John Holman

Science In a Social CONtext

Ways of Living

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Introduction

Every community is closely linked to its environment; people live, work and relax in it. They develop new technologies to make their living conditions better. Their ways of thinking, i.e. how they explain everything around them, expresses their view of life and is influenced by the environment.

To understand this linked interaction between society, its technology and its science, we shall begin by standing well back from the present and looking at an ancient way of thinking and living which was very different from ours.

Then we will learn about a science which developed out of our modern way of living – ecology. This will be useful for understanding the new agricultural technologies which provide our food, and change the rural environment. It is also essential for maintaining the purity of our water and our air.

The majority of our ever increasing population now live in the cities. Here too our activities, our industry, traffic, housing and employment affect our ways of living. To cope with our problems we have developed new technologies which are bound to produce social changes, for which we must now begin to think and plan.

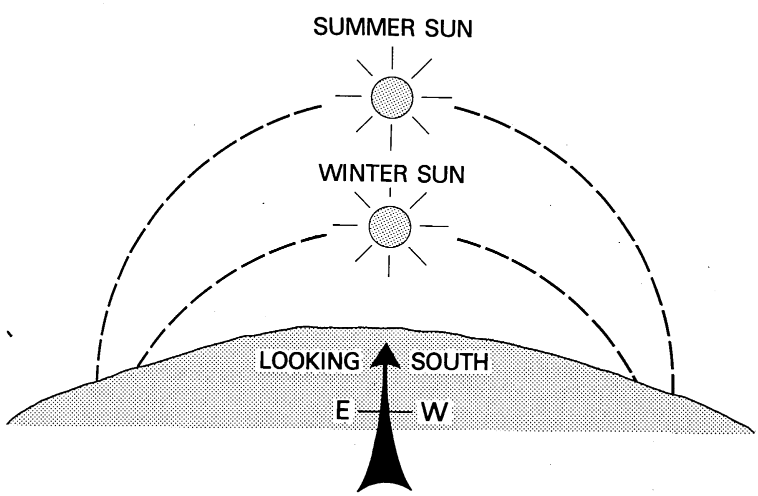
1 Technology in the Stars?

PREHISTORIC BRITAIN

Stone circles and isolated megaliths which can be seen standing or fallen in fields and woodlands are among the oldest human monuments in Britain. Some, like Stonehenge, are magnificent and much visited; others are remote and half forgotten but their significance or purpose remains unclear. In recent years it has been suggested that they might be the relics of a prehistoric science.

The latest radioactive surveys show that some of these sites are more than 4000 years old. This places them in late Neolithic times – the New Stone Age – before the use of metal or the wheel and long before the start of local recorded history. Some may be older than the pyramids of Egypt.

We cannot doubt that these monuments represent a concerted effort of a whole prehistoric society. The so-called 'blue stones' of Stonehenge, for example, weigh up to four tons each, there are 82 of them, and all were transported to the site in Salisbury Plain from Pembrokeshire in Wales, over 100 miles away.



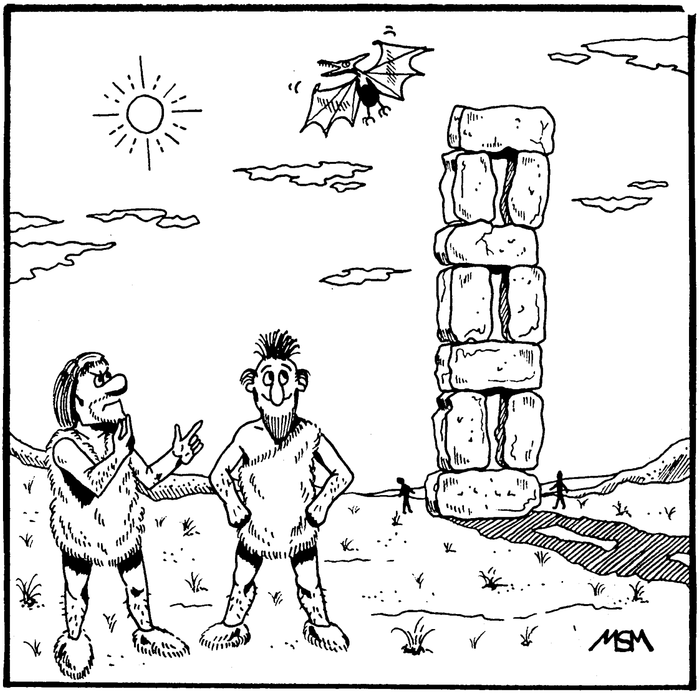
The rising and setting of the sun.

The society of the times had no more than a primitive Neolithic agriculture but they clearly thought it worthwhile to invest a large work force and the surplus needed to feed them, in order to build these monuments.

Nearly 5000 years ago when the first Stonehenge was constructed there was only a large circular ditch and bank enclosing a circle of pits. Outside it stood one huge megalith, called the Heelstone, about 12 feet tall, with some timber posts around it. Careful surveys of the circle have shown that erosion has since lowered the level of the ground by about 1 foot. At the time it was first erected, an observer from inside Stonehenge, on midsummer's day, could have aligned the top of the Heelstone level with the distant horizon, at almost exactly the spot where the midsummer sun would have risen some fifty centuries ago.

Aerial view of Stonehenge. The Heelstone is at the bottom centre.

Many of the other stone circles, and there are more than a thousand of them still recognisable in the British Isles, have outlying stones which are orientated towards the midsummer sunrise or sunset. Some of the Scottish stone circles seem to be connected with the position of the



"I don't know -- I still think they would look better in a circle."

lowest level of the summer full moon. At least one of the Irish stone monuments contains a stone-lined underground passage-grave through which the sun would have shone only on midwinter's day. Some circles have similar astronomical lines to outlying stones thereby giving a very clear impression of purpose in their construction. Curiously enough, the circles themselves do not fit into any known pattern.

Some archaeologists have argued that these ancient stones were a kind of primitive calendar for telling the time of year from the position of the sun's rising or setting. This would be very important for an agricultural community, so that if this guess is right these monuments are a kind of primitive *technology* – knowledge applied practically which would be useful to man's way of living. Others argue, from the cremated human bones found buried beneath many of these great stones and in the circle of pits in the first Stonehenge, that these were religious sites. The ancient people who spent such labour building them may have seen a connection between life and death, sunrise and sunset.

Was it possible that both these purposes, technological and religious, could have been combined here?

Do we manage to combine our technology with our beliefs, loves and way of living?

For more certain evidence we need to turn to an ancient society which has left us written evidence about the way they worked and thought.

BABYLONIAN ASTRONOMY

Under the clear skies of Mesopotamia, astronomy may have started as early as 4000 BC. Here also there are relics of primitive observatories, not stone circles, but ziggurats which were like pyramids flattened on top to make a platform for star-gazing, along with a shrine dedicated to some ancient god.

About 1640 BC there ruled a King Ashurbanipal who was interested in astronomical records. From far and wide he collected these and had them copied into a great and enduring library of clay tablets. From these priestly messages we can learn not only about their methods and calculations, but also their aims and way of thinking.

The year was divided into *lunar months* – from one new moon to the next. This was a more difficult task than it seems since there are not exactly twelve such months in one year. Sometimes it was necessary to add a whole 'lunar leap month' to keep the two time scales in step. In every 19 years there would be 12 years of 12 months and 7 years of 13 months. This was awkward. (The date of Easter is still calculated in much the same way.)

Sometimes the calculations went badly wrong. One tablet orders an extra month to be added right in the middle of the growing season, because 'the year is not good'.

