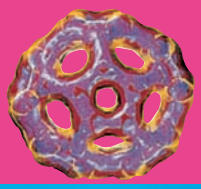
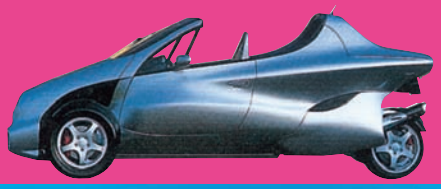
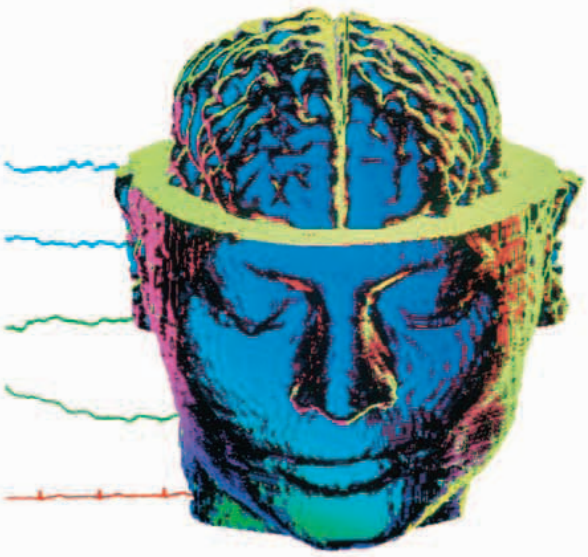
DK Eyewitness

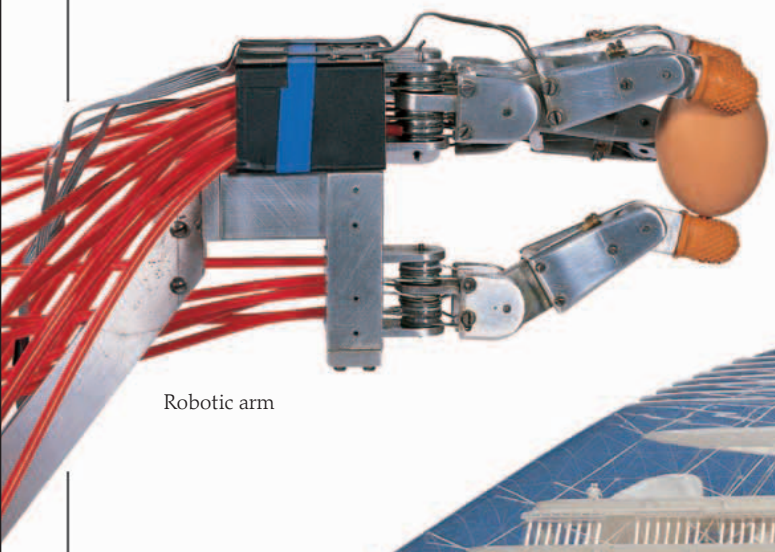




FUTURE

Eyewitness
FUTURE





Robotic arm

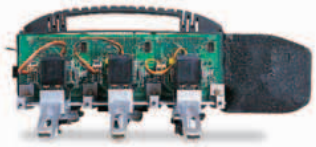
Virtual reality headset

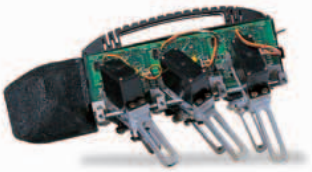
Videophone

Office building of the future

Replacement body parts of the future

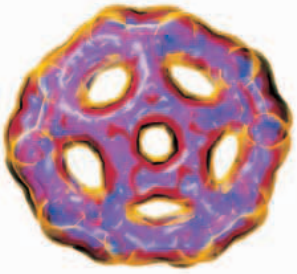
Lightweight three-wheel car





Eyewitness
FUTURE

Written by
MICHAEL TAMBINI



A buckyball

Virtual reality robopal

Pocket-sized television

Home workstation in the year 2020

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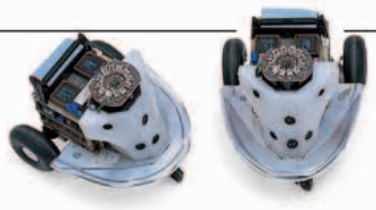
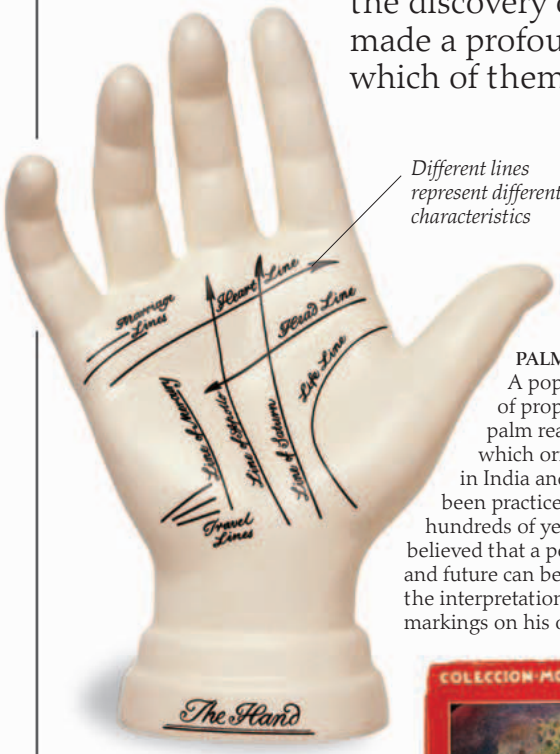


A brave new world

CRYSTAL-GAZING
For centuries, mystics and fortunetellers have made predictions. But their utterances owed more to a knowledge of human nature than anything else.

WE ARE FASCINATED by the future and excited by thinking about what might happen next. Through history, many people have tried to predict the future. Fortunetellers and prophets utter words of doom and warning, while futurologists anticipate scientific and social changes by analyzing existing trends. Imagine the 20th century without the car, telephone, computer, atom bomb, space travel, or the discovery of DNA. They have all made a profound impact on us – but which of them were predicted?



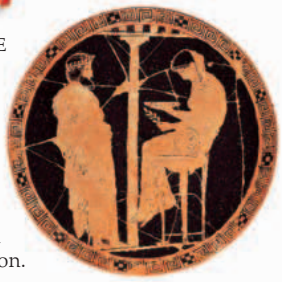
PALM READING
A popular form of prophecy is palm reading, which originated in India and has been practiced for hundreds of years. It is believed that a person's character and future can be discovered by the interpretation of the natural markings on his or her hands.

IT'S IN THE CARDS
Cards are frequently used to predict the future. Before a reading can be made, the cards have to be shuffled, placed face down, then turned over one by one.

NOSTRADAMUS
The prophecies of Nostradamus were first published in the 16th century, and many believe he accurately foretold the future. He is said to have predicted the Great Fire of London and air battles in the 20th century.

SCIENCE FICTION
Science fiction writers are some of the most active forecasters of the future. Writers such as Jules Verne, H. G. Wells, Arthur C. Clarke, and Isaac Asimov have depicted worlds we may know well in the future.

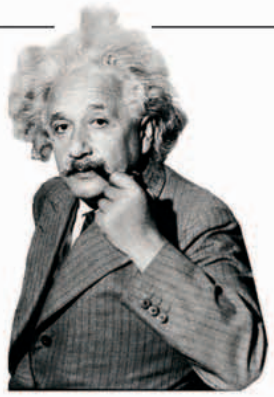
DELPHIC ORACLE
In Greece, at the foot of Mount Parnassus, stood the temple of Apollo. Here Apollo spoke through his priestess, who predicted the future and gave guidance. Today, the closest we have to oracles are the futurologists who predict based on scientific information.



1900s

I never think of the future – it comes soon enough.

–ALBERT EINSTEIN



ALBERT EINSTEIN
In 1905, Einstein proposed a theory of relativity, which was to revolutionize the field of physics. He later outlined a complete theory of gravity that explained how the universe works.

TAKING PICTURES
Black-and-white photography became very popular at the turn of the century. But when the Lumière brothers developed color film in 1904, there was an even greater surge of interest in photography.

TAKING FLIGHT
In 1903, the Wright brothers flew for just 12 seconds, covering a distance of 120 ft (37 m), and scarcely anyone paid attention. Yet this event changed the world. Today, we think nothing of traveling halfway around the world by jumbo jet.

INVENTIONS

1901 First transatlantic radio broadcast
1901 Hubert Cecil Booth manufactures the first vacuum cleaner
1903 Wright brothers make first powered flight
1904 Lumière brothers develop color photography
1907 French bicycle maker Paul Cornu's motordriven helicopter takes to the air

EVENTS

1900 Sigmund Freud publishes his book *The Interpretation of Dreams*
1902 Boer War ends in South Africa
1904 Japanese attack Port Arthur at start of Russo-Japanese War
1905 Albert Einstein proposes his theory of relativity
1908 Two-year-old Pu Yi ascends throne of China

1910s

Time present and time past are both perhaps present in time future, and time future contained in time past.

–T. S. ELIOT

MAKING CONTACT
The invention of the telephone began the great communications revolution. For the first time, it was possible to talk directly to people over great distances.

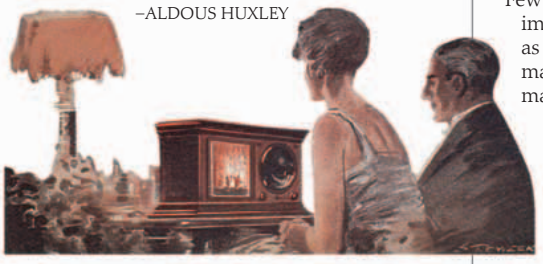
METAL THAT LASTS
By adding chromium to steel in 1913, a new metal that would not rust or scratch was created. Stainless steel has become a common part of everyday life.

