A Leaf in Time

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illustrated by Mic Rolph

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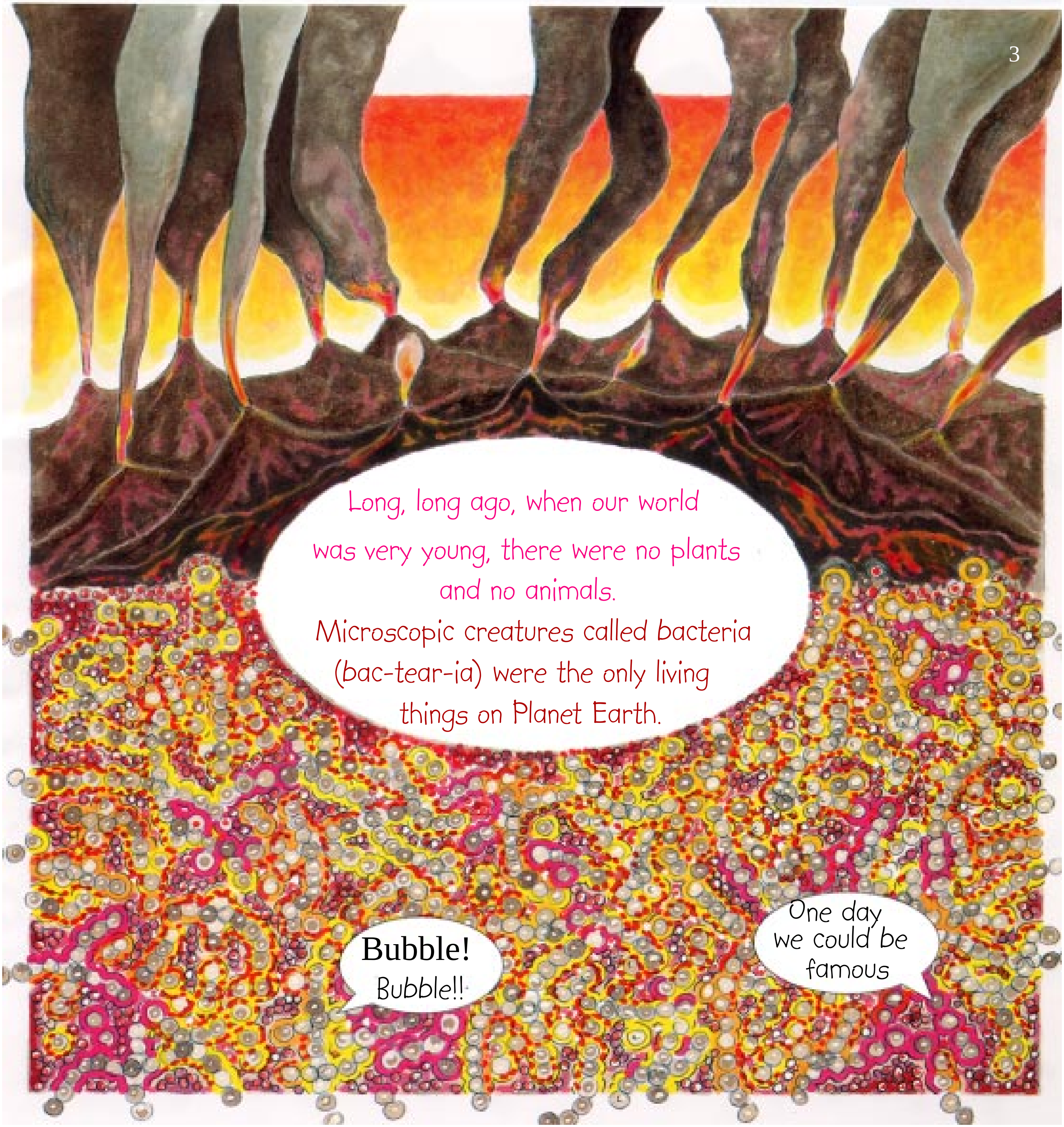
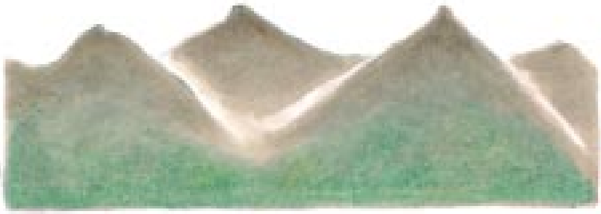
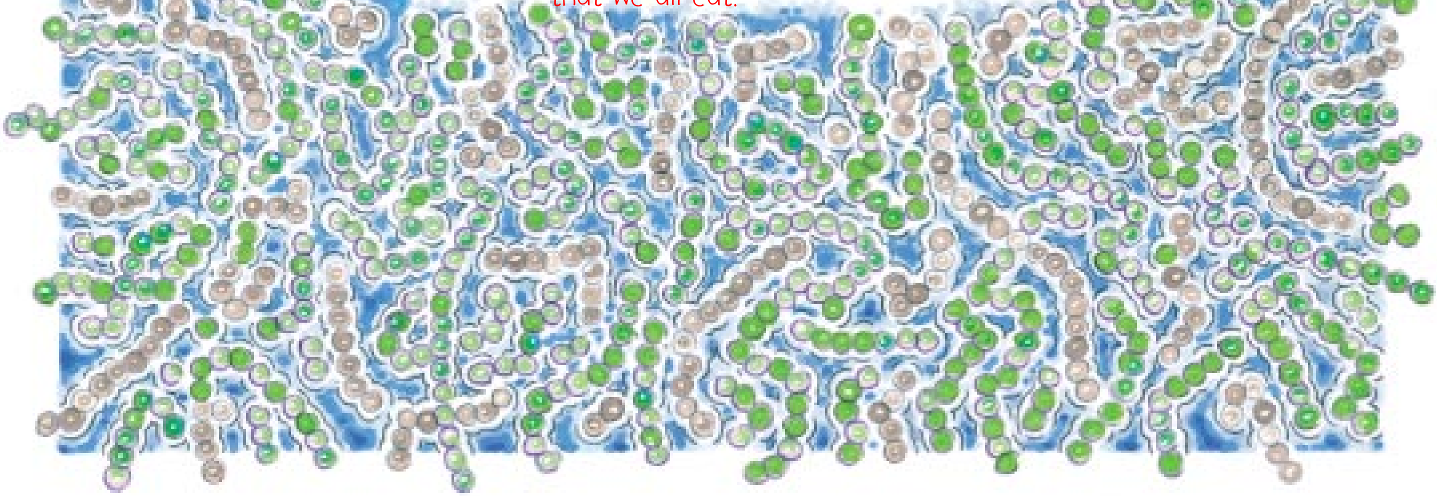


Long, long ago, when our world was very young, there were no plants and no animals.
Microscopic creatures called *bacteria* (bac-tear-ia) were the only living things on Planet Earth.



Then, and no one knows quite how, some of the bacteria began to turn bluish green . Every time the Sun shone on them they made a *very* important gas called oxygen . During the next *one thousand million* years the oxygen built up in the air arond the planet. Once there was enough oxygen, many strange and wonderful plants and animals appeared. Then they started to lilive on the land.

The blue green bacteria were called cyano(sigh-an-oh)bacteria. They were the very first plants. Ever since then, green plants have been making oxygen so that we could all breathe. Not only that, they have been making the food that we all eat.

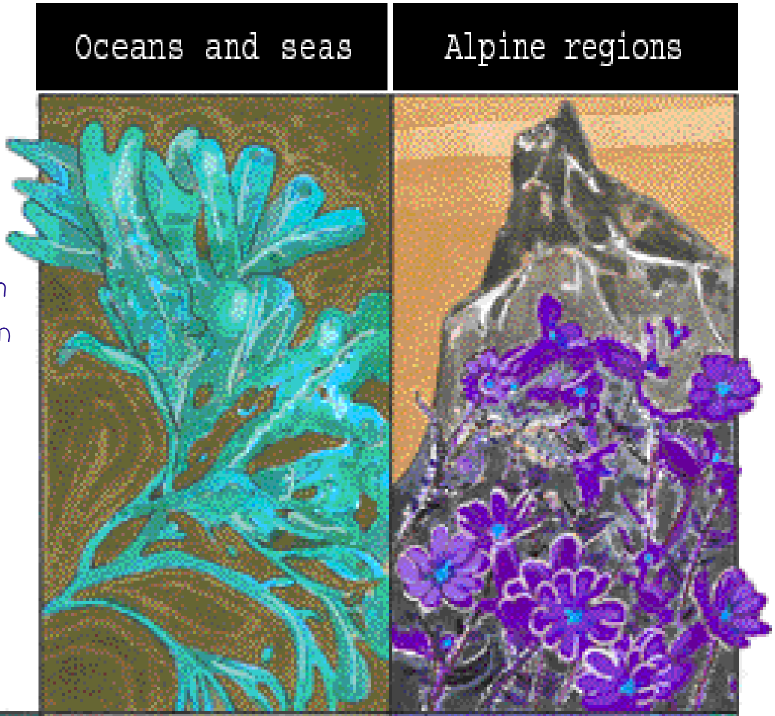


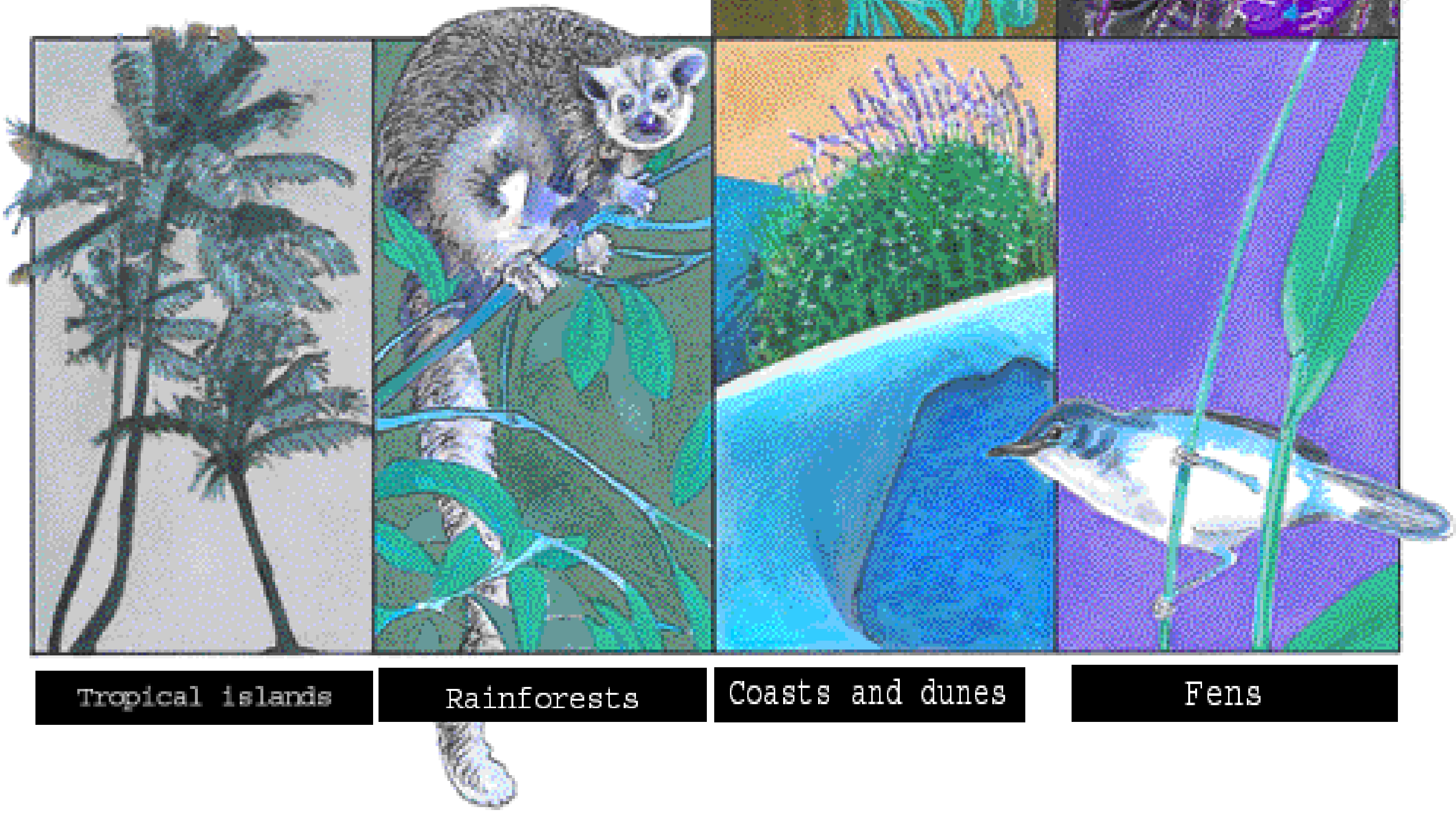
Plants feed all creatures, great and small. Plants made food for the first insects and reptiles. Much later they did it for the dinosaurs. Long after the dinosaurs became extinct, plants fed the first humans, and they still feed us today.