The lunar months were *named for their agricultural task.* In the city Ur, for example, the fourth month was written using the symbols for a cornseed and a hand.

The stars showing behind the rising moon were used to keep the months in step with the year. They provided a kind of natural 'clockface' in the sky, a constellation for each twelfth of the year. They were even mentioned in the Creation Epic:

> He made the stations for the great gods,
> The stars, their images, the constellations he fixed;
> He ordained the year and into sections he divided it.
> For the twelve months he fixed three stars.
> The moon god he caused to shine forth, the night he
> entrusted to him,
> He appointed this being of the night to determine the days. . . .

So far the evidence shows an astronomy which is almost an agricultural technology, with religious backing.

2 Thinking in the Ancient Way

PREDICTIONS AND OMENS

There are other clay tablets in this ancient library which show a quite different purpose to this astronomy. From the positions of the stars and planets predictions about war, prosperity or disaster were made.

> . . . when Venus appears in the east rains will be in the heavens, there will be devastations . . . on the eleventh day of Duzu Venus glows in the west, hostility will be in the land . . .

To us a calendar is no more than a list of days and dates. If the harvest is late we would not dream of blaming the calendar. For the Babylonians the calendar, with its difficult calculation of lunar months, was designed to find the *best dates* for their activities, and the best date was when the stars and the Moon-God looked as if they were in a favourable position. Crops sown in the fourth moon would do well, not because there would then be enough time for them to ripen, but because the *influences* were right.

There were rhythms in the sky which could be calculated, and rhythms on the earth: day and night; sowing and reaping; summer and winter; life and death. It was the job of the Astronomer-Priests to keep man's calendar in step with the cycles of the sky-gods, so that all would be well. If the two sets of rhythms were at odds it proved, not that the calculations had gone wrong but, that calamities would happen!

SYMPATHETIC MAGIC

This kind of harmony or sympathy between man and nature, where both could influence the other, was a part of ancient thinking called sympathetic magic. It was the way in which primitive people tried to understand the world of nature; it was *their science*. Just as we use our science to help us in our way of living, so primitive people used their magic to help them. Rain could be brought about by a dance in which the thudding of feet imitated the sound of falling rain. Midwinter bonfires were lit to encourage the return of the light and heat of the sun. Whenever there were similarities there were strong magical links which could help or harm people. There were three important bases for their beliefs:

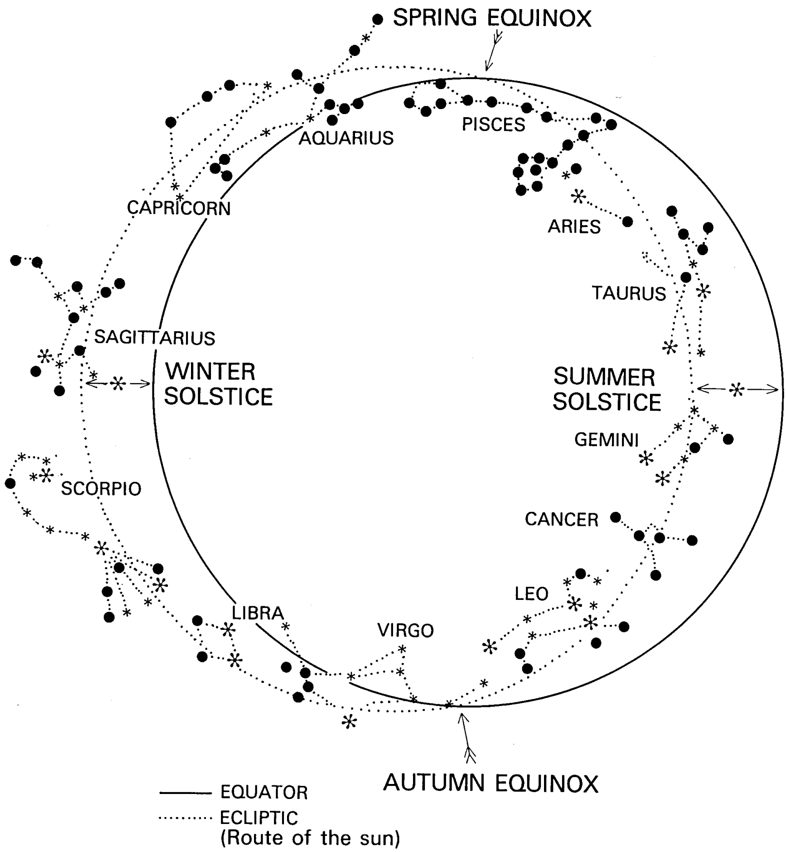
1 Men and stars, animals and plants were all linked by magical influences.
2 All events were aimed at things or people. It was as though the whole of nature was alive and had a purpose.
3 Nothing was quite inevitable – there were ceremonies which could ward off impending evil.

You can probably see that some of our superstitions, like a broken mirror bringing bad luck, still show traces of this old magical way of thinking; but they do little justice to the primitive view of the world. In large regions of the modern world a reverential attitude towards nature, which is much closer to the ancient one, still exists. Among the rural Hindu communities of India and south-east Asia there are still godheads connected with almost every aspect of life, shrines in the fields, and rites to be performed in order to make good crops. This produces a well-knit society with a clear philosophy of life. Even though transistors can now be found among the harvest offerings, this magical attitude towards nature tends to protect such societies from change.

Do you think that bringing in western style technology is bound to change such beliefs and attitudes?
Would it bring more good than harm?

ASTROLOGY

This a relic of the old magic view of natural happenings. The constellations of the Zodiac can be picked out from the star maps. They are not the most prominent (no one can be born 'under the Plough', for example) but they do trace out a yearly cycle through the sky. Just as the month-stars marked out the path of the moon for the earliest Babylonians, so the constellations of the Zodiac map out the path of the sun.



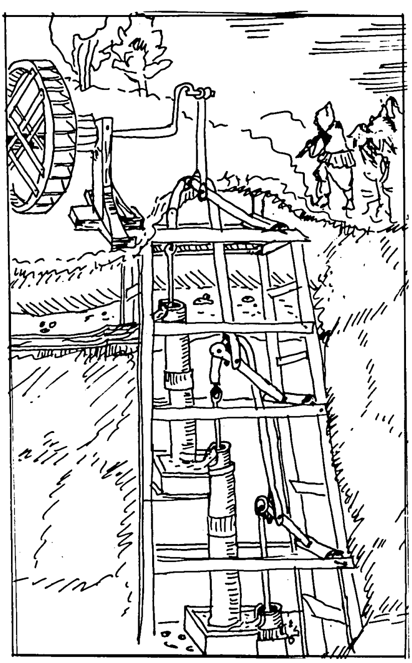
The zodiac.

The Chaldeans who marked and named these signs believed they had made such accurate observations and calculations that most of the chance and error was eliminated. No rites or ceremonials could now avert their predictions, but the sympathetic links between stars and men were felt to be as strong as ever. By 300 BC we find the very first horoscopes drawn up to forecast the life and character of an individual from the aspect of his birth stars.

Do you believe in astrology?
How could stars influence anyone?
Why do people believe in magic or astrology?

How do such different ways of thinking arise? It is usual to trace the beginning of modern science back to the sixteenth and seventeenth centuries, to the work of Copernicus, Galileo and Newton. Just why it all started then is hard to pin-point but there is little doubt that the invention of printing and the spread of knowledge played a large part in it. Education began to reach beyond the church and clergy and the new scientists were eager to learn all they could from craftsmen, builders and navigators. They were seeking knowledge about natural forces as well as new skills for making instruments and scientific apparatus. From them we have inherited and developed a way of thought that fits an energetic and progressive age and is vastly different from the magical reverential 'science' of primitive communities.