EASY TRANSPORT
Henry Ford was the first person to mass-produce the car, changing the nature of factory work as well as giving us the freedom to travel.

1920s

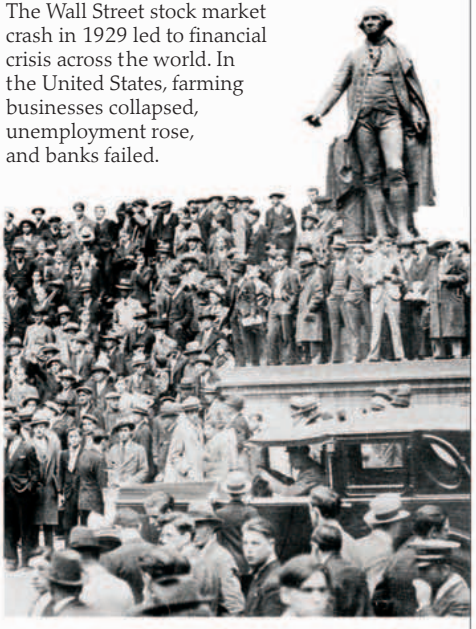
The most distressing thing that can happen to a prophet is to be proved wrong. The next most distressing thing is to be proved right.

–ALDOUS HUXLEY



A SCREEN IN THE LIVING ROOM
For more than half a century, television has provided us with news, drama, and entertainment. Viewers in the home have been eyewitnesses to historic events, from civil wars to the death of a president.

WALL STREET CRASH
The Wall Street stock market crash in 1929 led to financial crisis across the world. In the United States, farming businesses collapsed, unemployment rose, and banks failed.



1930s

You cannot fight against the future. Time is on our side.

–WILLIAM GLADSTONE

Nylon stockings

NYLON
Few materials have had such an impact on the fashion industry as nylon. This manufactured material was used to make many different products.

Whittle's jet engine

JET ENGINE
In 1937, British engineer Frank Whittle built the first prototype of a jet engine, which was put to practical use in 1941. Today, jet aircraft can travel faster than the speed of sound.

WRITING OF THE FUTURE
H. G. Wells wrote many science fiction novels, including *The War of the Worlds*, in which the Earth is invaded.

Wells at work on a novel

1913 Mass production of Ford's Model T begins
1913 Stainless steel first cast in Sheffield, England
1914 First traffic lights introduced in Ohio
1915 Heat-resistant glass Pyrex marketed
1915 First transcontinental telephone call between New York and San Francisco
1916 First tank goes into battle

1920 "Tommy" submachine gun patented
1921 18 million Russians starve because of severe drought
1921 First highway opens in Germany
1922 First diabetic treated with insulin, Canada
1925 John Logie Baird transmits first television pictures

1933 German post office opens the first "telex" service between Berlin and Hamburg
1934 British inventor Percy Shaw patents cat's-eye road studs
1935 Nylon developed by Wallace Carothers
1935 Kodak introduces the first color film
1937 Engineer Frank Whittle builds prototype of the first jet engine

1911 Norwegian Roald Amundsen reaches the South Pole
1911 Revolution in China overthrows the Ch'ing dynasty
1912 *Titanic* sinks in the Atlantic
1914 Start of World War I, which ends with German surrender in 1918
1917 Tsar Nicholas II overthrown in Russia

1920 Prohibition comes into force
1922 Tutankhamun's tomb uncovered, Egypt
1928 Flying doctor service begins in Australia
1928 Scottish bacteriologist Alexander Fleming discovers penicillin
1929 Wall Street crash leads to world financial crisis

1930 Clyde Tombaugh discovers Pluto
1936 Spanish Civil War begins
1937 Airship *Hindenburg* bursts into flames, killing 35 of the 97 on board
1938 Orson Welles broadcasts convincing radio version of H. G. Wells's *The War of the Worlds*
1939 Germany, under Adolf Hitler, invades Poland and starts World War II

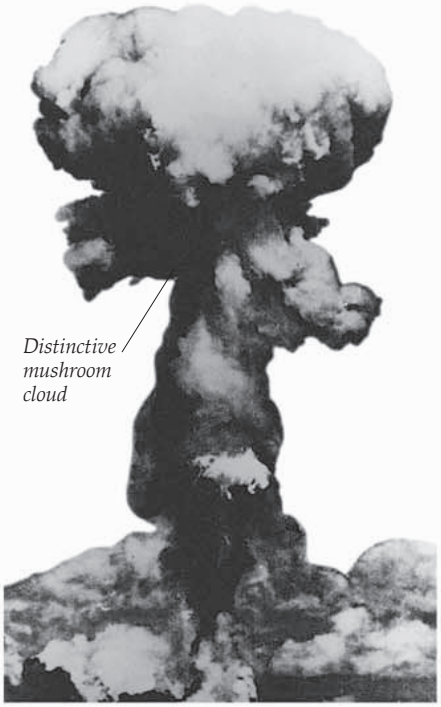
Continued on next page

Continued from previous page

1940s

We have to live with the bugs and the bomb not for the next ten years but the next ten thousand.

–ARTHUR KOESTLER



Distinctive mushroom cloud

ATOM BOMB
The atom bombs that destroyed Hiroshima and Nagasaki in 1945 left few doubts about their awesome potential, and so began an arms race among world powers.

ARTHUR C. CLARKE
Arthur C. Clarke has written many science fiction novels about space exploration. He also predicted the use of satellites for global communications.

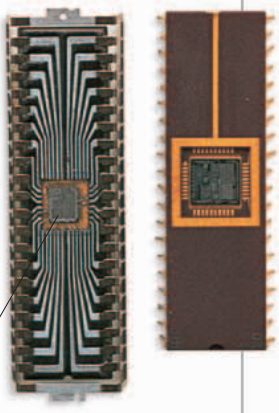
1950s

We are going to have to be rather clever to escape from our own cleverness in the past.

–SIR MARK OLIPHANT

DINERS' CLUB
The Diners' Club card was set up to make it easier for executives to eat out on a company account. Now credit cards are used everywhere and may soon replace cash.

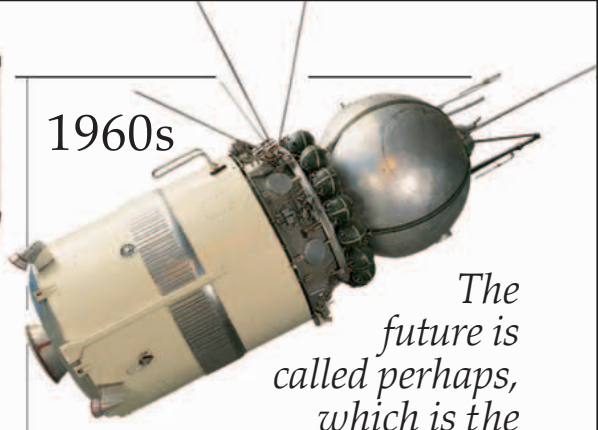
SILICON CHIP
The impact of silicon chips on this century cannot be overstated. Tiny wafers of silicon carry thousands of electrical components and are used everywhere, from computers to cars.



Silicon chip

FRANCIS CRICK AND JAMES WATSON
In 1953, Frances Crick and James Watson discovered the molecular structure of DNA. The genetic code for all life is contained within this molecule. Our ability to understand and manipulate it will be central to the 21st century.

1960s



TELSTAR
Telstar was the first communications satellite to orbit the Earth. It was owned by AT&T and launched by NASA.

The future is called perhaps, which is the only possible thing to call it. And the most important thing is not to allow it to scare you.

–TENNESSEE WILLIAMS

MAN ON THE MOON
As Neil Armstrong stepped onto the moon, he uttered the now historic words,"That's one small step for a man, one giant leap for mankind." The exploration of space is still in its infancy, yet humans seem driven to explore, and people are certain to follow in Neil Armstrong's footsteps.

Neil Armstrong on the surface of the moon

INVENTIONS

1941 World's first aerosol can patented
1943 Dutch doctor Wilhelm Kolff makes first artificial kidney machine
1945 Arthur C. Clarke predicts satellites in geostationary orbit for global communications
1945 Microwave oven patented
1947 First transistor made
1949 Maiden flight of the Comet jet

1950 First credit card, Diners' Club, introduced
1951 Engineers John Eckert and John Mauchly invent digital computer UNIVAC
1957 USSR launches *Sputnik 1*, first artificial satellite in space
1959 British designer Christopher Cockerell invents the hovercraft
1959 First silicon chip manufactured

1960 Theodore Maiman builds the laser
1962 First communications satellite, *Telstar I*, put into orbit
1963 Tape cassette machine patented by Phillips, Holland
1966 Vertical take-off and landing (VTOL) aircraft unveiled at air show
1967 France launches its first nuclear submarine

EVENTS

1945 World War II ends with Hitler's suicide
1945 Atom bombs dropped on Hiroshima and Nagasaki
1947 Pilot Chuck Yeager breaks the sound barrier
1948 South Africa's Nationalist party comes to power and imposes apartheid
1949 NATO formed

1950 North Korea invades South Korea
1953 Francis Crick and James Watson discover the structure of DNA
1953 Edmund Hillary of New Zealand and Tenzing Norgay of Nepal climb Mt. Everest
1954 British athlete Roger Bannister runs a mile in under four minutes
1955 Disneyland opens in California

1961 Cosmonaut Yuri Gagarin becomes the first man in space
1961 East German wall divides the city of Berlin
1963 President John F. Kennedy assassinated
1967 Six-Day War in Israel
1967 Christiaan Barnard performs first heart transplant in South Africa
1969 First man lands on the moon

1970s

We should all be concerned about the future because we will have to spend the rest of our lives there.