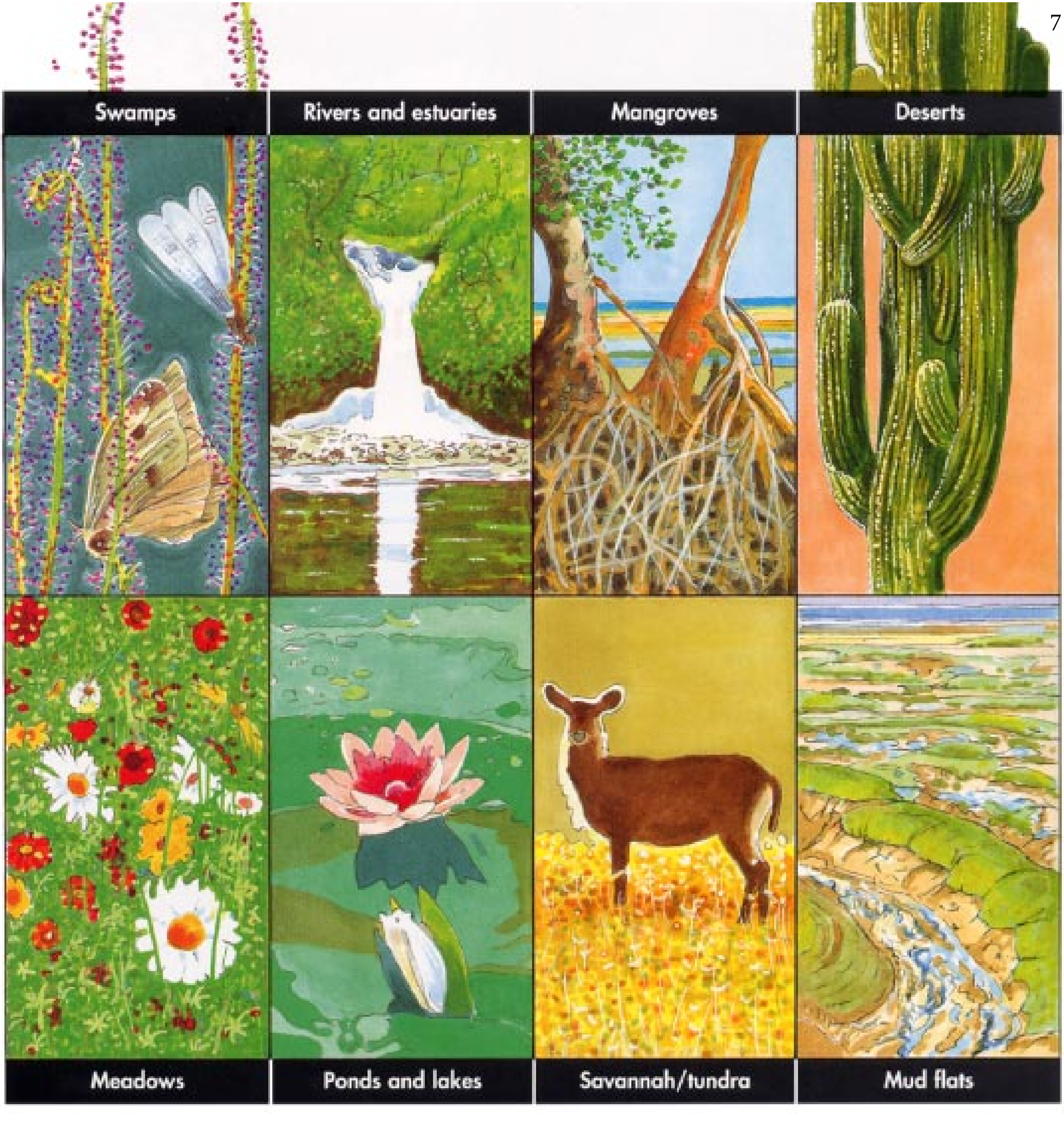
But who, or what, feeds the plants?

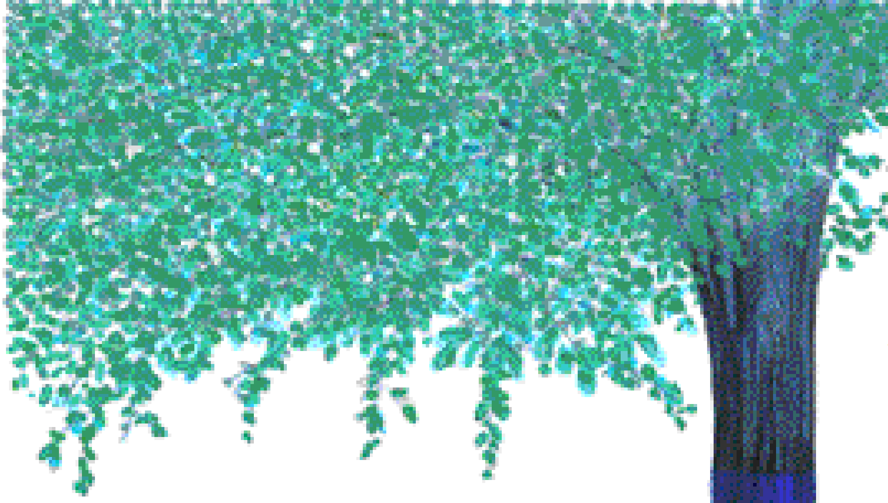
Gardeners and farmers like to think that they feed their plants, but they don't really– at least not very much. Plants live mostly on water, air and sunshine! In forests, plants and trees grow wild without help from humans, as they have always done. On farms and in gardens, plants get a little help from their friends – they need some minerals to replace those that are lost when humans take away crops to eat.

Here are some of the diverse places in which plants can survive.



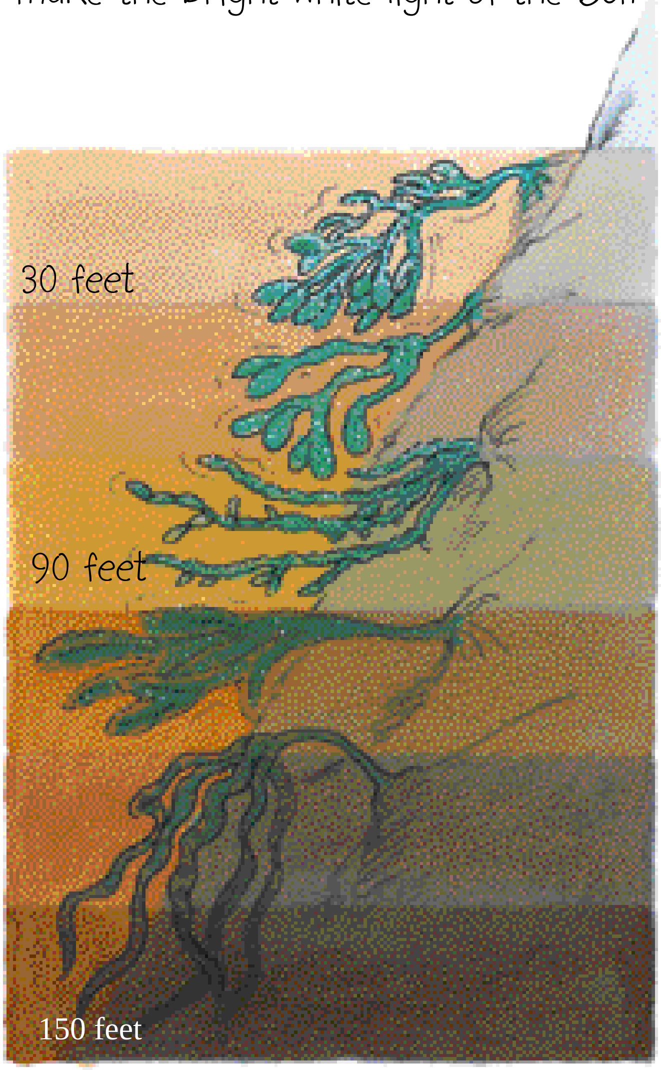



Swamps
Rivers and estuaries
Mangroves
Deserts
Meadows
Ponds and lakes
Savannah/tundra
Mud flats



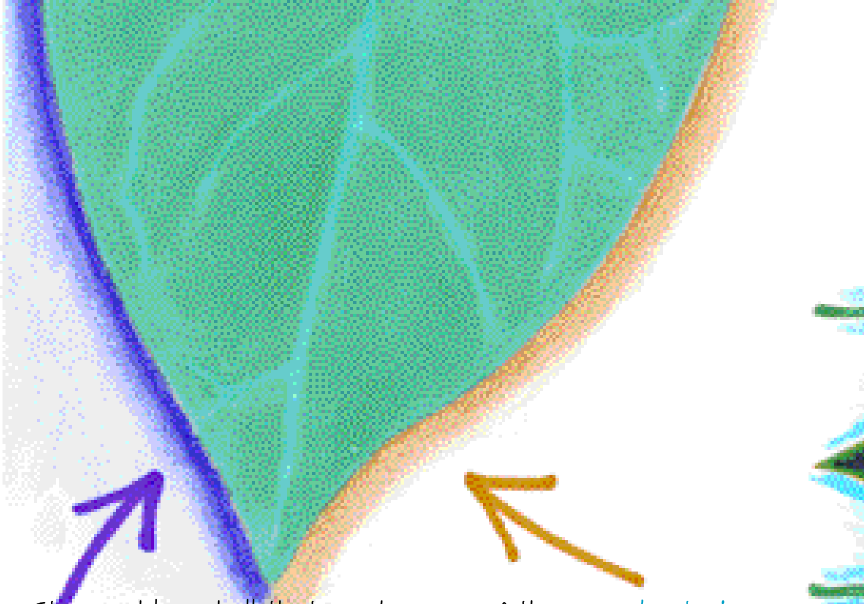
Sunlight is light energy. It is made of a mixture of light waves of all the colours of the rainbow (red, orange, yellow, green, blue, indigo and violet), which are jumbled together to make the bright white light of the Sun

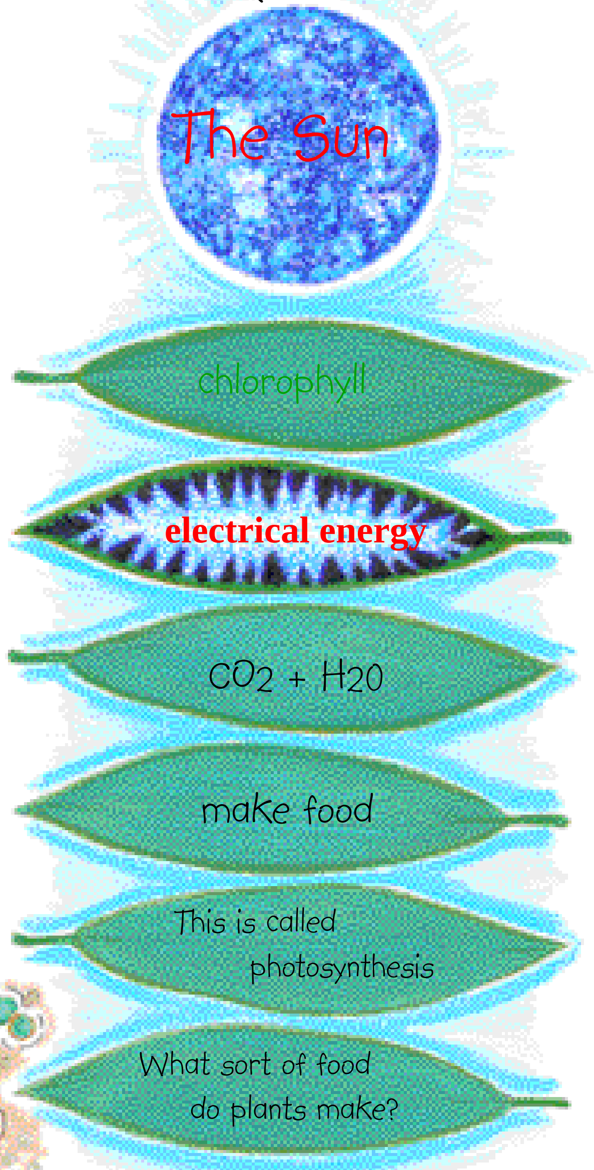
To make food for themselves and other living creatures, green plants use a gas called carbon dioxide (CO_2). This gas is present in very small amounts (about one part in three thousand) in the air that we breathe and is also dissolved in water (H_2O). As long as plants have water and light, they can use carbon dioxide to make leaves, flowers, fruit, wood or seaweed.