1 There is active curiosity now, not passive acceptance.
2 Since we no longer believe that nature is alive and has power over us we can feel free to examine and change things.
3 We are no longer content with 'divine purpose' as an explanation. We want to know how things work.
4 We want to use this knowledge for the benefit of our society.



From an illustration of a suction pump (Agricola 1556). Notice that the limit to which water can be pumped up was well known to these craftsmen, although no one yet understood the idea of atmospheric pressure. They have built the pump in three stages in order to clear the water from the mine.

So technology often preceded science; the craft skills were known from putting them into practice before the scientists had managed to explain them in theory.

3 Science for Modern Times

SOCIETY BECOMES INDUSTRIALISED

The first modern factory of the new industrial age was a water-powered silk-mill employing three hundred men which opened in 1722. During the next fifty years the revolution spread slowly to the cotton and wool industries and to the early iron works. In this first stage of change the workers' cottages were built on the sides of hills and valleys where the land was well drained and running rivers provided water power for the factories. Because water runs continuously the rhythm of work changed; men, women and children laboured in shifts, by night as well as by day. By 1792 coal-gas began to be used for lighting: in the city streets this produced greater safety, but inside factories it spread the night-shift system.

The second stage of the Industrial Revolution brought yet more changes in ways of living. Coal-fired steam engines ran the factories of the nineteenth century. Now the villages expanded into flat lands and valley bottoms: the very word 'slum' originally meant boggy land. Back-to-back dwellings swelled the cities, the population trebled,

Nineteenth-century back-to-back houses.

industry flourished, the factory owners became wealthy, but conditions for the workers grew worse. A pall of black smoke covered many of the new industrial regions; poverty, overcrowding and appalling sanitation brought continual outbreaks of disease to those who lived there. In 1840 the life expectancy at birth, in a city like Manchester, was barely 25 years.

No one in this industrial age believed in 'magical influence', but the effect of the changed environment was becoming all too clear. From this dawning understanding of the *interdependence of people and their surroundings* was born the new twentieth-century science of ecology.

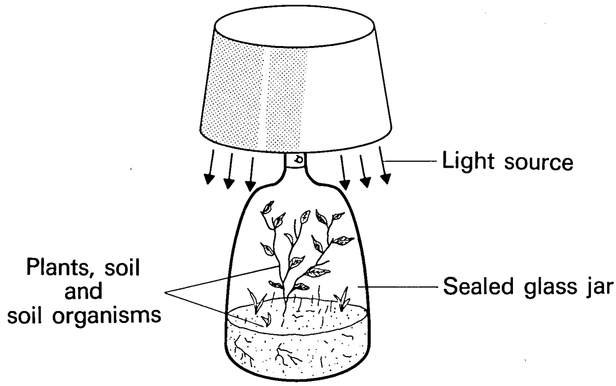
WHAT IS ECOLOGY?

One of the first successes of this new science was scored in China where a terrible outbreak of plague in 1910 caused more than 60,000 deaths. Research showed that the bacilli responsible for this were carried by the wild marmots of Mongolia. In odd years when the population density of these animals increased beyond a certain level, the bacilli multiplied and caused an epidemic which killed off a substantial proportion of the marmots as well as infecting man. Not only did this research provide useful information for controlling the outbreaks of plague, it also made several important ecological points relevant to man's other environmental problems.

1. The very success of any species, man, animal or plant, which leads to an increase of population and overcrowding also brings problems which do not exist when numbers are small.
2. Checks exist between creatures in the wild, which tend to return the total system into balance again. (There was a regular population of bacilli carried by the marmots which did little harm until the host animals increased in numbers and became overcrowded.)

Among human populations we cannot allow such dreadful natural disasters to control our numbers and so we need to understand all we can about the processes of ecological balance if we are to make life within our environment safe and satisfying.

We can start by examining a small balanced 'eco-system' existing in isolation, in order to get some idea about how different organisms react upon each other and on their environment. One of the simplest of these is a sealed glass jar containing plants, soil and soil organisms; it is

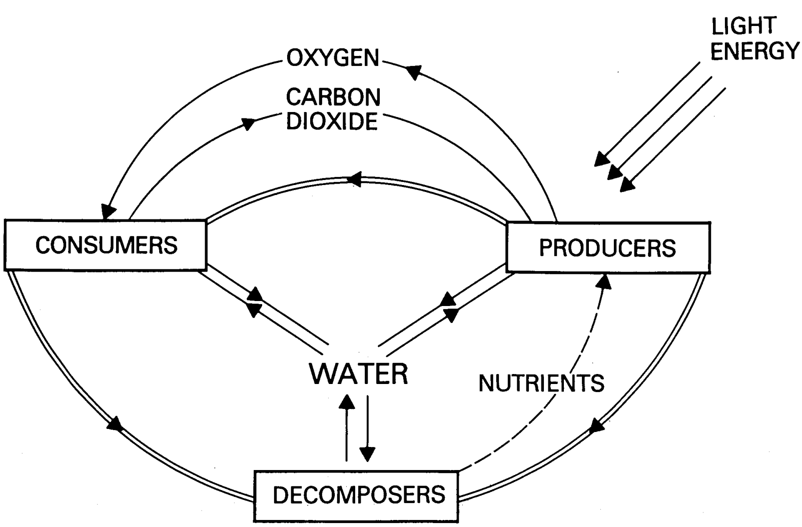


An eco-system in a bottle.

sometimes sold as a lamp base. In the interior of the jar the life-cycles of plant, animal and bacteria can exist in balance for several years. All that is need from outside the jar is a source of light energy.

Any such eco-system will contain *three* main kinds of living ingredients:

1 The *producers* making food by photosynthesis – green plants.
2 The *consumers* using this food – organisms feeding on leaves.
3 The *decomposers* breaking up dead plant and animal material to return it to the environment (soil and air).



The eco-balance.

You will notice that this system also contains *air* (nitrogen, oxygen, water vapour and carbon dioxide), soil which contains plant *nutrients* and *water* and light *energy*. All these are interconnected in a balanced network as shown in the diagram opposite.

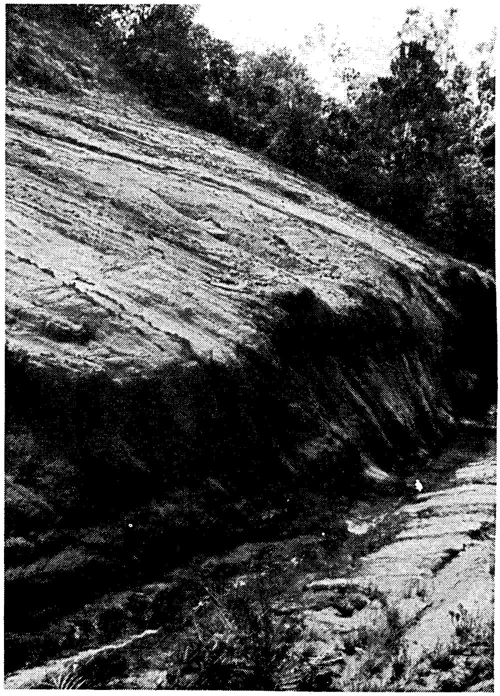
The three main living components form what you may recognise as the very simplest kind of food chain, but the air, water, nutrients and energy are also vital to the balance of the system. It will be important to remember these factors since each one will prove essential and even problem-laden within the eco-systems inhabited by man.