–C. F. KETTERING

FLOPPY DISK
Computer users in the 1970s were able to record data and install programs using disks that were literally floppy. Information is now often stored on compact discs (CDs).

BAR CODE
Information stored on a computer can be quickly accessed using a bar code. Bar codes have revolutionized supermarket checkouts, where the scanner reads the product labels.

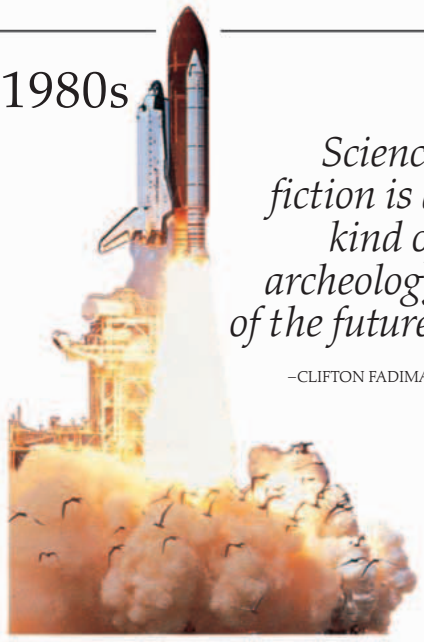
CONCORDE
Since 1976, the *Concorde* – a joint project by British Airways and French Airways – flew at supersonic speeds across the Atlantic. It was criticized for causing noise pollution.

the Concorde

1980s

Science fiction is a kind of archeology of the future.

–CLIFTON FADIMAN



SPACE SHUTTLE
The space shuttle is the first reusable manned spacecraft. The first four space shuttles were named after famous ships, *Columbia, Challenger, Endeavour*, and *Atlantis*, reminding us how much humankind loves to explore.

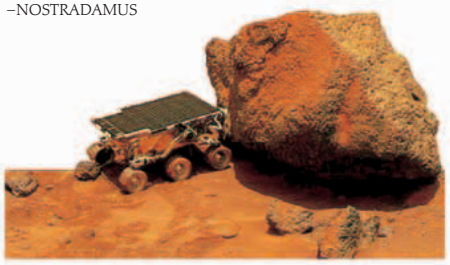
Antenna

MOBILE PHONE
Our ability to make immediate contact with each other regardless of where we are is now taken for granted. Lightweight cell telephones are becoming as familiar as wristwatches. Many cell phones now allow users to access the Internet.

1990s

Such abundance of fire and fiery missiles shall fall from the heavens that nothing shall escape the holocaust. And this will occur before the last conflagration – in 1999.

–NOSTRADAMUS



DESTINATION MARS
The *Pathfinder* probe landed on Mars on July 4, 1997. It released the Sojourner, a wheeled vehicle that explored the Martian landscape. NASA is now making preparations to send the first astronauts to the red planet.

Headset gives 3-D vision

Data glove

VIRTUAL REALITY
Virtual reality is already being used for entertainment, as well as for medicine and design. In the future, virtual reality will become as familiar to us as movies.

1970 IBM creates the first floppy disk
1971 Food processor invented in France
1971 Soviet Union puts space station into orbit
1972 CT scanner introduced by British researcher Godfrey Hounsfield
1976 Supersonic airliner *Concorde* makes first commercial flight
1979 Catalytic converter developed in Britain

1981 World's first space shuttle, *Columbia*, blasts off
1981 Stealth fighter plane has maiden flight in America
1982 First artificial heart implanted
1984 Genetic fingerprinting introduced
1985 Desktop (DTP) publishing created
1985 Mobile phones launched in Europe

1991 *ERS-1*, Europe's first environmental satellite, goes into orbit
1992 Virtual reality is developed as a 3-D video game in the United States
1993 First voice-operated TV/radio remote control is launched
1998 Digital broadcasting introduced
2000 Entire human genome sequenced

1973 Australia's Sydney Opera House completed amid controversy
1973 Last American troops leave Vietnam, but war does not end for two years
1973 Bar codes first introduced on products for sale in America
1979 Nuclear accident at Three Mile Island, Pennsylvania

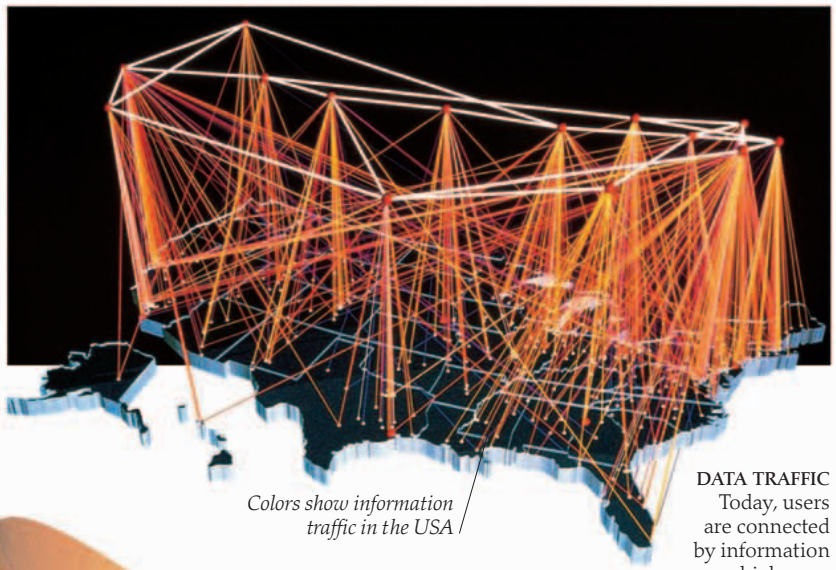
1980 Mt. St. Helens erupts in Washington
1982 Argentine forces surrender Falkland Islands to Britain
1985 Live Aid concert watched by 1.5 million people
1986 Space shuttle *Challenger* explodes
1986 Major nuclear accident at Chernobyl
1989 Berlin wall torn down

1992 Hole in ozone layer stretches over the coast of South America for the first time
1994 ANC leader Nelson Mandela elected as first black president of South Africa
2001 Terrorists destroy New York's Twin Towers
2004 Indian Ocean tsunami kills 275,000 people
2004 *Spirit* and *Opportunity* robot vehicles explore the surface of Mars

A shrinking planet

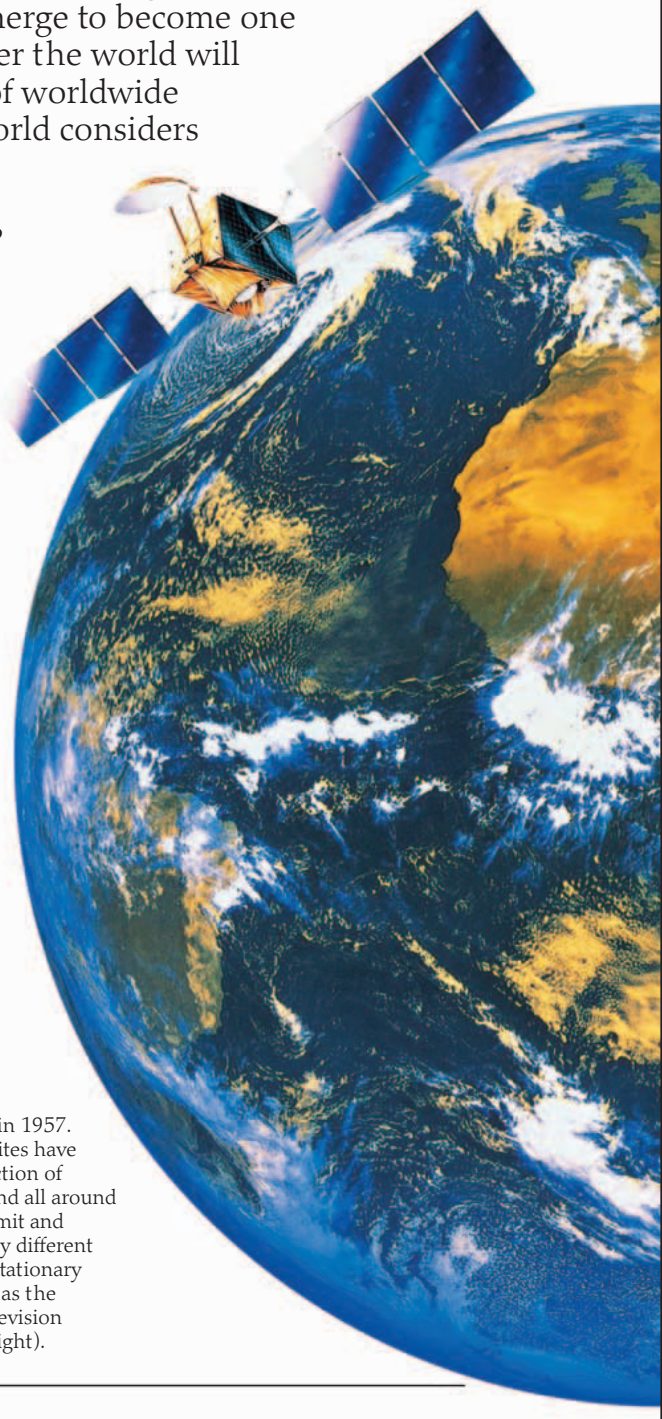
GETTING WIRED
Technology has certainly come a long way since this group gathered to listen to the latest sound recording! Via the Internet, it is now possible to connect to sites all over the world and share information – and music – with people from many different cultures.