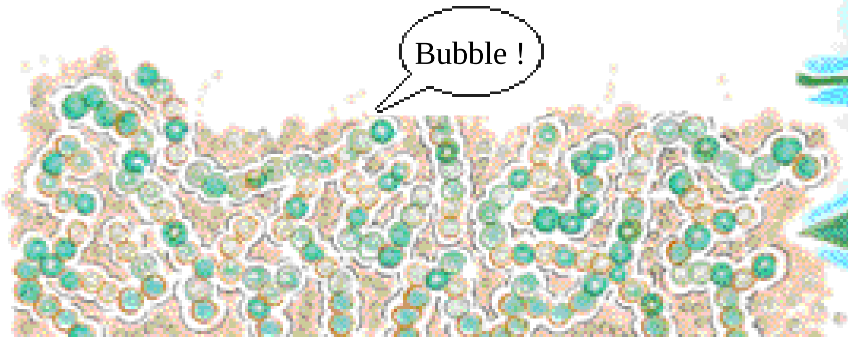
Leaves contain a special green substance called chlorophyll (chlor-oh-fill). Chlorophyll is very good at absorbing red and blue light waves of sunlight but it absorbs very little green light. This is why leaves look green - because we see nothing but the green light that they absorb least and reflect most.

Chlorophyll absorbs light energy and converts it into electrical energy. Leaves then use the electricity to make food from carbon dioxide (CO_2) and water (H_2O). This process is called photosynthesis (foe-toe-sin-thess-iss).





It was chlorophyll that made some of the cyanobacteria of primitive Earth turn bluish green. It is chlorophyll that makes leaves look green today.



First of all, green plants make carbohydrates (car-bo-hide-rates), which contain carbon, hydrogen and oxygen. The carbon and oxygen come from carbon dioxide gas (CO_2). The hydrogen comes from water (H_2O). Starch, from potatoes and sugar, from sugar cane, are types of carbohydrate.

Let's look at a leaf and see how, and where, photosynthesis happens. Inside the cells that make each leaf there are millions and millions of tiny particles called

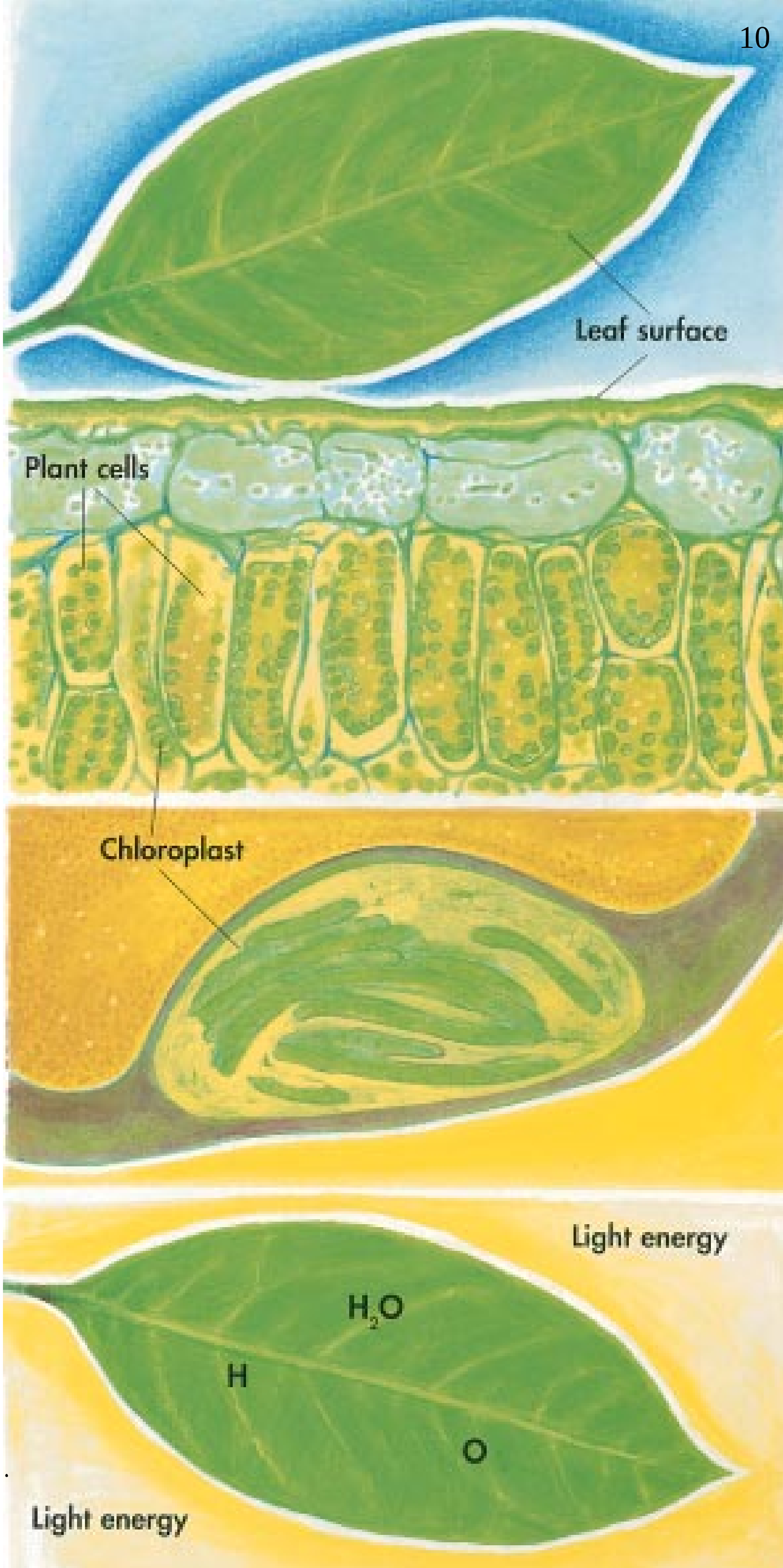
chloroplasts (cloroh-plasts).

There are as many chloroplasts in a leaf, the size of your hand, as there are people in the world.

Each chloroplast is like a tiny, living machine. It contains chlorophyll and it makes food for the plant (and often for us too!).

Chloroplasts originally came from cyanobacteria that started to live inside larger and more complicated bacteria; they made food for those bacteria in return for a home.

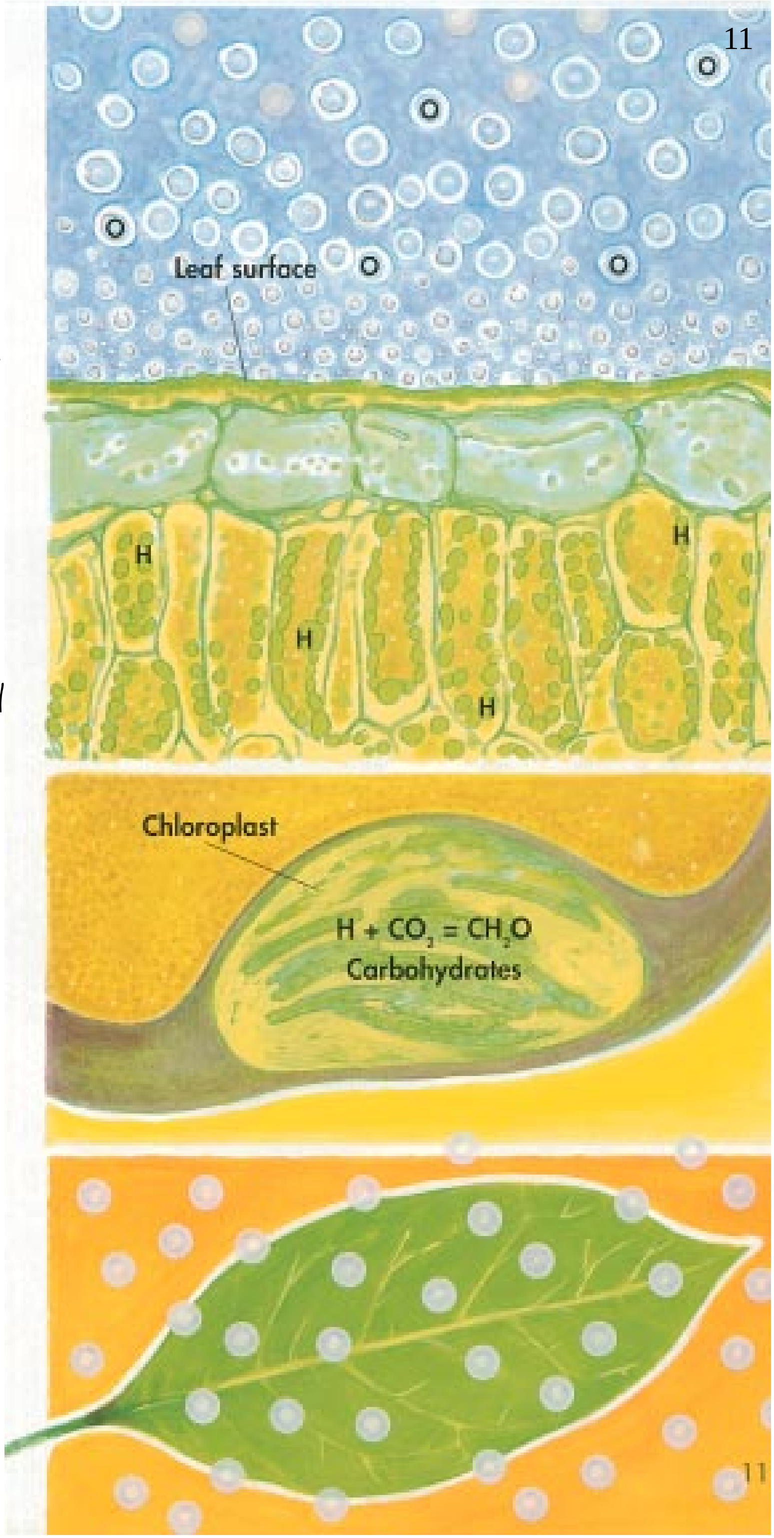
In photosynthesis, chorophyll absorbs light energy. This energy is then used to split water (H_2O) into hydrogen (H) and oxygen (O).



The oxygen (O) gas, which is madewhen water is split, escapes through tiny holes in the leaf that you can only *see* with a micro-scope. Hydrogen (H) is also a gas but, during photosynthesis, it is never allowed to escape.

Instead, the hydrogen (H) is kept inside chloroplasts by special *substances* which hold on to it tightly. They pass it from one chemical to another but never let it escape. In the end, hydrogen (H) joins to carbon dioxide (CO_2) inside the leaf tomake carbohydrates (CH_2O).