Take each living component in turn and show how any substantial increase in its numbers would bring about a natural check to restore the eco-balance once again.

CUTTING THE FOREST AND CLEARING THE LAND

In the wild there are far more varied and complex eco-systems. The producers of food are always photosynthesisers, trees, plants or bacteria, but consumers exist in many forms, including carnivores that feed on other, plant-eating, consumers. Each organism has its place in the system and it changes or affects the system by its presence there. In any particular season or year there may be slightly different numbers of the various species but the overall picture will remain the same unless there is a change in the climate or the arrival of a new species. The nearest thing to such a natural eco-system, unmodified by man, is the tropical forest of the Amazon basin or the tundra of the far north. Recently alarm has been expressed in some quarters at the continual clearing of the natural rain forest. Cutting down trees and burning them to clear the land alters almost every aspect of the eco-system – climate, air, quantity of energy arriving at the soil, the water cycle and the living organisms.

As the situation is so complicated it becomes very difficult to predict what the final environment will be like. Some even fear that the volume of carbon dioxide and soot released into the atmosphere could have an effect on the climate of the whole world (see the greenhouse effect, page 32). It is hard to balance all the arguments for and against the clearing of such a forest region from the point of view of the nation's population.



Erosion in a tropical rain forest.

Primitive man lived in small groups of nomadic food gatherers and hunters. He was a consumer whose activities fitted easily enough into the environment producing little overall effect in the local balance. Only when he began settled agriculture did the increase of his numbers and his method of farming begin to alter the eco-system. Even the domestication of animals can produce a dramatic effect. The introduction of goats to new environments such as Guatemala or Ascension Island, where they had no natural predator, has had an unfortunate effect on the vegetation. In other places grazing herbivores such as sheep, introduced long ago, have now become an integral part of a new landscape. The bare green downland of southern England, for example, has been shaped by centuries of sheep-farming. Saplings and shrubs have been grazed down and the growth of short grasses has been encouraged. It may all look quite 'natural' to us, but it is not kept in balance by natural processes.

Balanced?

Unbalanced?

In how many ways has the landscape immediately above been changed by our activities?

The world's increasing population is in real danger of malnutrition and even starvation. In many countries it is an ever present threat to life. We rely upon our agricultural technology to provide increasing quantities of food for us. This involves changing the natural balance of the countryside in many ways. We clear the original vegetation by digging and weeding, we plant our own crops and reap them, thus interrupting the food chain for the original consumers and decomposers. When we harvest plants which have used the soil's nutrients we create the need for more fertilisers. To increase the yields of our crops we have to attack the animal consumers that exist in the eco-system with everything that our technology can invent – traps, poisons, guns and insecticides. Every successful species alters the environment and deprives other less successful species of their food supply, but no other species has ever done so to such an extent as man.

In the 1950s these crop pests were vigorously attacked by the use of DDT against the insects, and a myxomatosis virus to keep down the numbers of rabbits. The resulting changes in the environmental balance of the countryside were so massive and so sudden that they provoked considerable public reaction. Many butterflies and rabbits, which had been familiar parts of our environment for so long, were wiped out. Birds too, which either preyed on young rabbits or were poisoned by eating dying insects, perished in large numbers. New laws were passed to restrict the amounts of DDT which could be used on the land; some of the butterfly populations have recovered and the rabbits are back.

In ecology there are so many different pathways linking an organism to its environment that it was only to be expected that man himself might feel some effects from these new agricultural methods. At first it was feared that DDT, which was such a common insecticide that traces of it were being found in food and vegetation worldwide, might prove poisonous to man. It certainly builds up gradually in the fat of the human body, as well as in that of all other consumers, but in a relatively harmless form. Other insecticides and chemical herbicides (used for abolishing weeds by spraying) are more directly dangerous. In many cases masks and protective clothing must be worn by the operatives, indeed there were some deaths from the use of the chemicals dieldrin and DNOC before their full potency was realised. Most agricultural chemicals, although not DDT, break down into harmless substances when they are in contact with the ground, and are then washed away.

What is more worrying about insecticides is the emergence of insects which are resistant to them. Insects breed so fast that the few who survive spraying may soon repopulate the field with a new strain which is little affected by any further applications of the same chemical. Then, if their predators, larger and slower breeding insects, have also been killed off by the insecticide the situation could become even worse than it was in the beginning. In other cases smaller insects which the original pest had preyed upon increase to such an extent that they in turn become a pest. It is a situation which needs the most careful ecological understanding. Chemical insecticides are now much more carefully tested before being put on the market.

AN ALTERNATIVE WAY WITH PESTS

An alternative method of control is to find the natural predator and introduce it into the locality. This was done with outstanding success in the following cases:

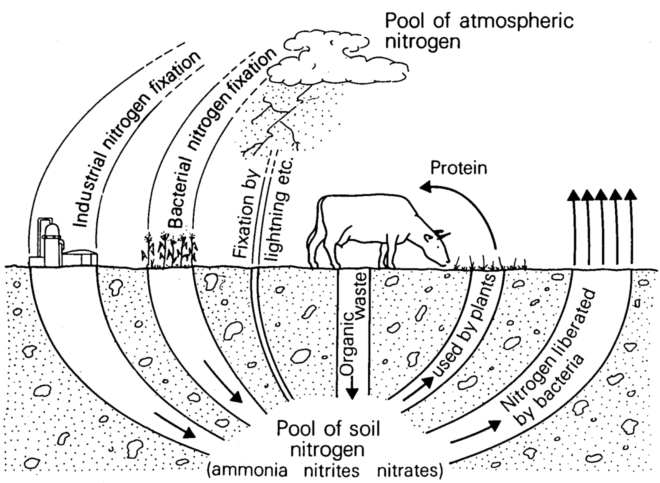
1 In 1887 the orange orchards of California were in danger of being rendered useless by 'scaley fungus' on the trees which was thought to have been brought over from Australia. Returning to that country biologists were able to find the natural predators and introduce them into the infected orchards. One of them, a kind of ladybird, flourished so abundantly on this aphid that it rapidly brought the whole problem under control. The production of oranges increased threefold within a single year.
2 The prickly pear cactus which grew in such numbers in Australia was brought under control by the deliberate introduction of a moth whose larvae feeds upon it.

In both cases the pests had been introduced from another country and had no natural predators in their new environment. Similar methods can be used to control harmful native pests. Their predators are carefully reared in order to be released when numbers of the pest population rise above a certain level. Such a method might appear to be considerably cheaper and safer than the use of insecticides but the continual monitoring of the insect populations in the fields is obviously expensive in terms of labour.

Which of the following problems arising from the treatment or non-treatment of pests, do you consider the most worrying: inadequate food production, the destruction of wildlife, the possible risk to our health?

FERTILISERS

In a natural eco-system the main plant nutrients, nitrates and phosphates, are kept in balance, more or less, by the activities within it. Because we need to take the food crops away from the locality, to feed the town dwellers, more of these nutrients must be added to the fields. Soluble compounds of nitrogen, from which the plants can build up valuable proteins, are the most in demand. There is a great pool of available nitrogen in the air around us, but only a few methods of getting it into the soluble form in which the plants can use it. Our industry plays a vital part in this by making nitrogenous fertilisers by the well known Haber (Ammonia) Process. This, however, uses up our precious fuels and is becoming increasingly expensive. There are also some bacteria which live on the roots of clover and pea plants that are capable of 'fixing' nitrogen from the air into a useful form for plants.