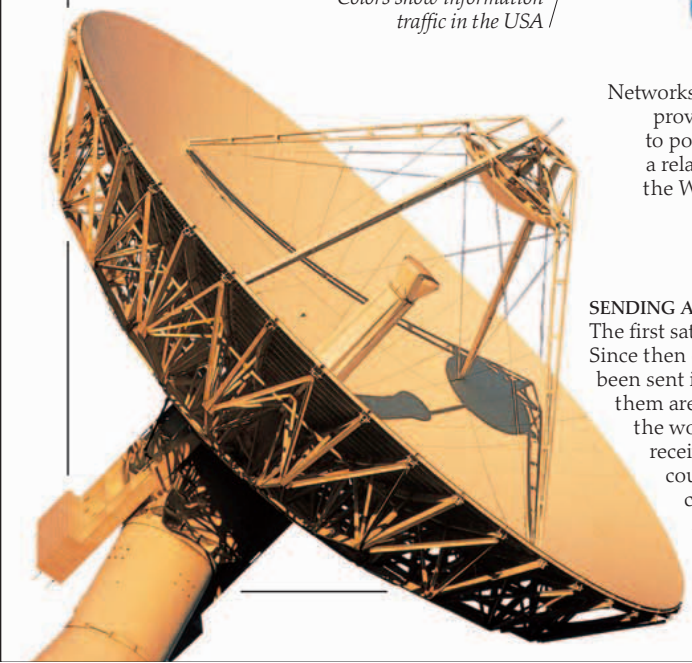
THE WORLD IS GETTING SMALLER, or so it seems. Today, there are 150 communications satellites in geostationary orbit around the Earth, gathering information and enabling us to communicate with each other. Mobile phones, fax machines, and electronic mail keep us in touch wherever we are. Instant news reports, from cultural events to wars and famine, are routinely transmitted into our homes. The Internet, which began as a modest communications network between a number of universities, now has millions of users all over the world. Different strands of technology are starting to converge, and soon televisions, telephones, and computers will merge to become one technology. Access to doctors and other experts from all over the world will be available via video conferencing. However, this picture of worldwide communications can be misleading, as two-thirds of the world considers it a luxury to own a phone, let alone a personal computer. Information technology could benefit the entire world, but how long will it be before access to it becomes truly global?



Colors show information traffic in the USA

DATA TRAFFIC
Today, users are connected by information superhighways. Networks like this one in the USA provide scientists with access to powerful computers. This is a relatively small network, but the World Wide Web is global.





SENDING AND RECEIVING MESSAGES
The first satellite, *Sputnik 1*, was launched in 1957. Since then over two thousand more satellites have been sent into space, although only a fraction of them are operating today. On the ground all around the world, satellite dishes (left) transmit and receive news and information. Many different countries have put into orbit geostationary communications satellites such as the *Intelsat K* (above right), and television satellites such as the *TDF-1* (right).

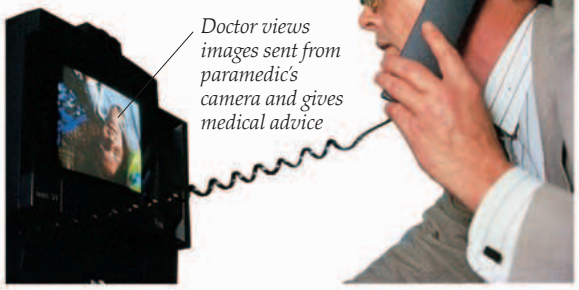
Today's videophones are smaller and less bulky than this

SEE MORE OF YOUR FRIENDS
This comical image from a 1956 magazine illustrates how people believed that having a videophone would invade privacy. It was not until the 1990s that technological advances made these machines a practical possibility.

FACE TO FACE
Video conferencing is already a popular form of communication among international businesses because it saves the time and expense of travel. Business people can hold meetings face-to-face, even though they may live and work at opposite ends of the globe. The system is also being used in schools, where experts from all over the world can be invited into the classroom to lecture or teach via video conferencing.

Equipment allows doctor to be "virtually present" at scene of accident

Headset is fitted with video camera, television screen, and microphone

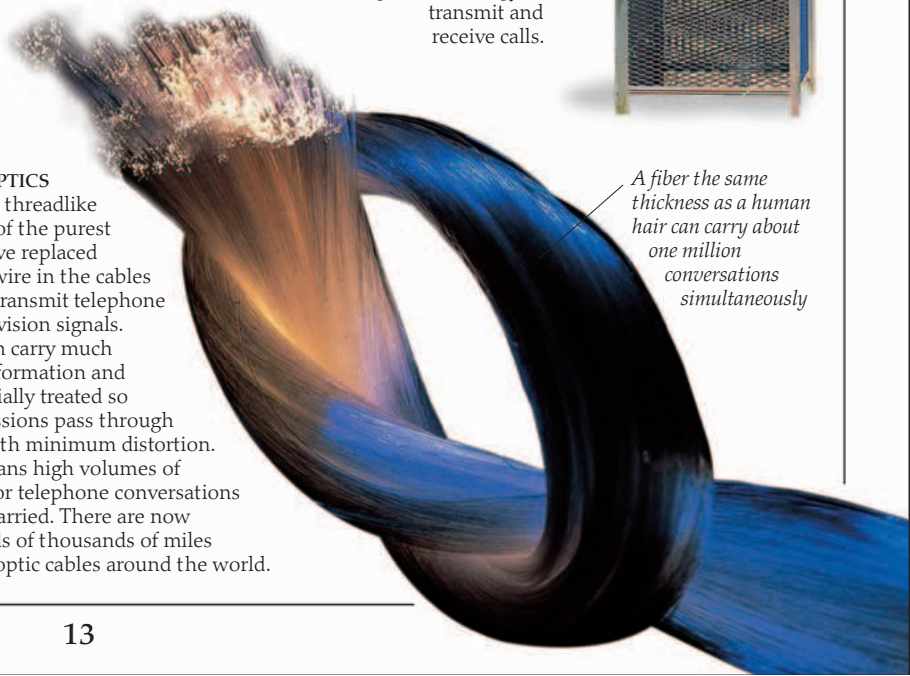


Doctor views images sent from paramedic's camera and gives medical advice

SAVING LIVES
It will not be long before a paramedic at the scene of an accident will be able to receive on-the-spot advice from a doctor at a hospital. The paramedic will receive diagrams showing him or her what to do. This life-saving equipment is a combination of video conferencing software and a satellite communications network.

A panel of solar cells collects and stores energy until someone wants to make a call

SOLAR TELEPHONES
Many places around the world have no electricity. Solar power may provide the answer. This solar-powered telephone booth uses the sun to generate energy to transmit and receive calls.



FIBER OPTICS
Flexible, threadlike strands of the purest glass have replaced copper wire in the cables used to transmit telephone and television signals. They can carry much more information and are specially treated so transmissions pass through them with minimum distortion. This means high volumes of images or telephone conversations can be carried. There are now hundreds of thousands of miles of fiber optic cables around the world.

A fiber the same thickness as a human hair can carry about one million conversations simultaneously

Watching the Earth

BIG BROTHER IS WATCHING YOU
George Orwell's gloomy novel of the future, *1984*, predicted a society dominated by state control. Video screens not only provided constant propaganda but were also linked to surveillance cameras. Terrified citizens were rarely out of the sight of "Big Brother."

1 THE BLUE PLANET
In the 1960s, satellites and astronauts sent back the first pictures of our planet from space. From a long distance, our planet is predominantly blue and, compared with the giant scale of the universe, looks small and fragile.

HAVE YOU EVER WONDERED what your house looks like from space? Well, now you can find out. Satellite imaging is becoming so sophisticated that, using a device like Google Earth, you can see images of your town, street, and house. You might even be able to see your car parked outside. The author George Orwell (1903-50) predicted a future in which our every move would be monitored by governments obsessed with control. In some ways he was right. Today, satellites watch us from space, and video cameras record our movements in shopping centers and other public places. But satellites have a variety of other useful purposes. Views of the Earth from the *Landsat* satellite provide us with vital ecological information. Satellites can also inform us of changes in urban and environmental conditions and warn us in advance of any major ecological problem threatening the Earth.

2 CLOUDLESS SKIES OVER EUROPE
With today's technology, satellites out in space can pinpoint particular details on Earth, such as expanses of vegetation, large rivers, deserts, and huge mountain ranges. But in order to do this, it is essential that the satellite's view is not obscured by thick layers of clouds. This sequence has been put together with cloudless images taken by a satellite.

Cloudless image of Italy

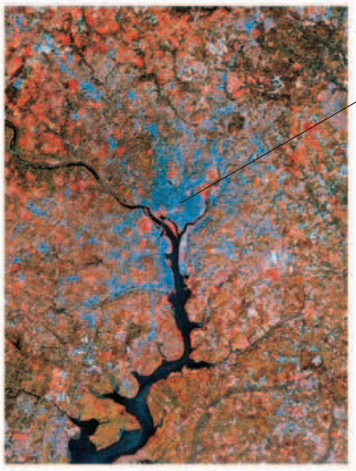
3 MOVING CLOSER
Zooming in even closer, it is possible to see additional detail. In the north of Italy, the southern Alps mountain range comes into focus. The pictures have been produced by taking thousands of satellite images and piecing them together with a computer. Using cameras that are able to home in to provide close detail, it is possible to see a small area of a continent.