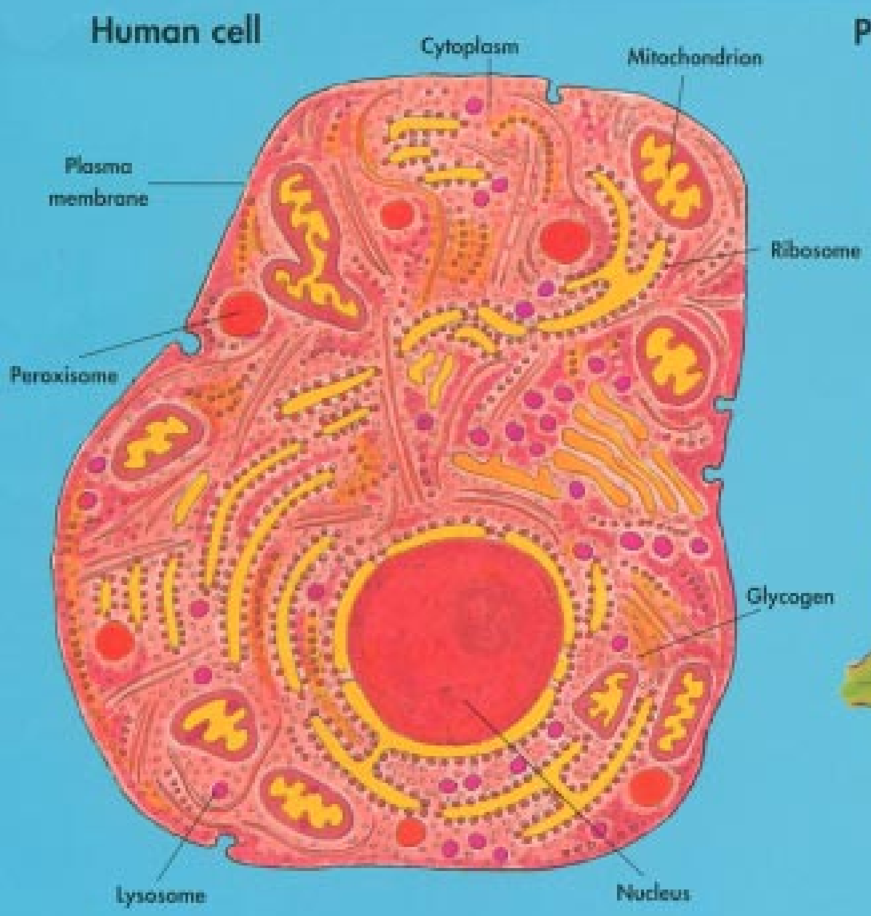
All you really have to remember is that green leaves use energy from sunlight to make carbo-hydrates and oxygen from carbon dioxide (CO_2) and water (H_2O).



So, when a plant makes a carbohy
drate, from carbon dioxide and water, oxy
gen is left over. This is the Oxygen which
we and other animals breathe, the oxygen
we need for life. Without photosynthesis,
the huge variety of life on our planet would
never have
developed.

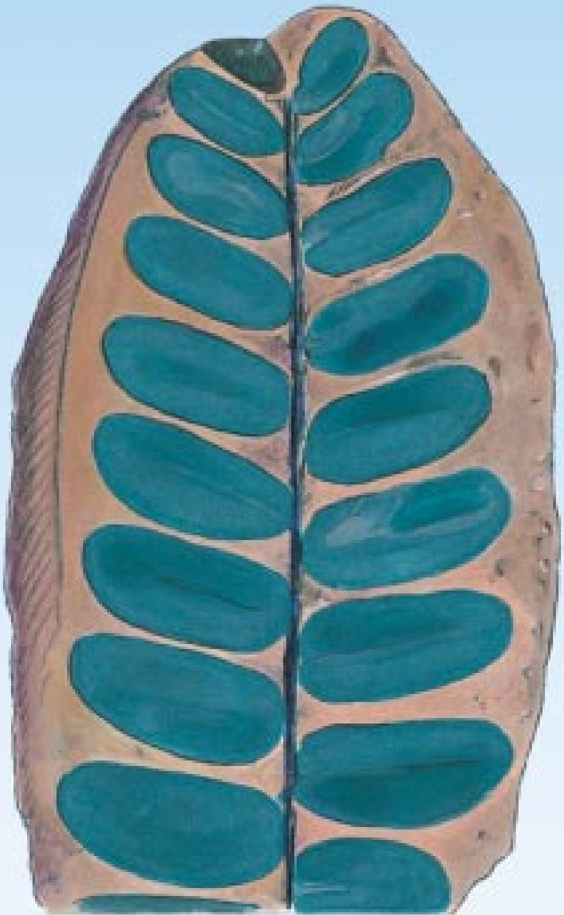
Plants can also make proteins (proteens). You might think of proteins as being meat and eggs, but the cells that make up plants and animals have lots of proteins in them. Just as modern machines are mostly made of metal and plastic, living cells are mostly made of proteins. Proteins help to make cells the shape and size they are. Without proteins, cells could not do all the different jobs they have to do.

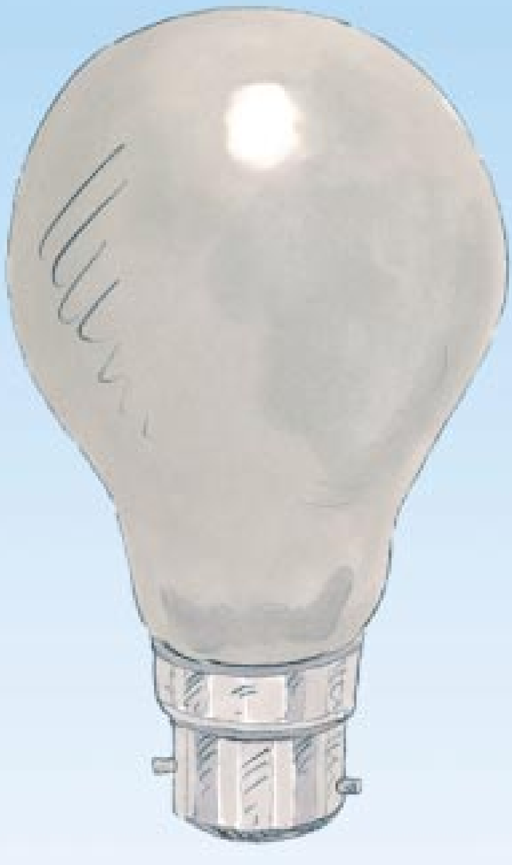
This is why plants cannot live entirely on air and water. When they use carbon dioxide, water and light energy to make proteins they also have to add other minerals, such as nitrogen, from the soil. Sometimes these elements come from chemicals or organic fertilizers put into the soil by farmers and gardeners.



Making food is a way of storing energy. Some of the energy stored during photosynthesis has stayed unused on our planet for millions of years. Even today, dead plants in marshes give off a gas called methane (natural gas) as they turn into peat. Back in the days of the dinosaurs (and before) dead plants also became buried in the ground. As millions of years went by, they gradually turned into fossil fuels, such as coal, and the natural gas and oil which we get from oil wells. You can sometimes find plant fossils in coal.

Fossil fuels are used to make all sorts of things, like plastics and the different kinds of gasoline which power cars and aircraft. They are used to drive turbines that make electricity. At the flick of a switch, electricity is made to provide light. So, humans have invented machines that do the opposite to plants: machines that turn chemical energy into electrical energy and then into light!





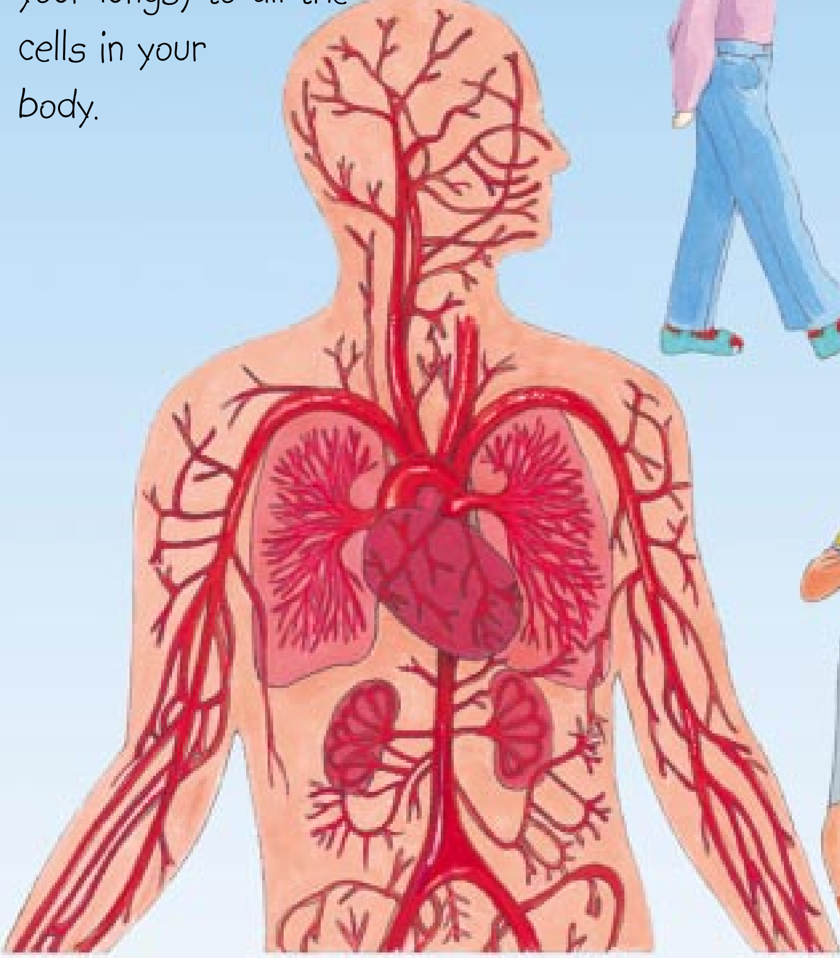
Fossil fuels are mostly made of hydrogen and carbon. When we burn them to warm our homes or drive machinery, the carbon and hydrogen are combined with oxygen from the air. Carbon dioxide (CO_2) and water (H_2O) are made and energy is released as heat, or light, or movement.

So, all of this energy really comes from the Sun. Plants captured it in photosynthesis many hundreds of millions of years ago, just as they do today.

Every time you eat, you also join oxygen which you breathe in, to the carbon and hydrogen in your food. Of course, you don't make fires inside you but you do get heat and other sorts of energy!

First of all you digest food in your stomach and intestine. Digestion breaks food down into smaller and simpler substances which pass into the blood-stream. Your blood carries them (together with oxygen from your lungs) to all the cells in your body.