The nitrogen cycle.

4 Looking after our Water

SEWAGE AND THE WATER SUPPLY

Sewage, like fertilisers, is rich in nitrates and other soil nutrients. Both can stimulate plant growth, but if the plants grow too much and in the wrong place the eco-system may get badly out of balance. In cow pastures it is common to come across a pool, or a stretch of river, where the growth of green algae (scum) on the water has increased to such an extent that the water has become stagnant and smells bad – it has been polluted.

The dense human population of towns produces the same problems. There is not a sufficient number of decomposers – bacteria – in the water of nearby rivers to dispose of the sewage; so it only increases the weeds and algae which block and pollute the river flow. In modern sewage-farms extra oxygen is added to the waste, encouraging bacteria to grow which will then cleanse it.

Water can dissolve oxygen and carbon dioxide; both are essential for a normal eco-system. Fish and the valuable bacteria which decompose the ammonia from urine into nitrates, use up oxygen. Should the amount of dissolved oxygen fall to a very low level neither the fish nor the *aerobic* (air-breathing) bacteria will survive. In their place there will be only a surface scum of fungus or algae, a few worms that can wriggle near the surface to breathe, and *anaerobic* bacteria. The last also feed on the dying vegetation but they turn it into methane, which is natural gas, and hydrogen sulphide which is foul-smelling and poisonous. Some anaerobic bacteria also produce extremely poisonous toxins such as botulin. Obviously it is essential for us to know the amount of oxygen in our water and the rate at which it is being used up.

Testing the BOD (Biochemical Oxygen Demand) of water
This is a very simple test by which you can get some idea of the demand for oxygen being made by the invisible organisms in a sample of water from river, canal, lake or pond. You will need two 250 ml bottles with ground glass stoppers such as are used in the chemistry laboratory and a solution of *methylene blue* containing 0.1 grams dissolved in 100 ml of distilled water. Fill one bottle with the water you are testing, allowing no air to enter. Then add 1 ml of the methylene blue solution by pipette, under the surface. Repeat this

procedure with the other bottle using distilled water as a control. Stopper both bottles carefully and put them away in a warm dark cupboard. Examine them each day and when the blue colour in the test sample disappears record the number of days passed. The decomposer organisms acting on organic material in the water will have then used up all the available oxygen.

No of days at 20°C	*Percentage of oxygen used up*	*Verdict*
Less than 3	Less than 50	Polluted
4	About 60	Satisfactory
5	" 67	
6	" 75	
7	" 80	Unpolluted Little oxidisable material.
8	" 84	
9	" 87	
10	" 90	

a Why must the bottles be kept in the dark?

b Some water is cloudy because it contains suspended solids. Even if these are not organic materials on which decomposer bacteria thrive, this darkness decreases the oxygen content of the water. Why is this?

c Natural ponds in cattle pasture usually have a high BOD. Is this pollution?

d The state of the river Thames has been so much improved by new and expensive sewage works that several edible types of fish are now caught in its waters. Why is this considered a good thing?

e Decomposed sewage is rich in *nitrates* which feed algae, reduce BOD and are extremely dangerous to infants causing the 'blue baby' condition. Yet these nitrates and the *phosphates* also present in sewage are essential fertilisers which are getting increasingly expensive to buy. What should be done with sewage?

INDUSTRY AND WATER

The water supply is affected by our living in many other ways. There are minute but dangerous quantities of lead in the water from old lead plumbing in the houses. Like the lead in the air from petrol fumes (page 30) this can damage the mental development of children. On the other hand we deliberately add fluoride to our water to reduce dental decay.

By far the biggest consumer of water in this country is industry. This uses water for cooling machinery, and for cleansing its products. Everything which happens to this water before it is returned to the natural system, will have some effect upon life in the water and upon us.

1 Hot water discharged into rivers by industrial processes lowers the amount of oxygen the water can dissolve and increases the rate of metabolism of fish. You can imagine the result.
2 Detergents used to be a great risk both because their foam prevented aeration of the water and because they were toxic to fish. New biodegradable detergents can be broken down by common bacteria and present fewer problems.
3 Oil is often spilt from tankers and finds its way into rivers and lakes where it spreads over a surprisingly large area. It interferes with the solution of oxygen from the air and damages water birds.
4 Chemical industries commonly release their waste products into the nearest large body of water. Some of these are poisons. All are diluted by the water and many are oxidised, thereby increasing the BOD, and turn into safer products. A few, like mercury, build up gradually to highly dangerous levels in fish and those that eat fish. In Japan several hundred people in the small fishing village of Minamata suffered from mercury poisoning due to its discharge from a neighbouring chemical works. More than fifty died and many were paralysed. Mercury attacks the brain and nervous system and is dangerous at levels as low as one part in a million in the blood stream.

Local reaction to the dumping of industrial waste materials can be very angry – and with good reason. Yet industry is vital to our society, to produce goods, power, medicines and, indirectly, food. It is also a source of employment for our people and wealth for our country.

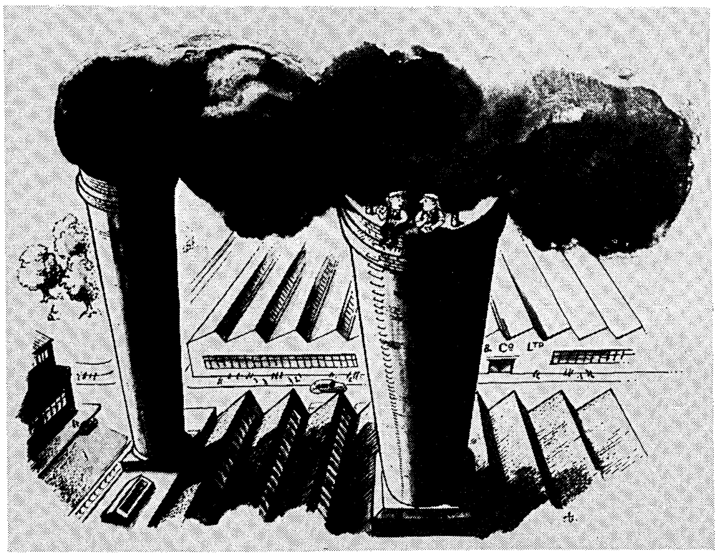
What authorities have the responsibility to protect the health of industrial workers?

If waste was being buried near your home, what tests would you wish to have carried out? To whom would you complain if you were worried about this?

5 Looking after our Air

SMOG AND THE CLEAN AIR ACT

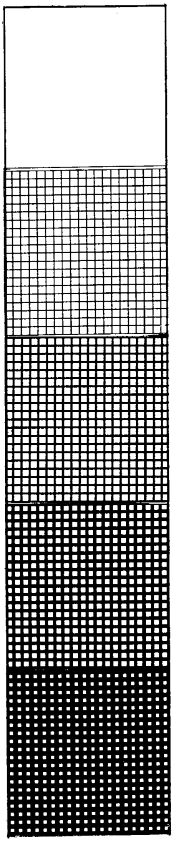
Our atmosphere contains an average of 21% oxygen, 79% nitrogen and small quantities of carbon dioxide and other gases. They can be kept in balance by several natural processes such as respiration, photosynthesis, bacterial action and solution in the ocean. Additional substances are released into the air in three main ways: volcanic eruptions, the burning of fuels, and the exhausts of vehicles.

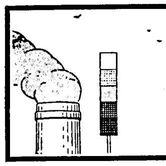


'Mind if I smoke?