Eye of the storm at the heart of the hurricane

WATCHING THE WEATHER
Satellites and spacecraft allow meteorologists to monitor weather conditions on Earth. This view from the space shuttle *Atlantis* shows Hurricane Florence in 1988 as it swept dangerously across the Atlantic Ocean. Weather satellites in orbit can see how clouds are moving, and forecasters use this information to predict the weather.

Southern Alps mountain range

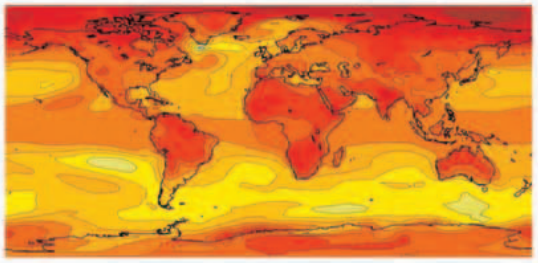
4 MOUNTAIN SCENERY
The snowcapped ridges of the mountain range come into view. So far, this photographic technique has been used only by the militaries of various countries, but will soon be available for commercial purposes. It will be possible to own pictures of your house taken from space.



View of the city center of Washington, D.C.

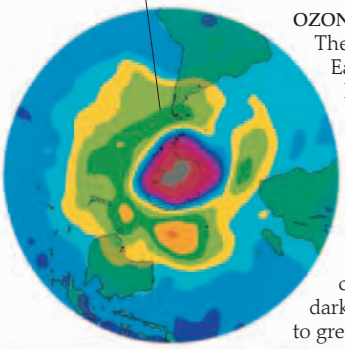
EYE IN THE SKY
The first *Landsat* satellite was launched in 1974 to monitor changes on Earth. Since then, four successors have been launched, each providing increasingly detailed data about urban areas, deforestation, pollution, and natural disasters.

TEMPERATURE TRENDS
These computer-generated maps show world temperature trends. The evidence suggests that temperatures will increase considerably in the 21st century, which many believe to be an indication of global warming. If this is the case, the consequences will be devastating for many parts of the world.

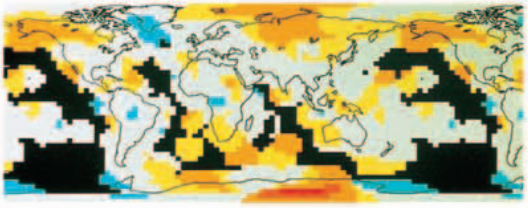


Predicted temperatures for 2050

Highest ozone concentration



OZONE DEPLETION
The ozone layer shields Earth from the Sun's harmful ultraviolet rays, but certain gases are depleting the protective layer. This picture (left) shows the ozone hole over Antarctica. The colors show ozone concentration, from dark red for the lowest to green for the highest.



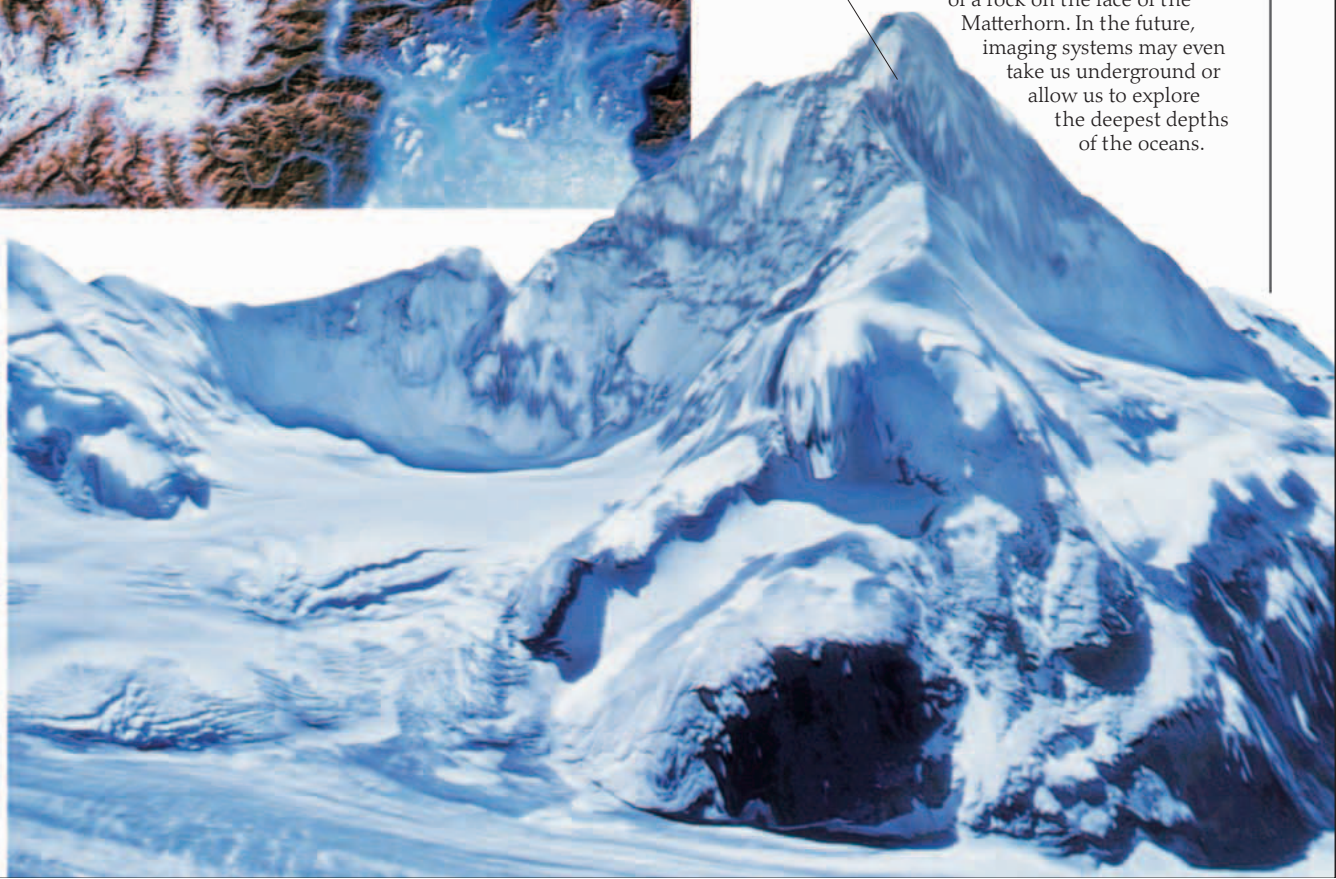
Temperature trends 1965-1985

5 IN DETAIL
It is now possible to see clearly the details of the thick vegetation in the valleys between the high mountains in the range. At this distance, we can make out the courses the rivers follow and how much snow covers the giant mountaintops.

Contours of the rivers

3-D image of Matterhorn

6 HOMING IN
Satellite imaging is able to focus on a 3-ft (1-m) area. So, from space it is possible to take pictures of a rock on the face of the Matterhorn. In the future, imaging systems may even take us underground or allow us to explore the deepest depths of the oceans.



The growing world

TOO MANY MOUTHS TO FEED
Overpopulation puts a strain on resources. In many countries, a natural disaster, such as flooding or crop failure, already causes famine. The lack of clean drinking water or an inadequate supply of food will devastate entire communities.

THE WORLD'S POPULATION IS GROWING at an incredible rate. In the last 200 years it has accelerated from about one billion to about 6.5 billion and is only now beginning to show signs of slowing down. The birth rate is higher than the death rate and, according to the social scientists who study population trends, these rates are unlikely to balance out until the world population reaches 10 or 11 billion. With advanced medical care, improved living conditions, and a healthier diet in the future, we will live longer, be more active, and have a better quality of life. But if the planet is to sustain such a high population, it will be necessary to preserve and protect its natural resources. Nations will have to work together to reduce pollution, protect the forests, control pesticides, and find alternative sources of energy to fossil fuels.

GETTING OLDER
Improved medical care, a better diet, and a healthier lifestyle lead not only to a longer life but also to a fitter one. Because of this, it is likely that many people will live to the age of 100 or more from the beginning of the 21st century.

GROWING POPULATION
In just over a century, the world's population has tripled in size. Up until the early 1800s, the population remained under one billion. However, better health and living conditions resulted in the birth rate exceeding the death rate, and by 1900 there were two billion people in the world. Less than 50 years later, the population reached three billion. Today, it has reached more than 6.5 billion and is expected to continue to rise at a rate of about one billion every 12 years. This chart shows the dramatic rise in billions from 1800, showing how the numbers are likely to become stable from 2100 onward.

CITY SPRAWL
The world's population is concentrating more and more in urban areas. Cities with a million inhabitants are commonplace, and some exceed this – in Japan, the Tokyo-Yokohama metropolitan area has a population of over 33 million. It is estimated that cities and urban areas are gaining 60 million people a year, steadily increasing the pressure to provide jobs, housing, and public services.

Power station in Moscow

POLLUTED ATMOSPHERES
We consume billions of tons of fossil fuels every year, using up natural resources and polluting the atmosphere. The exhaust fumes from motor vehicles, together with emissions from factories, produce noxious smogs that have catastrophic consequences both for people's health and for the environment.