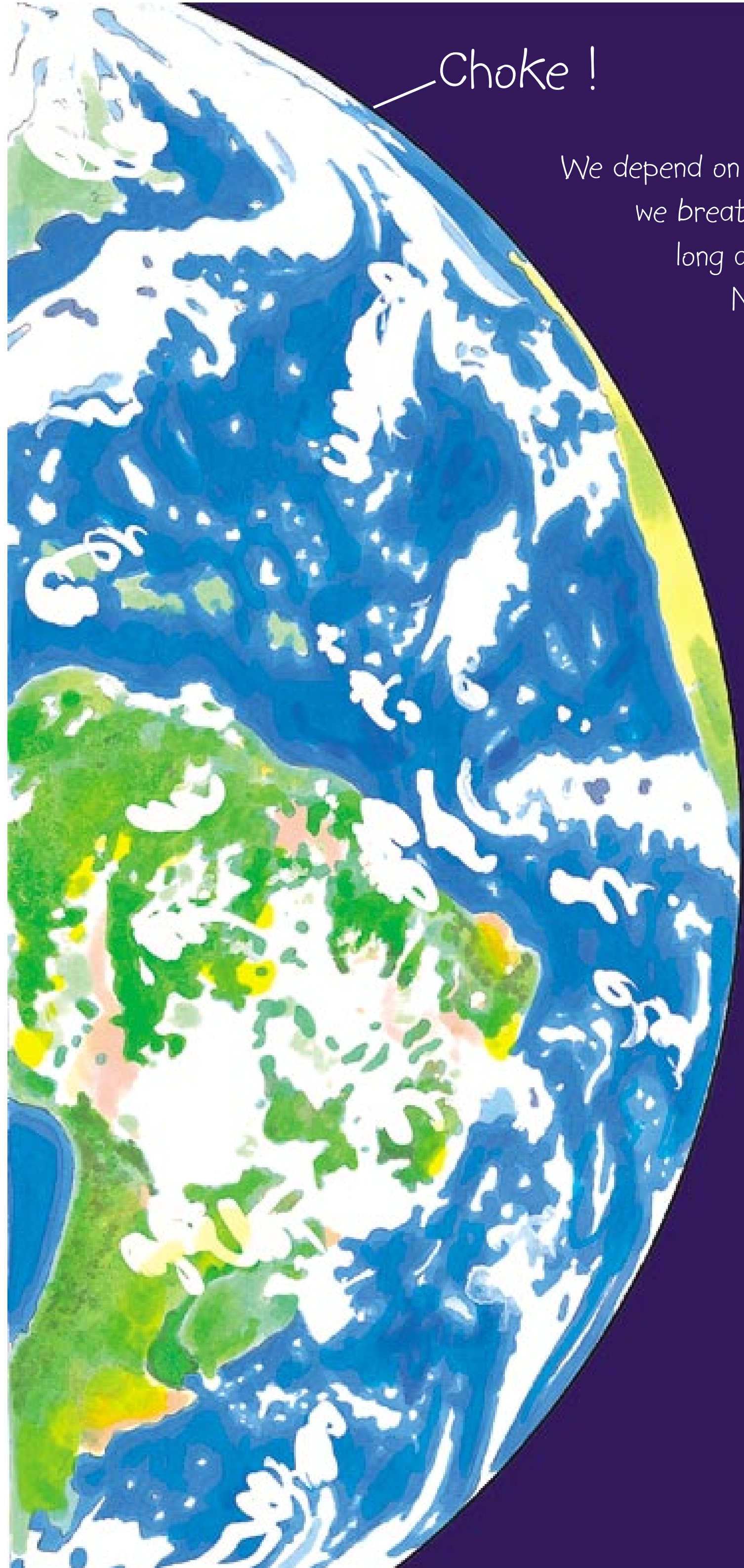
Every cell in your body can join carbon and hydrogen in food to oxygen, bit by bit. It is a kind of burning but not as fierce as when you put a log on a fire. This kind of biological burning is called respiration (ress-per-ay-shun). Respiration gives you energy to walk and run and to keep you warm and alive This energy lets you cells multiply, so that you can grow..



When you breathe out, you return carbon dioxide and water to the air. (You can see the water in your breathon a cold day, or if you breathe out on to a mirror.)

Plants also respire, and at night they take in oxygen and give off carbon dioxide just like you. However, when the Sun rises, photosynthesis starts, and the green plants on the land and in the sea quickly turn this carbon dioxide and water back into carbohydrates.

In bright light, photosynthesis is much faster than leaf respiration. This means that carbon dioxide is taken in and oxygen given off. This is just as well. What would we do for food to eat and oxygen to breathe if photosynthesis didn't work so quickly when the Sun shines brightly?



We depend on past and present photosynthesis for the air that we breathe and the food that we eat. Photosynthesis from long ago has given us coal, oil and gas. Now that there are more humans on the planet than ever before we are using more and more fossil fuels. People used to walk or have horses to ride and to pull their ploughs and wagons. Now, most of us depend on some sort of machine for most everything that we do.

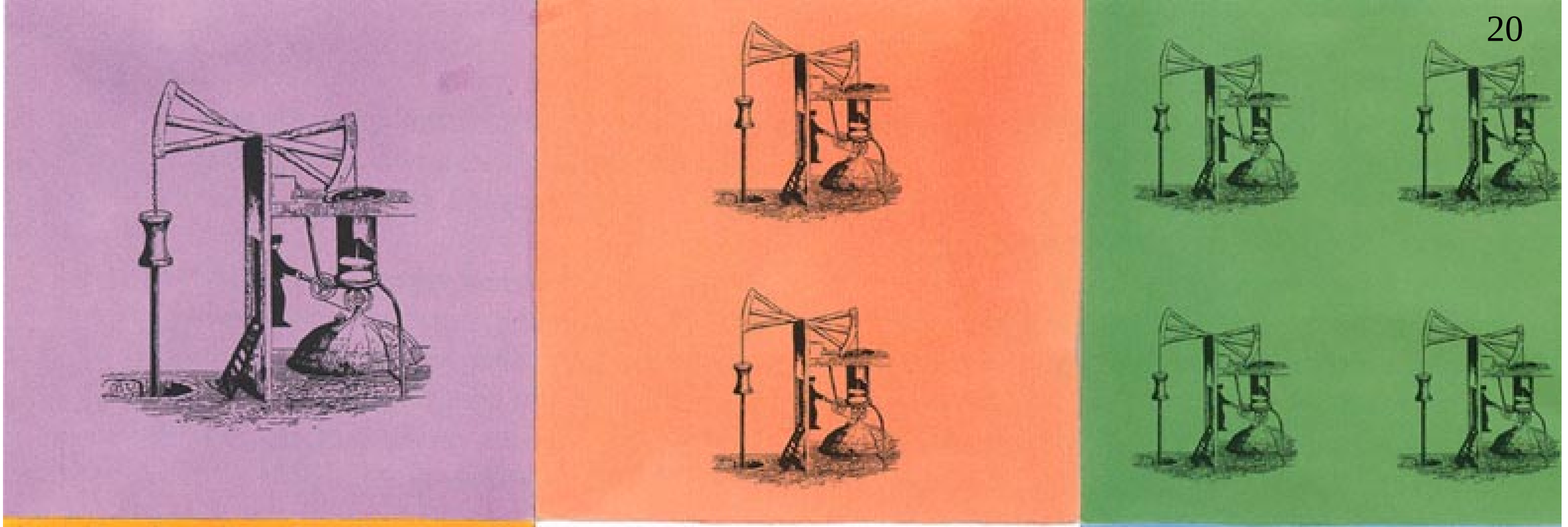
Fossil fuels are used to make nearly all these machines , as well as to run them.

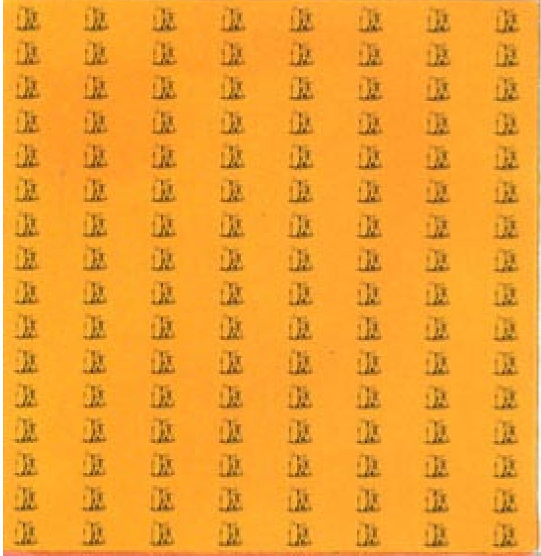
This means that human beings are now putting carbon dioxide back into the air more quickly than the plants can take it out again.

This is becoming a big, big problem!

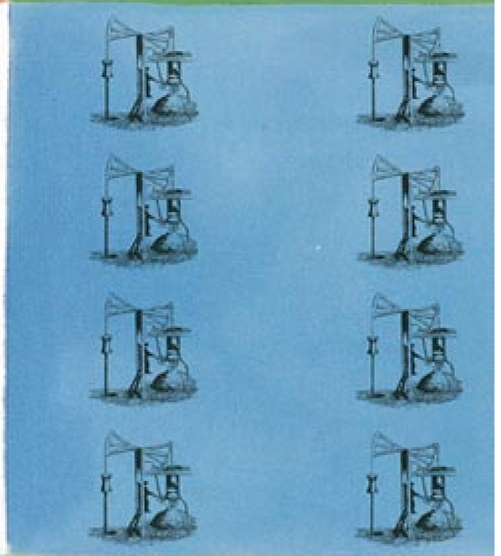
It all started when humans began to make more iron. Long before there were any people or plants, there was a great deal of iron metal in the ground. When the first cyanobacteria started to make oxygen, the iron turned rusty. This is why you can often see red soil and red stone. In some places, there is so much iron rust in the rock that it is called iron ore. People have been turning this ore back into iron metal for hundreds of years. (Perhaps they discovered how to do this when they found bits of iron in places where they had lit a fire.)

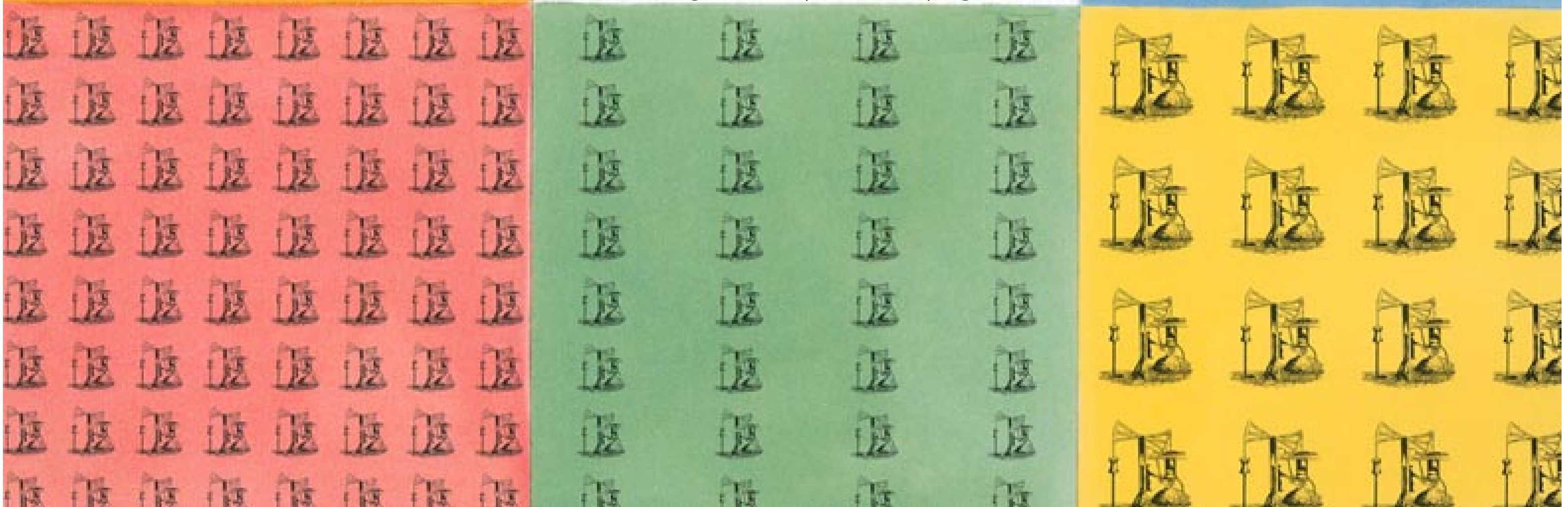
Later on, iron was made by heating iron ore in charcoal fires. This was called smelting. Huge piles of wood were allowed to smoulder slowly to form charcoal, which is mostly carbon (C). This was then heated with iron ore until the oxygen in the ore joined to the carbon. This made carbon dioxide (CO_2), and the iron became metal again. For a long time, people used only small amounts of iron for arrows, spears and tools.