Tiny airborne particles are all around us. You can get some idea of the amount in your neighbourhood by observing the layer of dust that forms on a lightly greased glass surface which has been left undisturbed for about one week. Of course small particles are slower to settle than large ones so that this test is not so good as pumping the air through a very fine filter, but it will enable you to see the particles under a microscope. They may be smooth pollen grains, sharp pieces of grit, fluff from fabric or tarry globules. We absorb at least 40,000 particles with each breath we take.

Atmospheric dust in large quantities certainly can reduce the global temperature. Records show that volcanic eruptions are almost always followed by cold summers. The mean world temperature has been falling in recent years, could this be due to the increasing number of solid particles released into the air by man's activities, or is it just due to a change in the sun's radiation?





HOW TO USE THE

Ringelmann Smoke Chart

TO CHECK CHIMNEY LOSSES

The intensity of smoke leaving a chimney is estimated by comparing its shade with the standard shades of the Ringelmann Smoke Chart. The intensity is recorded as a Ringelmann number, this being the number of the standard shade most closely resembling the smoke. Estimation of intermediate shades is possible under favourable conditions.

1 Mount the chart on a board, preferably so that no margin intervenes between the squares and the viewing edge of the mounting board.

2 Fix it so that it may be seen as nearly as possible in line with the top of the chimney. Keep the observation angle as low as possible.

3 The chart and the top of the chimney should be surrounded by the same background of sky.

4 The distance of the chart from the observer should be such that each square appears of uniform shade; i.e. about 15 metres for the average observer.

5 The chart is most reliable when used with uniform illumination from the sky, but if the sun is shining, or the sky bright on one side, the direction of the bright illumination should be more or less at right angles to the line of vision and should not be from behind or in front of the observer.

6 A chart ceases to be reliable when it becomes soiled.

The paper on which the charts are printed, and the ink used, were selected after scientific tests to ensure reasonable durability consistent with accuracy. The ink is virtually non-reflecting, and *it is important that the charts should not be varnished or covered by glass or any other substance with reflecting properties.*

Published by

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The Ringelmann smoke chart: one of the most practical, economic and sufficiently accurate methods of assessing smoke density.

These solid particles form nuclei on which droplets can condense when the air becomes moist. In the days before the Clean Air Act (1958) the smogs which formed in London were called 'pea-soupers' because they were a dirty yellow colour from these tarry particles. Widespread and inefficient burning of coal was the culprit and these smogs were killers. In 1952 there was a smog so thick that pedestrians had to feel for the edge of the curb, they could barely see two yards ahead. After twenty-four hours, during which hospitals and doctors worked without pause to help those with respiratory diseases, the smog cleared and records show that no less than *four thousand people had died* from its effects!

The two major provisions of the Clean Air Act were the banning of the use of domestic coal in populated areas designated as 'smokeless', and regulations on the height and efficiency of factory chimneys. At first there was an outcry against this reduction of personal freedom in 'the Englishman's home' as well as predictable indignation from manufacturers at the expense of new chimneys. The results, however, were remarkably successful. There have been no more smogs, deaths from bronchitis have been reduced, buildings are cleaner and, for reasons which we will examine later, there is less corrosion of exposed stone and metal.

How would *you* decide in cases where there was a clash between claims for individual freedom of choice, and the good of the general public? Eg: coal fires, cigarette smoking, drinking-and-driving, nude sun-bathing.

SULPHUR DIOXIDE, THE ACID GAS

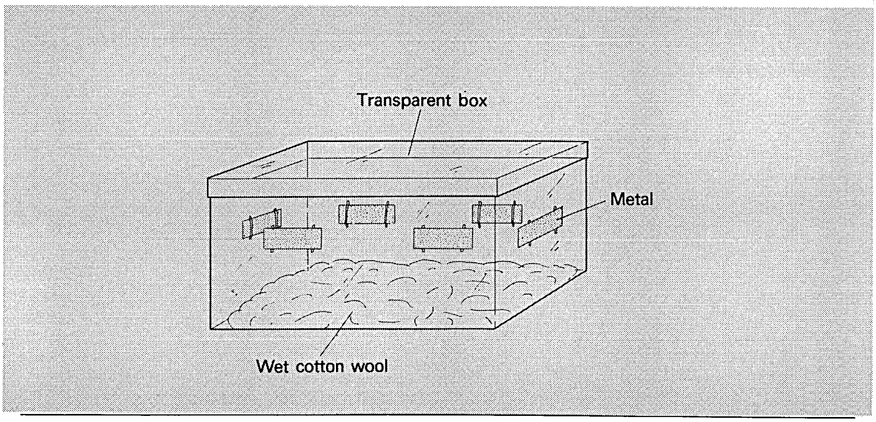
There is sulphur in coal, especially low grade coal, and in oil. When these are burnt it makes sulphur dioxide which is *invisible*. It is also made during several industrial processes. Even smokeless fuels, which can still be burnt in our homes, contain between 1 and 3% of sulphur. Sulphur dioxide dissolves in rain to form an acid and it is the chief cause of corrosion to metals and stonework in our cities. It also affects plant life so you can get some idea of how much of it there is around by looking for lichens which are specially sensitive to its presence. If there are patches of orange lichen on the stones in your area, the amount of acid sulphur dioxide cannot be very great. The high new chimneys of factories carry it away from ground level so the air in our towns is now less acid, even though the total quantity of sulphur dioxide released into the atmosphere trebled between the years 1950 and 1970.

The sulphur dioxide at these higher levels in the atmosphere travels considerable distances and comes down as 'acid rain'. This happens in countries like Canada and Sweden, and also in British regions of high rainfall such as the Lake District.

Acid rain damage to the nose and chin of a statue in Chicago.

There is little doubt that sulphur dioxide is bad for the health of those who suffer from bronchitis and asthma. It is also ironic that Britain imports almost exactly the same weight of sulphur each year as that which billows out from industrial works in this unwelcome form. What can be done while sulphur is still cheaper to import than to reclaim from smoke before it pollutes the air?

You can examine its effect on metals for yourself by lining the base of a transparent sandwich box with cotton wool soaked in a solution of sodium metabisulphate and fixing samples of different metals to the sides of the box with sticky tape. Set up a control box lined with wet cotton wool. Close and seal both boxes and watch the metal surfaces over the next week. Most people believe that it is wet air which causes corrosion; you may find the results of this experiment surprising.

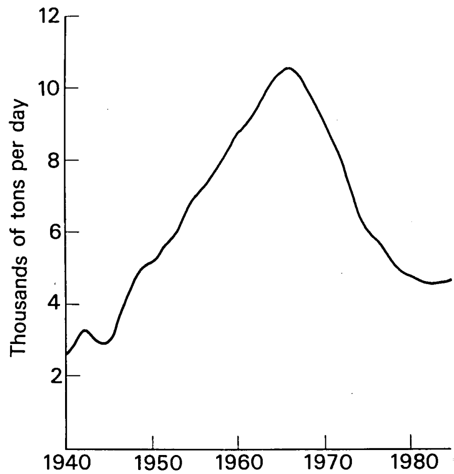


DANGER FROM CAR FUMES

The motor car is a special agent of pollution producing two highly dangerous gases. One of these, carbon monoxide, is deadly. It prevents our red blood cells from utilising oxygen and deaths following the running of a car engine in a closed garage are always due to the inhalation of this gas. It is made by the incomplete burning of petrol and can be much reduced by efficient tuning of the engine. Those who work in close quarters to starting and stopping traffic, like policemen, are most at risk. Control devices on the exhausts of cars were pioneered in the state of California and when legislation made them compulsory, the effect on the levels of carbon monoxide near main roads was immediate.