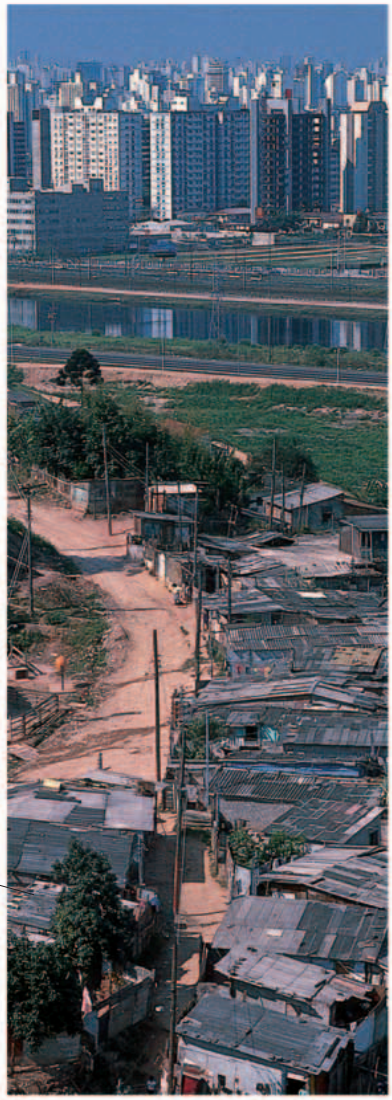
THIRST FOR FOREIGN CULTURE
Certain cultures have become more attractive and desirable than others. The American way of life has a huge impact on the desire for consumer goods throughout the world. In the future, such a demand for consumer goods may deplete our natural resources.

CONSERVING OUR FUTURE
The high demand for lumber and agricultural land has meant that vast tracts of South American jungle are being lost forever. This has a devastating effect on plants and animals and causes enormous damage to the Earth's atmosphere. Governments must promote better agricultural practices before it is too late.

Coca-Cola is successfully exported throughout the world

More than 668 million drinks of Coca-Cola are consumed worldwide every day

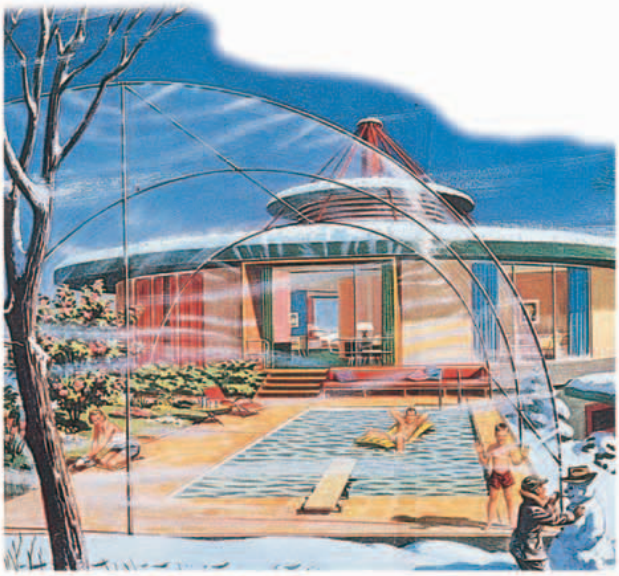
Slum dwellings lie not far from modern buildings in Sao Paulo, Brazil



GROWTH OF DEVELOPING COUNTRIES
When poor agricultural workers migrate from the countryside to urban areas they put a great strain on housing and public services. Over 260 cities in developing countries now have populations of over one million, and there are at least 15 "megacities," each with a population of over 10 million inhabitants.

Environmentally friendly

TECHNOLOGICAL PROGRESS HAS provided us with many advantages, and will continue to do so in the future, but not without a price – the damaged ozone layer and the effects of greenhouse gases may have terrible consequences for the future of our planet. Air pollution is causing acid rain, and water contamination is killing wildlife. Natural resources are rapidly being used up, and many large tracts of rain forest have been destroyed. Because of our actions, some of the animals on our planet have become extinct, while others are endangered. If we do not take a more responsible attitude toward our finite resources, the results will be catastrophic.



VISIONS OF THE FUTURE
Creating your own artificially controlled environment once seemed an exciting prospect. Some architects have taken great pleasure in designing future homes, such as this one, from the 1950s, which rotates to face any direction. A climate-conditioned dome makes it possible to enjoy summer activities in the middle of winter. Such schemes can be seen today in vacation resorts and leisure centers.

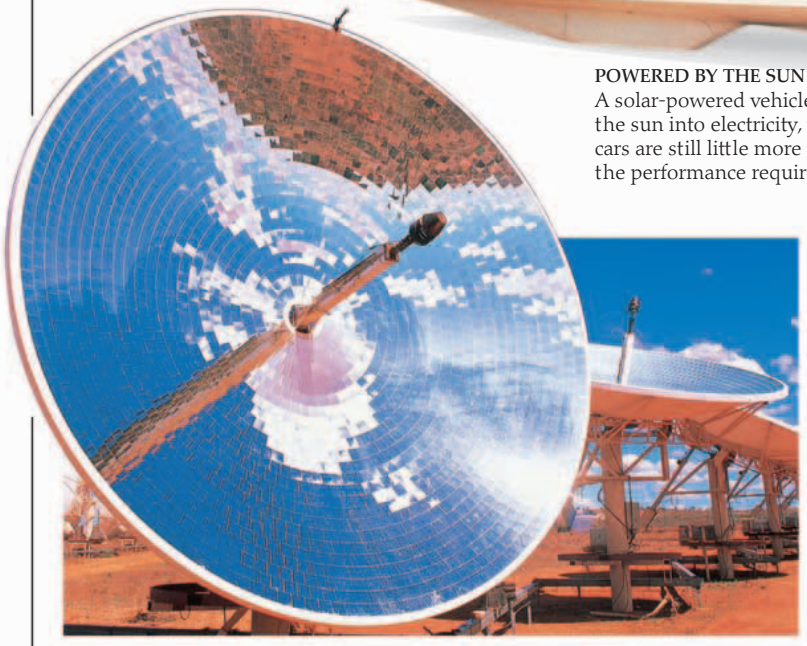
IDEAL FOR THE CITY OF THE FUTURE
The car is a very popular form of transportation. But people are concerned by the levels of pollution it produces and the future scarcity of gas. Manufacturers are therefore designing cars with clean, fuel-efficient engines.

Lightweight body means engine has to do less work and so requires less fuel

ALTERNATIVE TO GAS
Scientists around the world are searching for alternatives to non-renewable and expensive fossil fuels. Alcohol, which is made from distilled grain, is one alternative to gas. It has been successfully used as fuel in countries without natural oil reserves.

Honda's solar car in the World Solar Challenge Race

POWERED BY THE SUN
A solar-powered vehicle uses solar cells to convert energy from the sun into electricity, which drives its electric motors. But solar cars are still little more than expensive novelties and fall short of the performance required by many drivers.



SOLAR POWER STATION
Solar energy has enormous potential, but it is costly to collect and difficult to convert and store. Flat-plate collectors are used in some homes for heating water, but because of the relatively low temperatures produced, it is not practical to convert the heat energy into electricity. Concentrating collectors (left) can focus sunlight onto a single point and generate temperatures high enough to power steam-turbine electric generators. A computer turns the dishes to make sure they face the sun throughout the day.

Streamlined shape allows wind to flow smoothly

Building supported by tripod megastructure

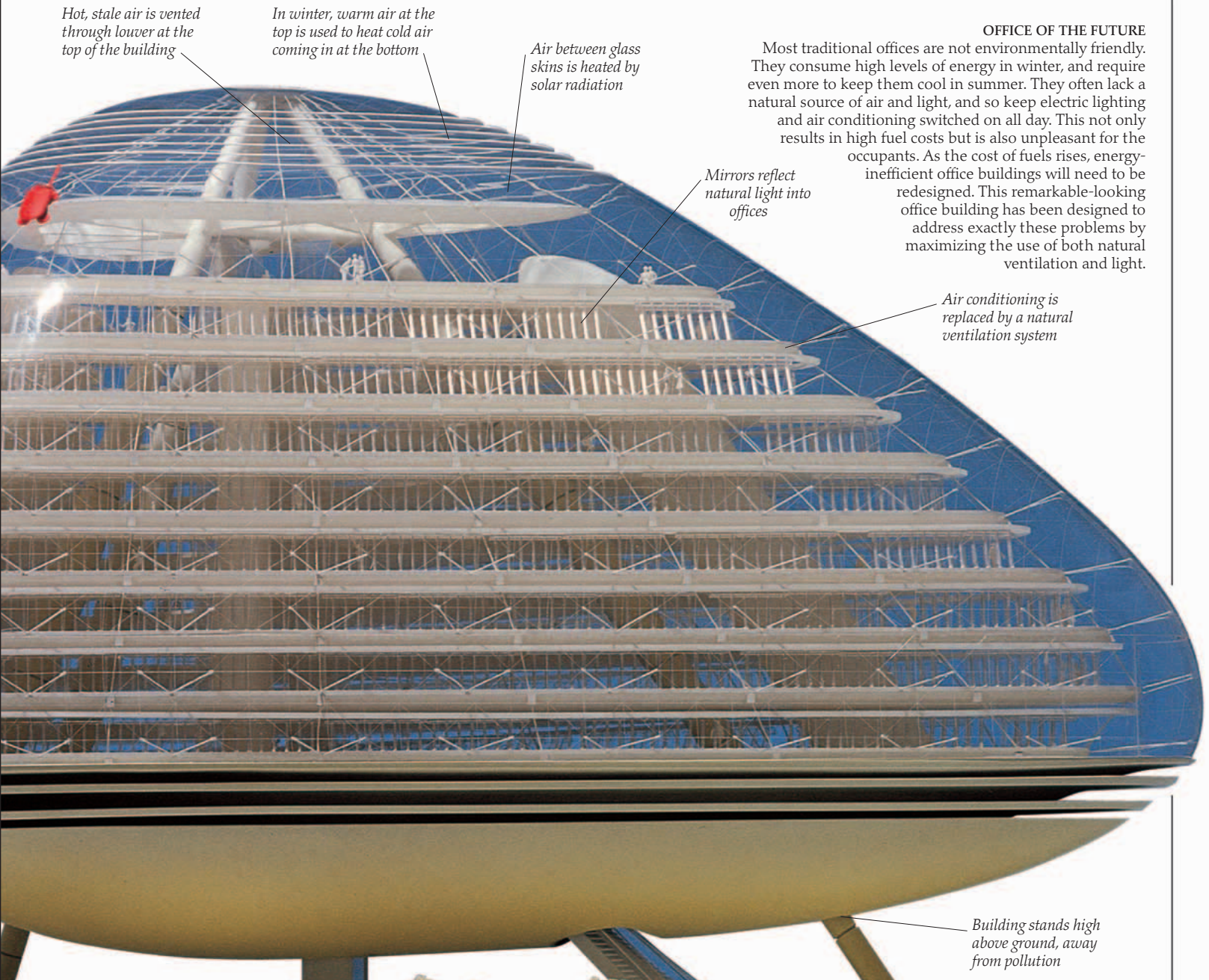
RECYCLING
Increasingly, people are becoming aware of the value of recycling. Today, we generate an enormous amount of waste, and there are increasing problems with its disposal. In the future, we will manufacture products that are built to last and can be repaired. They will be easily dismantled and reused in sometimes surprising ways (right) or at least disposed of safely and efficiently.