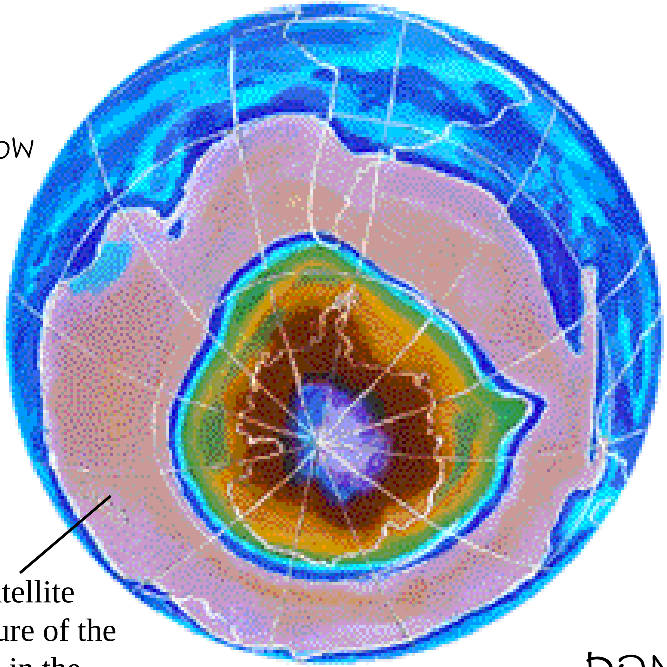


This amount of smelting did not release a llot of carbon dioxide (CO_2). What caused the problem was when humans started to invent new machines in the early nineteenth century. For example, steam engines needed coal to make them work and so carbon dioxide was released. Steam engines also made it easier to make more iron and more steam driven machines.



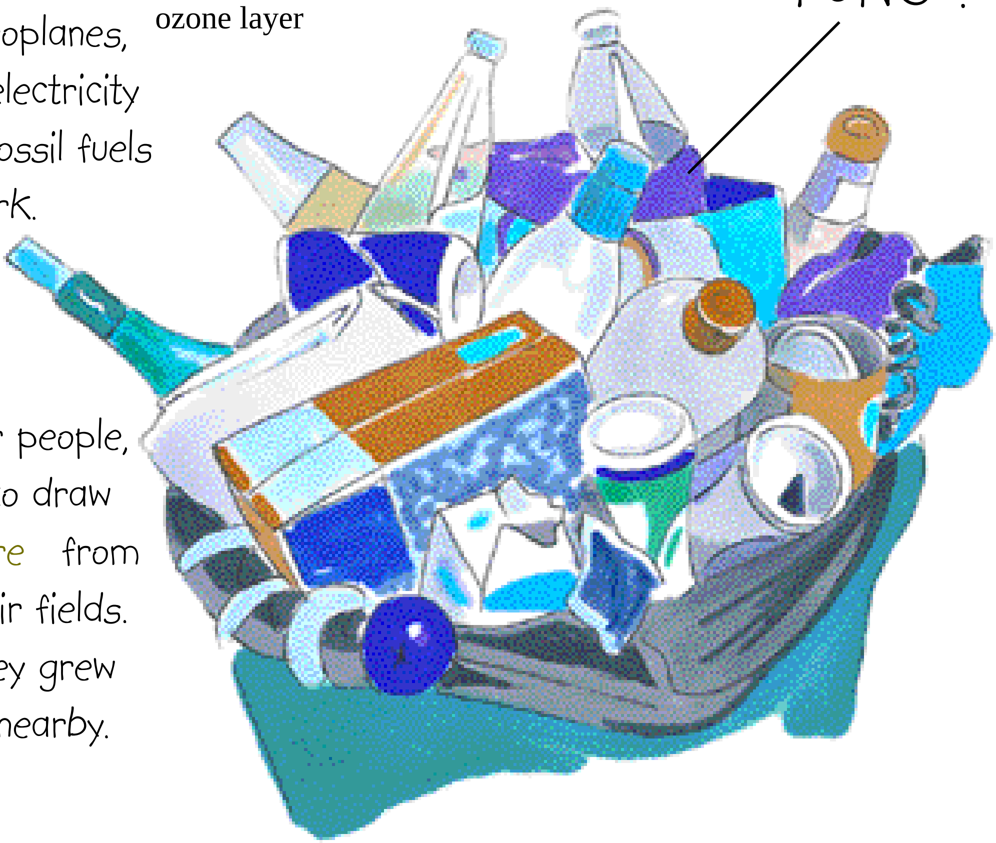


Farm machines made it possible to grow more food. More food made it possible to feed more people. More people made more machines. More machines produced even more carbon dioxide.



A satellite picture of the hole in the ozone layer

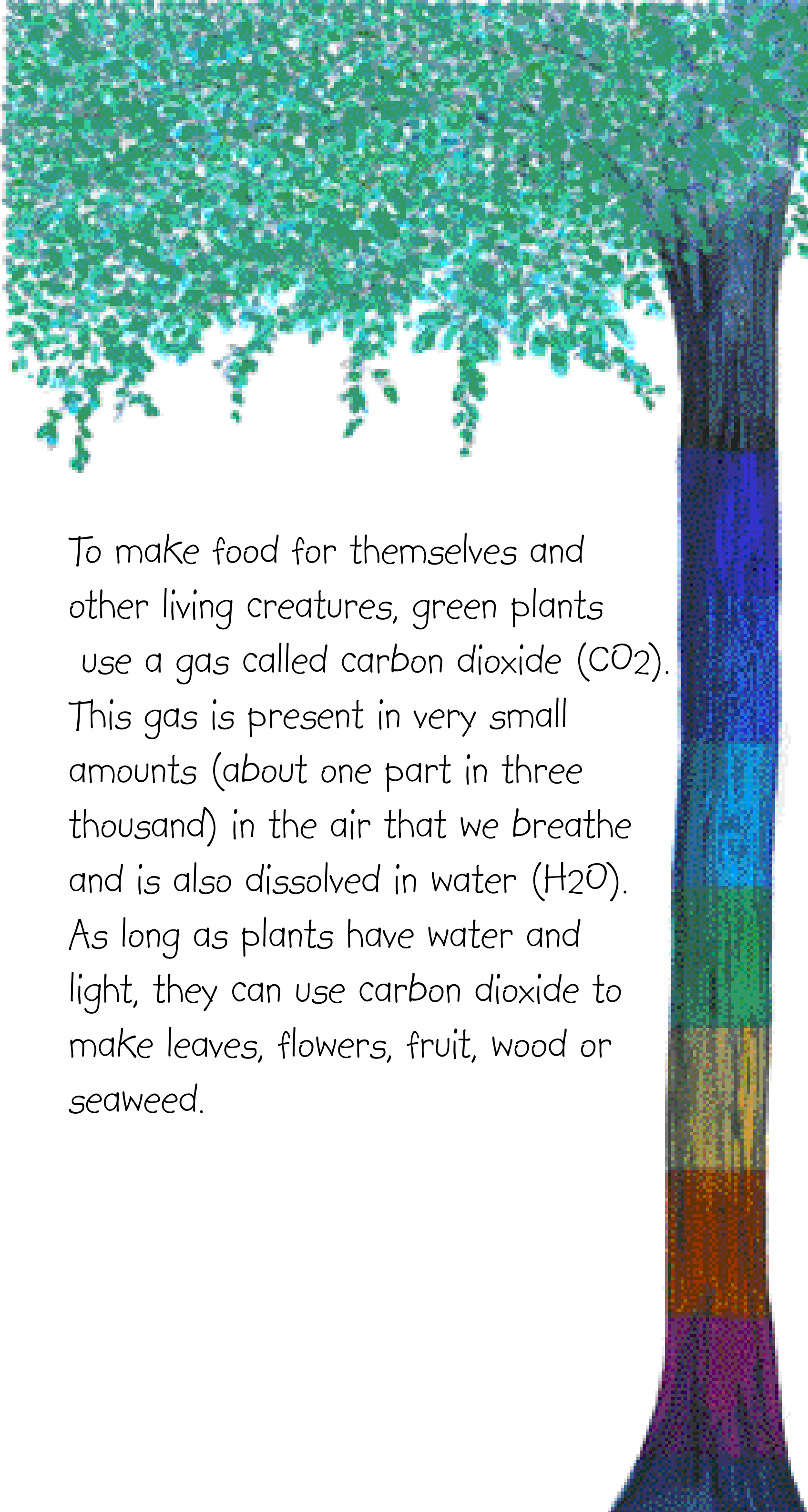
Not many machines use coal today, but our cars, aeroplanes, trains and most of our electricity generators need other fossil fuels to make them work.



When there were fewer people, farmers used horses to draw ploughs. They put manure from horses and cows on their fields. Then they ate what they grew or took it to markets nearby.

Two hundred years ago, there were fewer than four million people in the United States of America. Today there are fifty times more. One third of the fossil fuel burned there is used to make electricity. One third is used by automobiles aircraft, boats and ships. The rest is used in homes, offices and factories. All of this makes about 18 tons of carbon dioxide per year for every person in the USA. Poorer countries produce less carbon dioxide but, if they get richer, they make more.