Tetraethyl lead is added to high octane petrol in order to improve its performance. It is well known that inhaling lead vapours can cause brain damage, especially to young children. Studies have shown both high lead levels in the air and also slightly lower than average IQ in children from areas near to motorway junctions. However, there are other reasons, apart from the lead fumes, which might account for this.

This whole subject is very controversial. Doubt has been cast on the statistics, and the experts differ in the advice that they give. Some legislation to reduce the lead content of petrol has been recently introduced. In America lead-free petrol can be bought at the pump station but it costs more than leaded petrol. Cars have to be specially modified to take this kind of petrol. How can you balance extra cost and extra fuel consumption, against the possibility, however small, that we might be making some kids slow-witted for life?

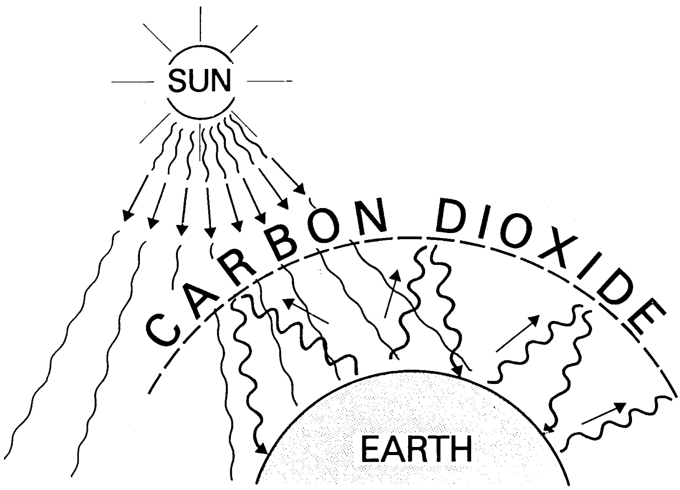


Emission of carbon-monoxide in Los Angeles, USA.

THE CASE OF CARBON DIOXIDE

We exhale this innocent gas with every breath. Burning fossil fuels makes more of it, but trees and vegetation can turn it back into oxygen. By cutting down forests and burning them we are increasing the atmospheric levels of this gas every year, even though some of it dissolves in the oceans.

Like the other gases in the air, carbon dioxide lets through the heat and light of the sun, but it is not so good at letting out the heat which the warm earth re-radiates back. It absorbs a great deal of this heat and then reflects it back to us. This 'greenhouse effect' is like the way glass can trap the heat of the sun in a greenhouse. The fear often expressed is that higher concentrations of carbon dioxide will make the global climate warmer. Perhaps this will make some of the polar ice caps melt and so raise the levels of the oceans. It may sound to you like science fiction but the calculations are quite sound. If we clear the sooty smoke from our air by Clean Air regulations, this invisible carbon dioxide will still remain. It could affect life in the sea, life on the land, as well as the temperature of our world.

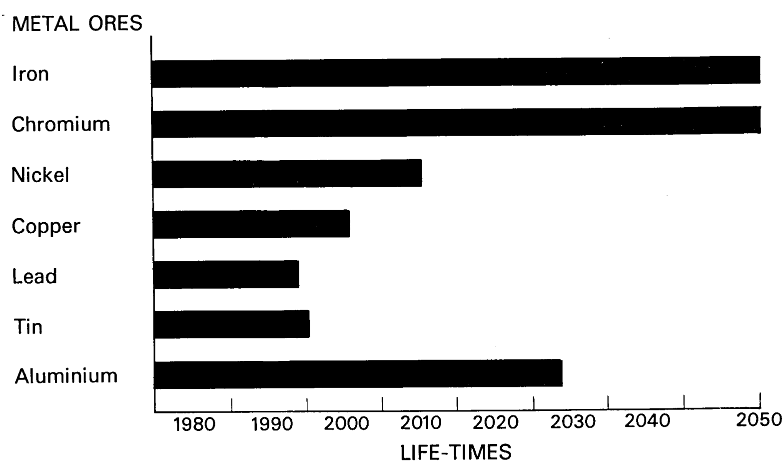


The greenhouse effect: carbon-dioxide absorbs a lot of the heat radiation from the earth and re-radiates it back to earth, which is very like the way glass can trap the heat of the sun in a greenhouse.

6 Where are we Now?

MINERAL AND FUEL RESOURCES

There is more to man's effect on his environment than his production of food and the disposal of his natural wastes. Because man is a 'tool-making animal' he has always extracted the materials that he needed from the land and discarded them after use. In Neolithic times the most valuable mineral resource was flint and the most extensive mines were at Grimes Graves in Norfolk. The curious humpy landscape there still bears witness to the large area of devastation that must have been produced, as one shaft after another was used up and then abandoned. We have the same problem of the disposal of manufacturing wastes and running out of natural resources, but to a far greater extent. Apart from fossil fuels our most valuable resources are the metal ores. Our whole way of living depends upon their use and although they are all around us they are a finite resource which is running out. In the forseeable future some of them may become very rare indeed.



Is the world running out of resources?

The chart shows the estimated lengths of time that the world's resources of these ores may last at the present rate of use. There are four factors which might change these deadlines:

1 New resources might be discovered.
2 Poorer ores, which are not economic to work at present prices, might come into use.
3 If the price goes up we may have to find ways to use less.
4 We might recycle more scrap metal.

All these possibilities present challenges to develop new technologies and to adopt new ways of living.

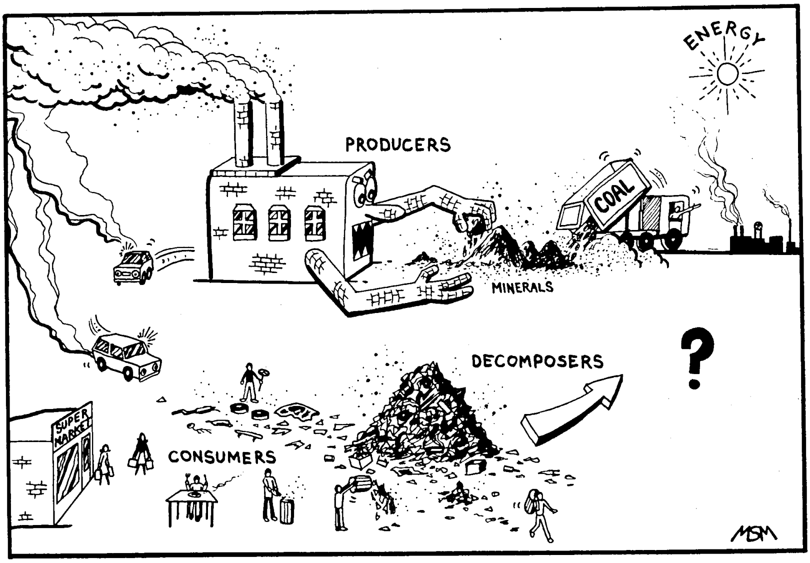
In the case of our supplies of *fossil fuels* the situation may be even more urgent. We use these fuels to obtain *energy* for transport, for industry, and for heat and power in the home. The shortage and the price of these fuels affects our living in all these different ways and, in the future, may change many activities which we now take for granted.