Rubber tire is removed from car

Tire ready to be re-formed after shredding

Handbag made from shredded car tire

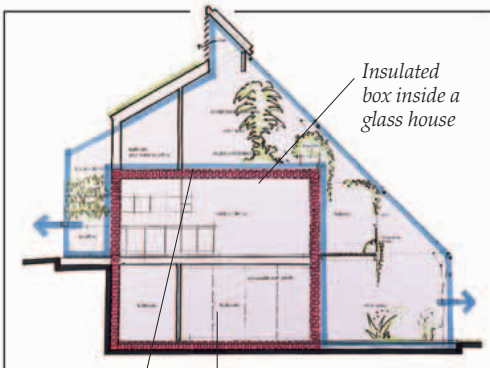
OFFICE OF THE FUTURE
Most traditional offices are not environmentally friendly. They consume high levels of energy in winter, and require even more to keep them cool in summer. They often lack a natural source of air and light, and so keep electric lighting and air conditioning switched on all day. This not only results in high fuel costs but is also unpleasant for the occupants. As the cost of fuels rises, energy-inefficient office buildings will need to be redesigned. This remarkable-looking office building has been designed to address exactly these problems by maximizing the use of both natural ventilation and light.



Continued from previous page

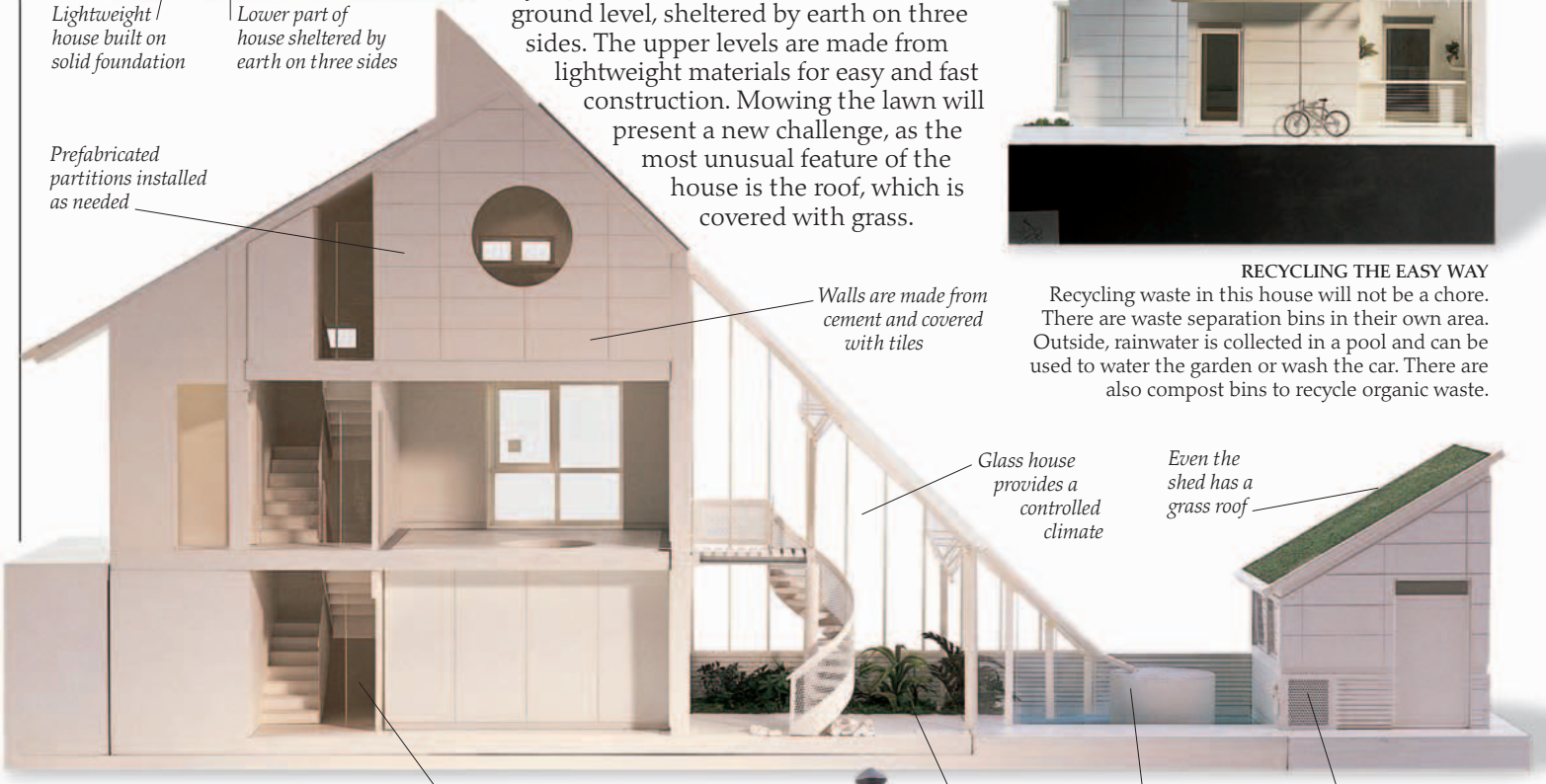
Home of the future

Most houses built today take advantage of energy-saving features, but few are as well-designed as the Integer Millennium House in England. This high-tech building dramatically reduces the consumption of natural resources. It is designed as a house within a house – an inner box surrounded by a glass house. The lower floor is below ground level, sheltered by earth on three sides. The upper levels are made from lightweight materials for easy and fast construction. Mowing the lawn will present a new challenge, as the most unusual feature of the house is the roof, which is covered with grass.



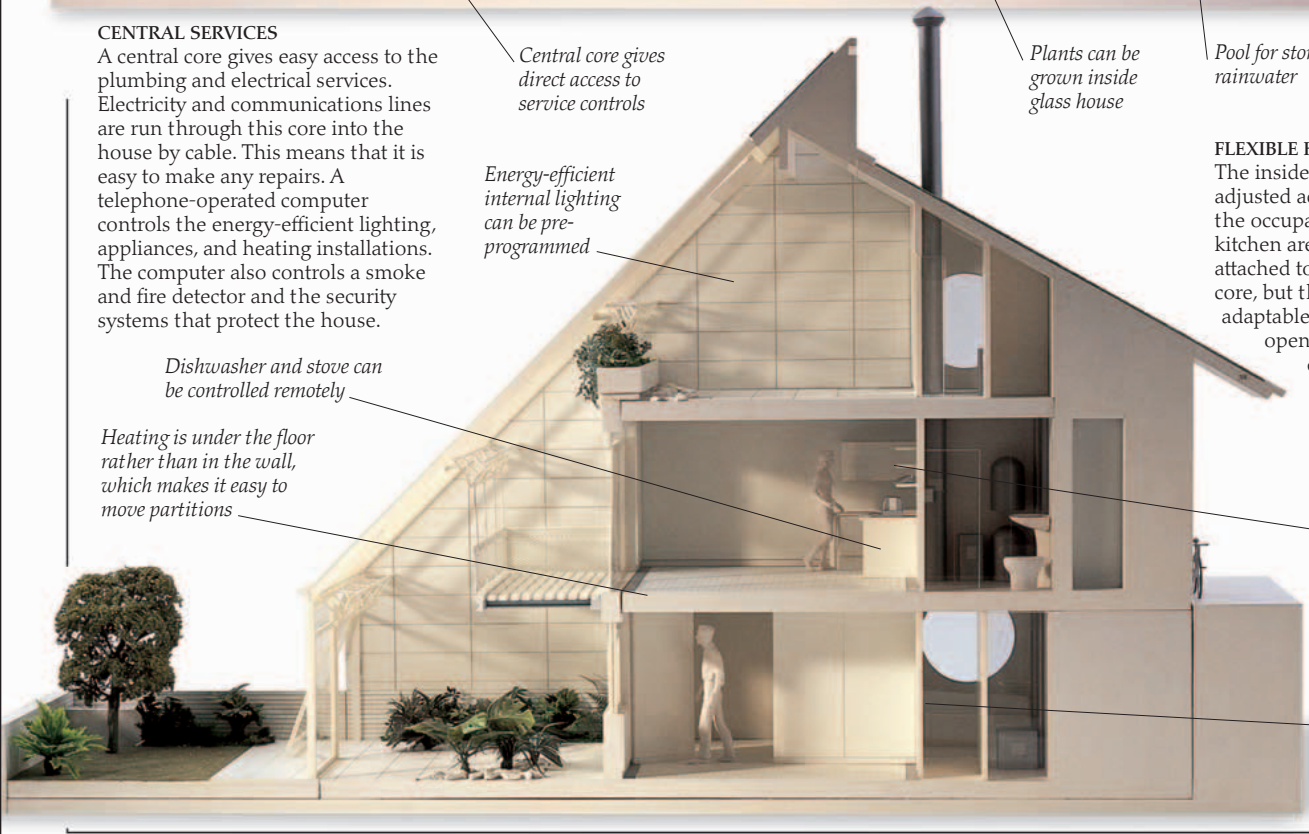
RECYCLING THE EASY WAY

Recycling waste in this house will not be a chore. There are waste separation bins in their own area. Outside, rainwater is collected in a pool and can be used to water the garden or wash the car. There are also compost bins to recycle organic waste.