North America at night
as seen from space



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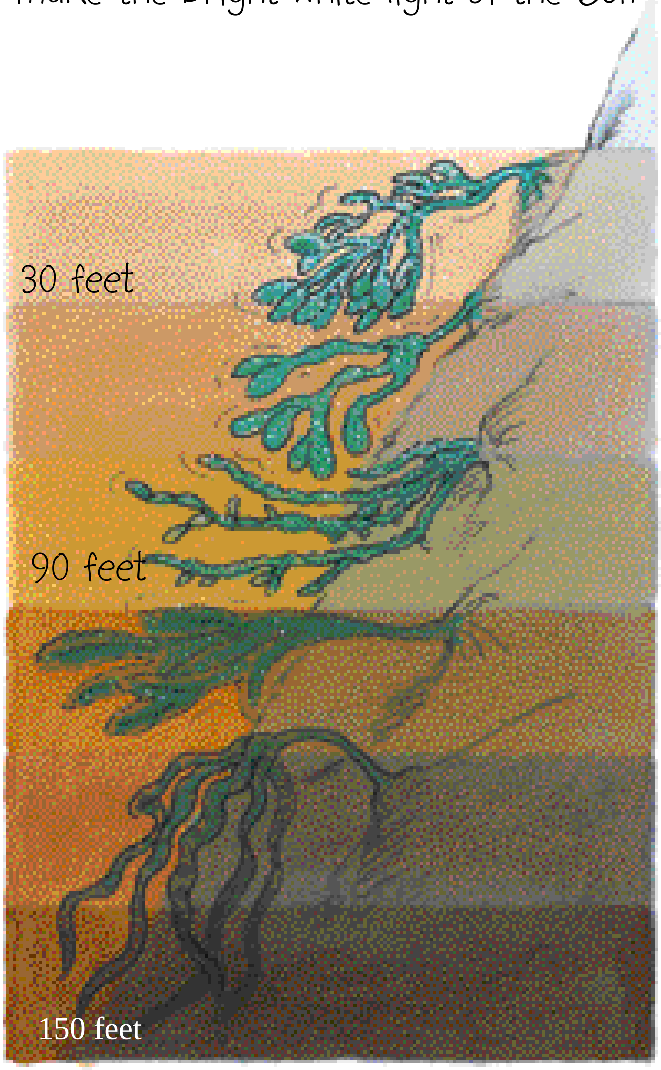
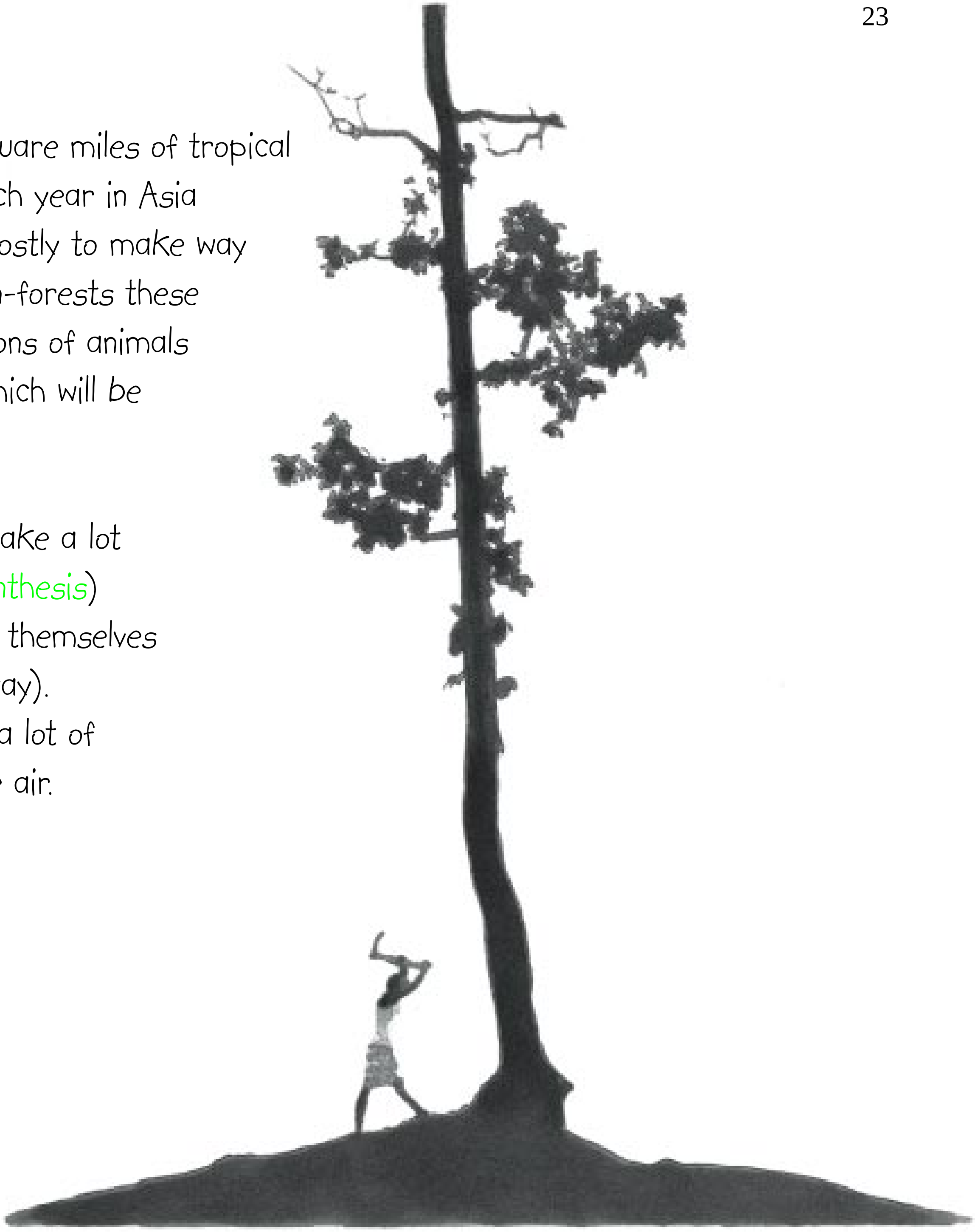
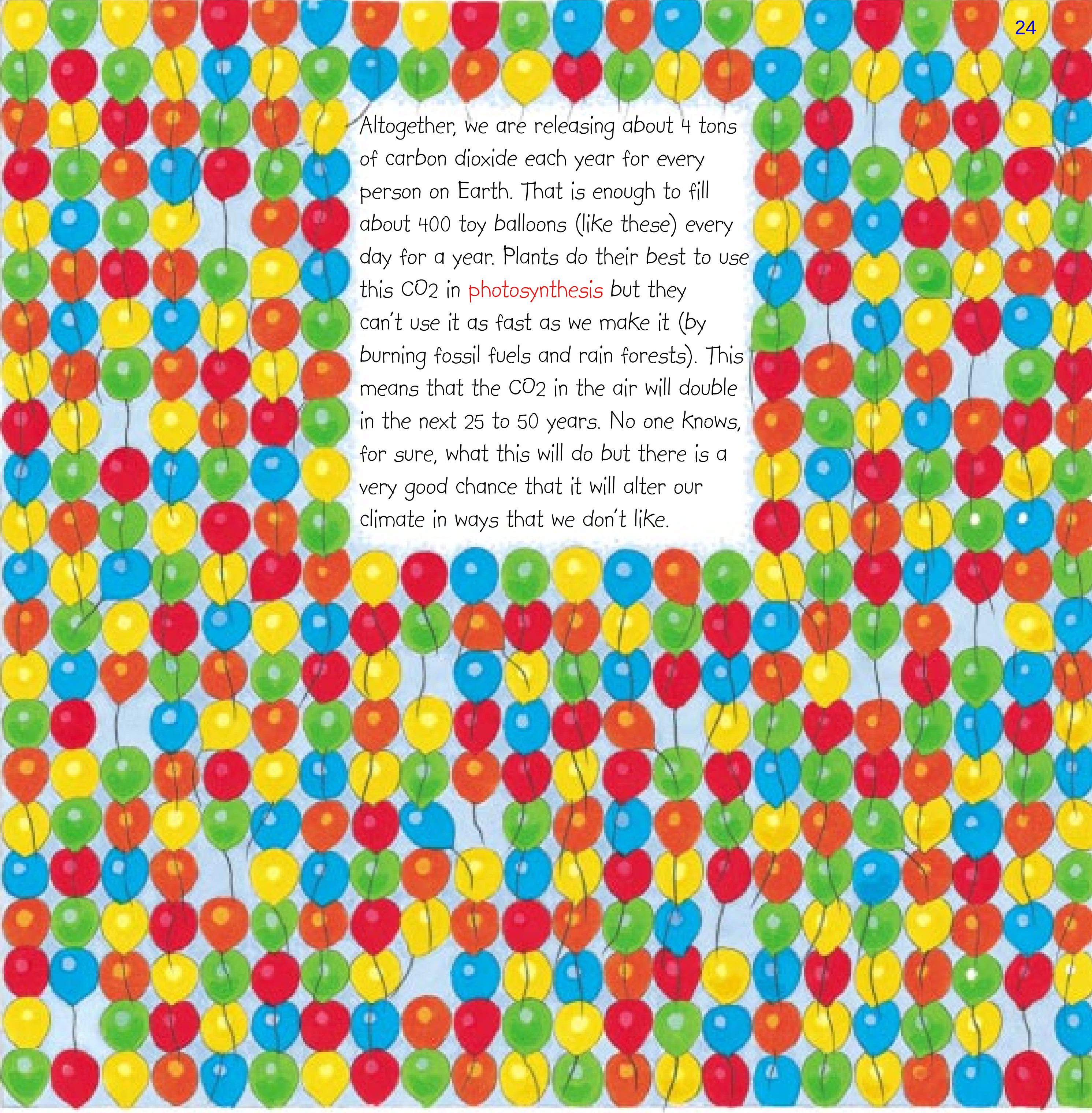


Many thousands of square miles of tropical forests are burned each year in Asia and South America, mostly to make way for farms. Like all rain-forests these are the homes of millions of animals and plants, many of which will be lost for ever.

Ancient rain-forests make a lot of oxygen (by photosynthesis) but they also use a lot themselves (in respiration and decay). Burning them has put a lot of carbon dioxide into the air.





Altogether, we are releasing about 4 tons of carbon dioxide each year for every person on Earth. That is enough to fill about 400 toy balloons (like these) every day for a year. Plants do their best to use this CO_2 in photosynthesis but they can't use it as fast as we make it (by burning fossil fuels and rain forests). This means that the CO_2 in the air will double in the next 25 to 50 years. No one knows, for sure, what this will do but there is a very good chance that it will alter our climate in ways that we don't like.

This is because carbon dioxide, like steam and some other gases, is very good at absorbing heat. You know how much colder it can feel when a cloud (which is made of steam) passes over the Sun. Clouds (and carbon dioxide) also stop the Earth cooling down too much at night, just as blankets keep you warm in bed.

Gases such as water vapour, carbon dioxide and methane are called greenhouse gases.

Rotting vegetation in marshes gives off methane. So do paddy fields of rice, coal mines, oil wells, cows and sheep. and even leaky gas pipes. If it were not for these gases , the world would be a very much cooler place (about -18 °C , on average, rather than about +15 °C as it is now. But greenhouses can get too warm!

Scientists think that carbon dioxide and methane are now increasing so much that the temperature on Planet Earth will gradually become warmer.

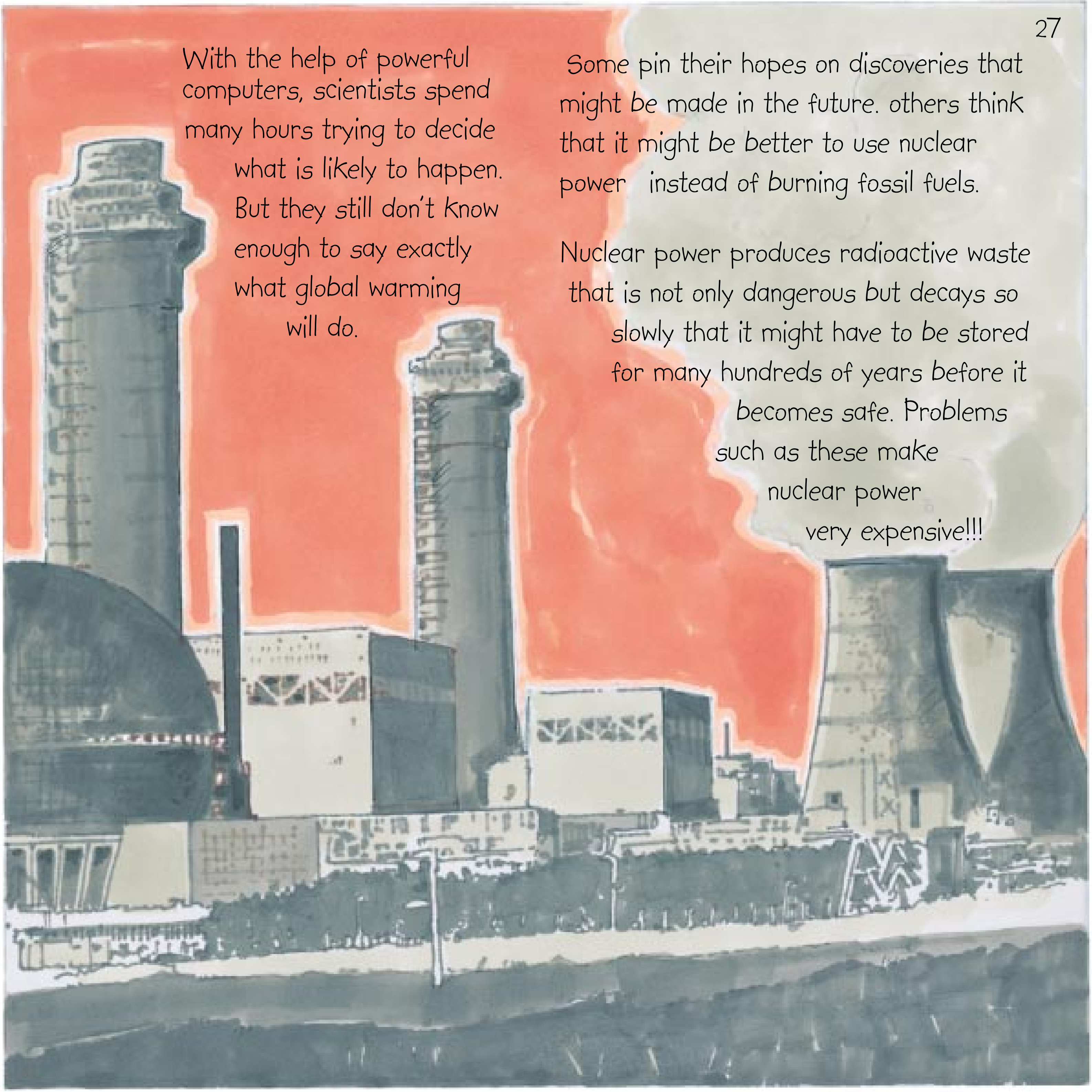
They wrap our planet in an invisible blanket which traps some of the Suns heat, just as a greenhouse does.

This is called global warming.

People in cold countries might like that but, if it gets too warm and too much ice melts at the North and South Poles, big cities like New York, London, Sydney and Bombay would be flooded. There could be less land and more storms and droughts. People who live on low-lying islands, such as the Maldives in the Indian Ocean, fear that their land and homes could disappear completely. Other island countries, like Great Britain, depend very much on ocean currents for their climate. If these change direction, these places could become colder rather that hotter.

Many living creatures might flourish in a warmer world. Most plants grow better when it is warm and when they have plenty of carbon dioxide and water. In some places it might become wetter as well as warmer, and then there might be new rain forests. On the other hand, many parts of the World have too little water, even now.