Petroleum oil reserves . . . may last 30 years
Natural gas reserves . . . may last 50 years
Coal reserves . . . may last 300 years
Uranium ores . . . may last 30 years (much longer with new types of reactors)

You will probably know that scientists are trying to develop new technologies to obtain the energy that we so desperately need from the 'renewable' sources which cannot run out: sun, wind and waves. Once again our style of living will depend upon the technology that we are able to use (see the book *Energy: the Power to Work* in this series).

RECYCLING PROBLEMS

In natural ecological systems we have complete cycles of use where decomposers process the dead organic material into forms in which it can be used again. In doing this the organisms gain energy. Unfortunately there are no such organisms available to close up the loop in the mineral world; man not only has to do his own recycling, he also has to put some of his valuable energy resources into the process if he wishes to reclaim the material.



There are three main reasons why a new attitude towards our mineral resources is necessary:

1 growing scarcity of rich deposits;
2 saving on the cost of imports;
3 spoiling the aspect of the environment.

Take each of the following commodities in turn and say why you think that a more economical use of it would be valuable to our society: glass, plastics, steel, paper, lead.

To avoid wasting our precious natural resources we have to look critically at several different parts of our complicated society.

Manufacturers: Are they deliberately turning out items which have a very short time of use, 'inbuilt obsolescence'? Do they use the lower purity recycled materials where it is possible?

The packers: Do we need the elaborate packaging that is often provided? Recycled glass is usually coloured; what about tomato ketchup in brown bottles?

Us, the consuming public: Are we prepared to use our clothes and cars until they are worn, or do we want to follow changing fashions? Are we ready to return empty bottles and sort out our waste so that paper, aluminium, tin cans and plastics can all be collected separately?

The government: Will it finance research into recycling processes? New methods are needed for separating tin from steel in tin cans, for sorting out the different kinds of plastic and for removing all the copper components from derelict motor cars (scrap steel must have less than 0.15% copper in order to be useful). Fluctuations in the world price of wood pulp for papermaking hit hard at the enterprises for collecting and recycling paper. Since most paper finishes up as rubbish which the local authorities have to collect and dispose of, should they contribute to the cost of recycling?

HOMES IN THE CROWDED CITY

Towards the end of the last century a new building material – reinforced concrete – came into use. The principle is to cast concrete (which is strong under compression) in a network of steel rods (which are strong under tension). As cements improved and methods of pre-stressing the steel developed (in order to compress the concrete when set) a new housing form became possible, the skyscraper block of flats or offices.

Twentieth-century town planners were determined to do better than the Victorian builders of the slums. They set up new standards of ventilation and sanitation for all dwellings, planned 'green belts' where no building could take place around the big cities, and stopped ribbon development along inter-city roads. By the late 1950s, however, the planners were faced with an appalling housing problem. Wartime bombing, vigorous slum clearance (in one year alone more than 64,000 houses were condemned and demolished) and an unexpected increase in the urban population, meant that about three million people needed new homes within the restrictions of the green belts. The solution seemed to lie with the high-rise blocks of flats made possible by new building technology.

The results have not always been happy. Many residents were depressed by the new style of living, especially those with young families. Vandalism has made the lifts and amenities of some blocks almost unusable; some blocks of flats remained half unoccupied, others have had to be demolished. Only the luxury tower blocks have been a success.

What is the reason? Did the occupants want to move?
What are the disadvantages of high-rise living?
How can the social scientists help us to understand this problem?

THE IMPACT OF NEW TECHNOLOGIES

It is easy enough to hope for new advances in science that will provide us with 'miracle cures' for all our problems, but the truth is that every new technology alters our way of living in our environment, brings us benefits and also new social problems for us to sort out.

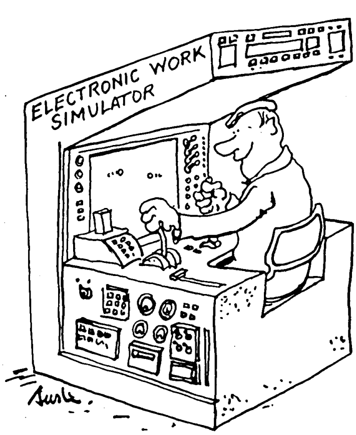
Trade unionists march in protest against the closure of The Times newspaper in 1978. In 1982 the same battle was being fought.

The 'microelectronics revolution', for example, has brought us many advantages; we can now communicate by satellite all round the globe: in medicine we can 'scan' the whole body, outside and inside, without cutting the skin, to detect any centres of trouble; we can also insert tiny electronic pacemakers to regulate the heart beat and prolong life.

We can also automate our factories to control the products to a higher standard than ever before, and to eliminate much of the routine labour involved. But eliminating work means a loss of jobs which, whether by sacking or by voluntary retirement, means more unemployment. It is little wonder then that the introduction of 'new technology' is considered a mixed blessing by many workers and their unions. The newspaper business has been torn by strikes and disputes ever since the issue was first raised. Cheaper newspapers are no consolation to those who lose their livelihood, but would keeping old-fashioned technology safeguard it any better?

Microelectronic computers can store incredible amounts of information in a tiny space, sort it out, and process it as we want it. They can be used in a variety of ways – to improve our education, to enable us to work or shop from our homes, to help the police track down criminals (or keep files on all of us!), or to replace office workers.

It is almost certain that many traditional kinds of jobs will disappear. Could we also use these computers to help us enjoy our leisure, for fun, for knowledge, for art, for sport, or for sociability? Technology arises from our needs and our inventiveness; how a society uses it is a reflection of its beliefs about the quality of life.



Suggested Reading

Rings of Stone A. Burl (Francis Lincoln)

A modern 'coffee-table' book with beautiful photographs and a fairly balanced account of evidence and theories (of which there have been plenty!).

The Origins of Astrology Jack Lindsay (Muller)

An authoritative book, not new, but well written and should prove fascinating to those with a taste for ancient Astrology and its development.

Technology and Survival E. Braun, D. Collingridge (Butterworth)

This is a small, cheap paperback written by SISCON authors for first year undergraduates. Nevertheless it is fairly simple to read, contains plenty of data including the 'limits to growth' debate, and questions on each chapter.

The Man-made Future C. H. Waddington (Croom Helm)

The school library needs this. It contains chapters on almost every aspect of contemporary concern including planning towns of the future and ways with rubbish disposal.

Guide to the Study of Environmental Pollution William Andrews (Prentice-Hall)

It is not difficult to find books on pollution which take an ecological standpoint. This is one which is fairly well illustrated and interesting, but more for the adult than the pupil.

Material Gains Christine Thomas (Earth Resources Research)

Too dense for bedtime reading but packed with information on every aspect of recycling which would be very hard to find elsewhere.

The Pollution Handbook R. Mabey (Penguin)

A small practical book addressed to school children and full of ideas for experiments. Plentiful illustrations.

Talking about the Environment Andrew MacKillop (Wayland)

This is one in a whole series of books designed to start discussion by quoting from both sides in all the arguments. It is very well illustrated and easy to read. Specially useful on the quality of life in the urban environment, recreation, vandalism and town planning.

Science In a Social CONtext is a series of eight books based on the project SISCON-in-Schools. The books provide a new course in science and society for general studies at sixth-form level. The course has been specially designed to make scientific problems accessible to the non-scientist, as well as to explain the social aspects of science to the scientist.

Ways of Living looks at the interaction between people and their environment and the effects of science and technology on the way we live and think.

The eight titles are as follows:

Ways of Living
How Can We Be Sure?
Technology, Invention and Industry
Evolution and the Human Population
The Atomic Bomb
Energy: the Power to Work
Health, Food and Population
Space, Cosmology and Fiction

Science In a Social CONtext
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