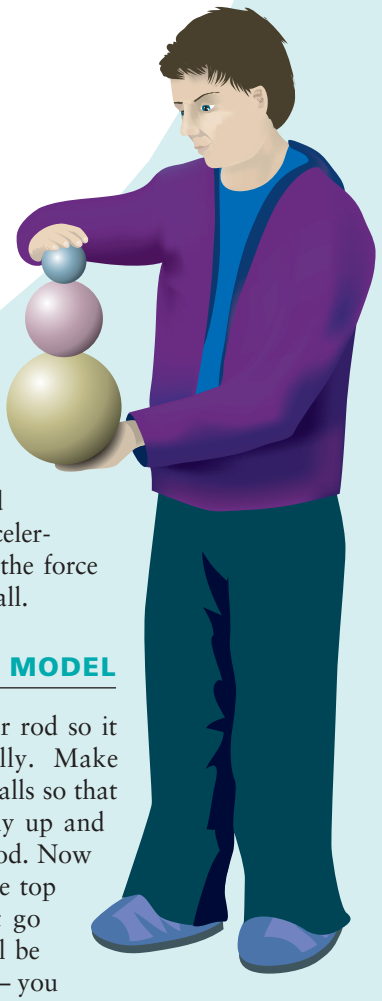

*Figure 1* Hold the three balls on top of each other before letting go.

For this spectacular trick, you will need bouncy balls of three different sizes. Hold them at arm's length, with the medium-sized ball on top of the biggest one, and the smallest on top of that. (Like all good tricks, this one is tricky to perform.)

Now, release the balls so that they fall downwards. When they hit the ground, you should find that the smallest ball ricochets upwards and reaches a surprising height.

## HOW IT WORKS

All three balls fall together at the same rate — that's something which Galileo explained.

What happens when the big ball strikes the ground? It bounces back upwards, imparting a shock to the medium sized ball, which in turn exerts a force on the small ball.

Think about what happens when a larger object collides with a smaller one — a tennis racket with a tennis ball, for example. Each feels the same force (that's Newton's third law), but the force will have a bigger effect on the object with the smaller mass. So the medium ball is accelerated by the force from the large ball, and the small ball is accelerated even more by the force from the medium ball.

## AN IMPROVED MODEL

Try fixing a wire or rod so it stands up vertically. Make holes through the balls so that they will slide freely up and down the wire or rod. Now hold the balls at the top of the rod and let go as before. They will be guided by the rod — you can even try the trick with four balls. The smallest ball should fly at least 10 metres into the air.

This may seem like a trivial experiment, but a scaled-up version was once suggested as a way of sending a simple spacecraft into orbit.

*David Sang writes textbooks and is an editor of* CATALYST.

# Fireworks quiz

Unscramble the following anagrams of substances used in the manufacture of fireworks. All the words can be found in the 'Fireworks' article on pages 1–3.

1 grow up, Den (9)
2 resist amputation (9, 7)
3 arch cola (8)
4 thor spots primulaceae (9, 11)
5 amusing me (9)
6 CRT rush demolition (9, 8)
7 ah, cells (7)
8 miniature Bart (6, 7)
9 precooled chirp (6, 8)
10 go mail manually (9, 5)

Answers on page 21