If deserts become bigger, there will be even more famines.



With the help of powerful computers, scientists spend many hours trying to decide what is likely to happen. But they still don't know enough to say exactly what global warming will do.

Some pin their hopes on discoveries that might be made in the future. others think that it might be better to use nuclear power instead of burning fossil fuels.

Nuclear power produces radioactive waste that is not only dangerous but decays so slowly that it might have to be stored for many hundreds of years before it becomes safe. Problems such as these make nuclear power very expensive!!!

Most scientists agree that prevention is better than cure. It is better to stop wasting energy than to look for more. It is better to release less carbon dioxide.

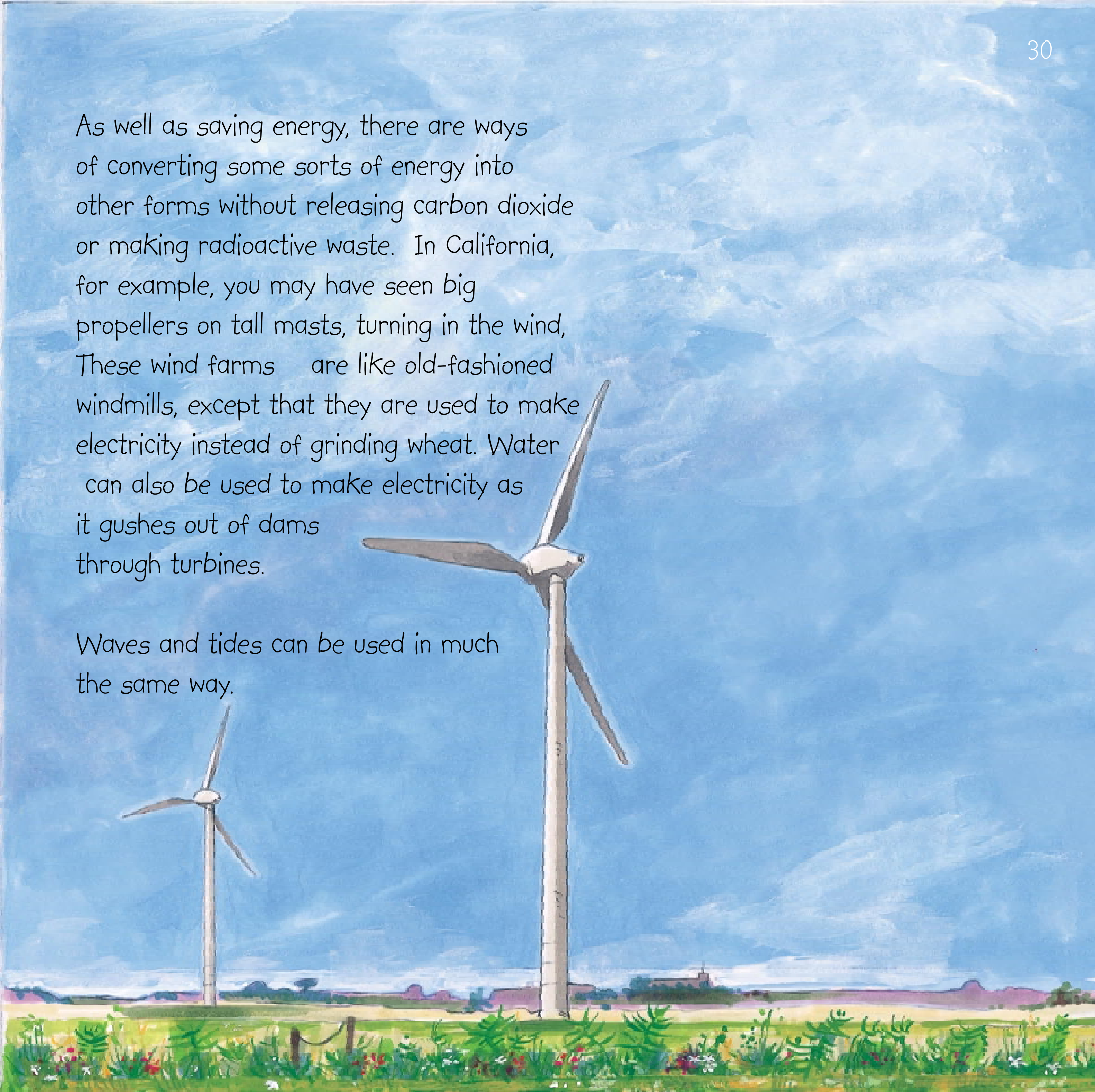
Using energy-saving lights helps. These use only one fifth as much energy as regular ones and they last much longer. Before it needs replacing each of these lamps saves about 1 ton of CO_2 being released when fossil fuels are burned.

Of course, even if these were Aladdin's lamps they would need some help. But there are many other ways of saving. Together, these could save as much as 3/4 of all fossil fuels.

For instance we can...

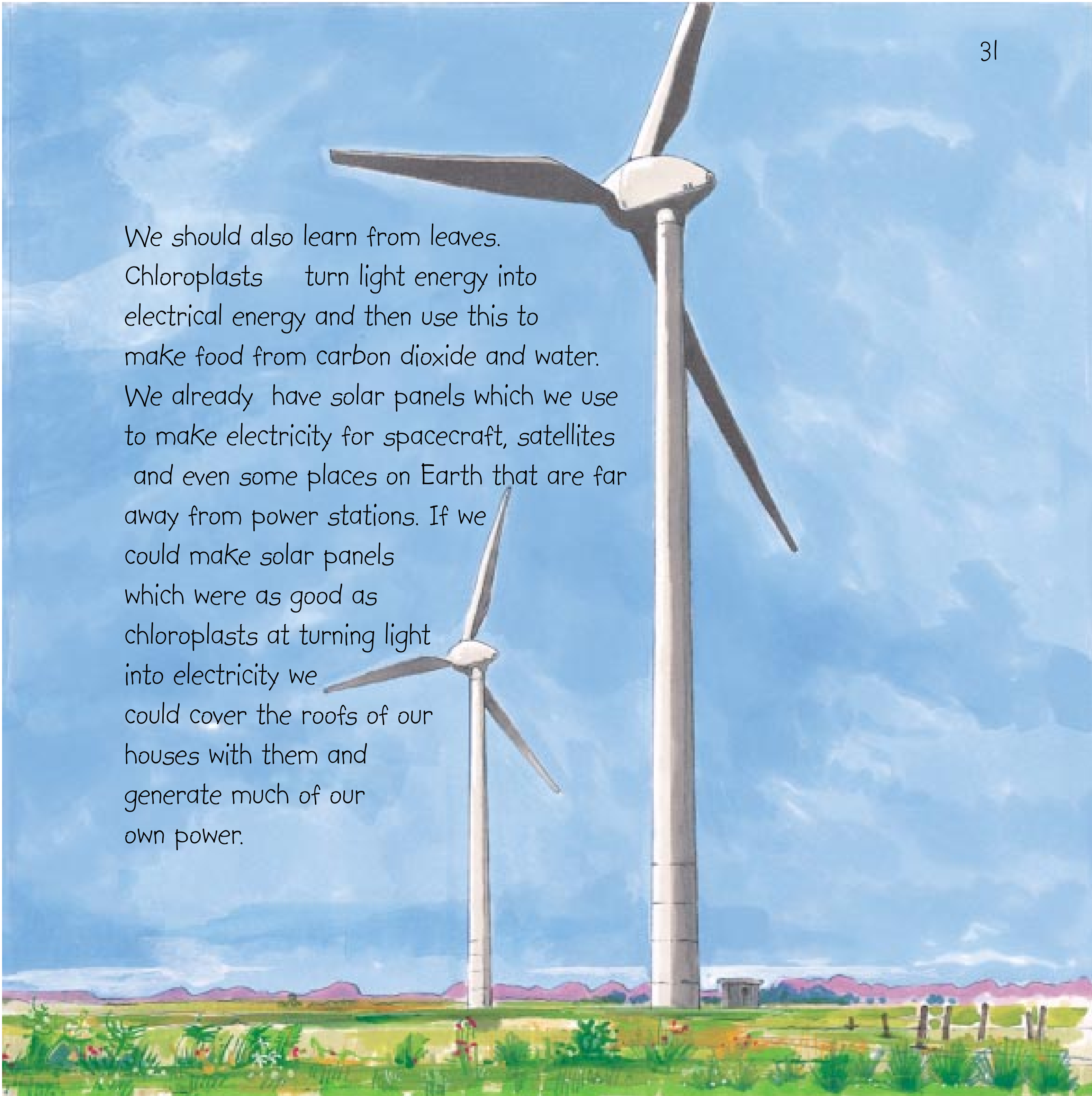
- SAVE WATER – PUT A BRICK IN THE CISTERN
- SAVE EVEN MORE WATER – BATH WITH A FRIEND !
- NOT USE UNNECESSARY PACKAGING
- USE PUBLIC TRANSPORT MORE
- PLANT NEW FORESTS – NEW FORESTS RECYCLE CARBON DIOXIDE
- USE RECHARGEABLE BATTERIES
- RECYCLE GLASS BOTTLES
- BURN USED TYRES TO MAKE ELECTRICITY – SAVING FOSSIL FUELS
- USE ENERGY-SAVING LAMPS
- RECYCLE USED ALUMINIUM CANS
- INVENT MACHINES THAT USE LESS ENERGY

Can you think of any more ways of saving fossil fuels?



As well as saving energy, there are ways of converting some sorts of energy into other forms without releasing carbon dioxide or making radioactive waste. In California, for example, you may have seen big propellers on tall masts, turning in the wind, These wind farms are like old-fashioned windmills, except that they are used to make electricity instead of grinding wheat. Water can also be used to make electricity as it gushes out of dams through turbines.

Waves and tides can be used in much the same way.



We should also learn from leaves. Chloroplasts turn light energy into electrical energy and then use this to make food from carbon dioxide and water. We already have solar panels which we use to make electricity for spacecraft, satellites and even some places on Earth that are far away from power stations. If we could make solar panels which were as good as chloroplasts at turning light into electricity we could cover the roofs of our houses with them and generate much of our own power.

Without photosynthesis, there would be no air to breathe, no food to eat and no fuel, Without fossil fuels from long ago we could not even grow enough food to feed everyone. But we are putting carbon dioxide back into the air faster than plants can remove it.

Your children and their children would like to have a green and pleasant world to live in, remember the dinosaurs? Unable to cope in the end, poor things, they still dominated Earth for at least one hundred million years. We humans have only been around for two or three million years but we are changing our world far too fast for comfort. But, if we stop polluting the air, and give plants a chance,

they will look after us!

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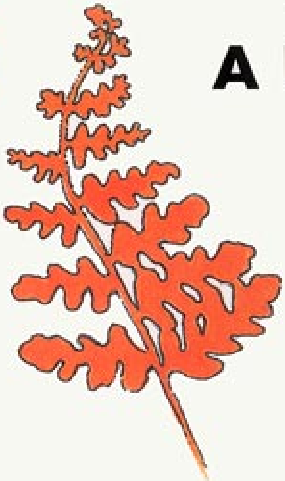


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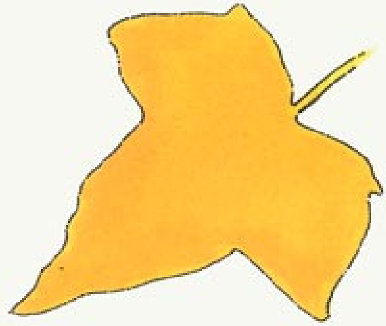
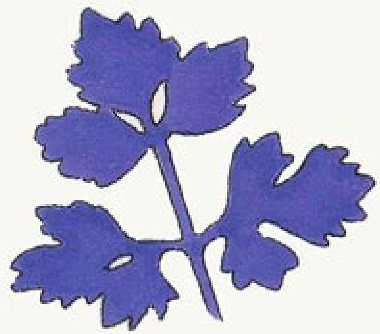


David Alan Walker is a plant biochemist and Emeritus Professor of Photosynthesis in the University of Sheffield (U.K.). He is a Fellow of the Royal Society (the British National Academy of Science) and a Corresponding Member of the American Society of Plant Biologists.



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