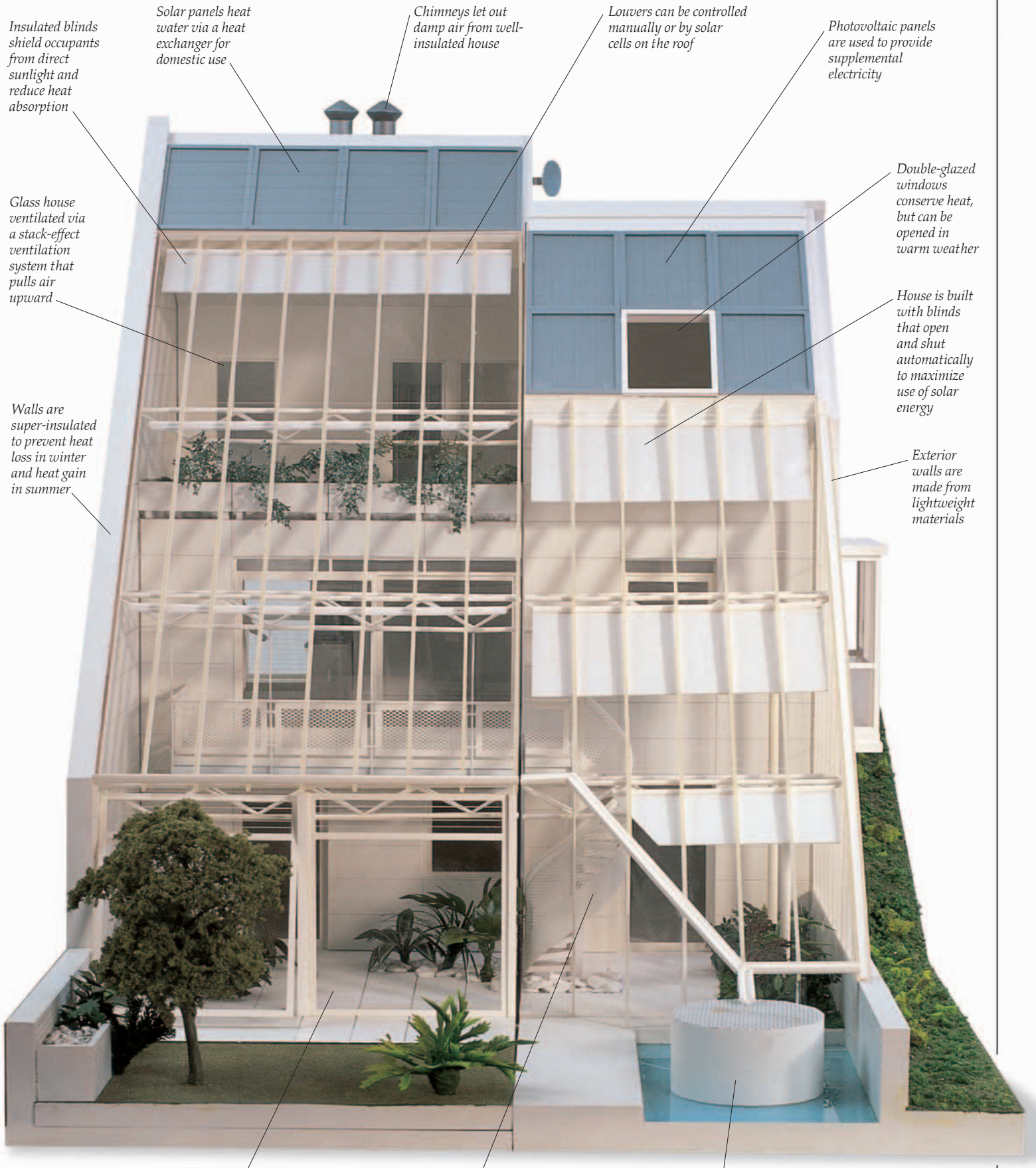
CENTRAL SERVICES

A central core gives easy access to the plumbing and electrical services. Electricity and communications lines are run through this core into the house by cable. This means that it is easy to make any repairs. A telephone-operated computer controls the energy-efficient lighting, appliances, and heating installations. The computer also controls a smoke and fire detector and the security systems that protect the house.



FLEXIBLE HOUSE

The inside of the house can be adjusted according to the needs of the occupants. The bathroom and kitchen are prefabricated and attached to the central services core, but the rest of the space is adaptable. The general structure is open, and partitions can divide the house, allowing the owners to change the number of rooms as needed.


Insulated blinds shield occupants from direct sunlight and reduce heat absorption
Solar panels heat water via a heat exchanger for domestic use
Chimneys let out damp air from well-insulated house
Louvers can be controlled manually or by solar cells on the roof
Photovoltaic panels are used to provide supplemental electricity
Double-glazed windows conserve heat, but can be opened in warm weather
Glass house ventilated via a stack-effect ventilation system that pulls air upward
House is built with blinds that open and shut automatically to maximize use of solar energy
Walls are super-insulated to prevent heat loss in winter and heat gain in summer
Exterior walls are made from lightweight materials
Whole front wall opens up, blurring distinction between inside and outside
Stairs lead down to the temperature-controlled garden
Rainwater collection system has a hand pump for watering garden

Futuropolis

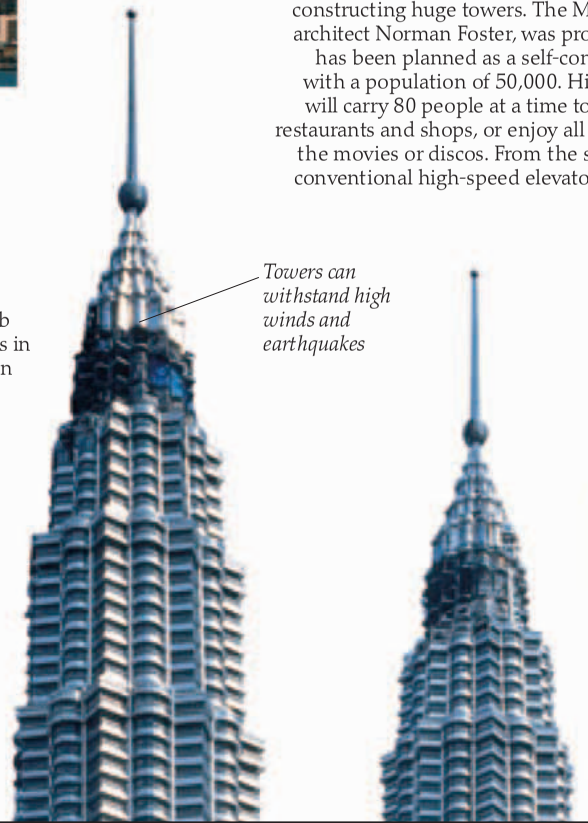
FLYING CITIES
This is how one visionary of 1929 saw New York in the future – as a traveling city suspended high above the ground. The nearest we are likely to come to cities in the sky are spaceships that will orbit the Earth.

PEOPLE HAVE TRADITIONALLY BEEN ATTRACTED to living in cities because of the cultural and economic opportunities they offer. It will not be long before most people become urban dwellers. It will be necessary to build new cities and rebuild existing cities to accommodate the huge increase in the world's population. These cities will need to be planned very carefully and existing transportation systems will have to be redesigned. High-rise offices and apartment towers, taller than ever before, will become self-contained, with their own shops, restaurants, and leisure facilities. They will operate like small towns, and the occupants will rarely need to leave them. The pollution caused by increased numbers of people will need to be managed, so the internal combustion engine will be banned and buildings will be energy-efficient, making use of renewable energy.

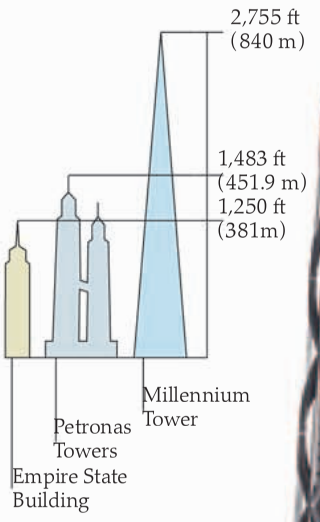
BUILDING HIGH
Today's Manhattan skyline demonstrates one architectural solution to the lack of space. Some of the world's tallest buildings are among those that crowd the island city of New York. The high price of land in the city encouraged architects to construct tall steel-framed skyscrapers on small lots.

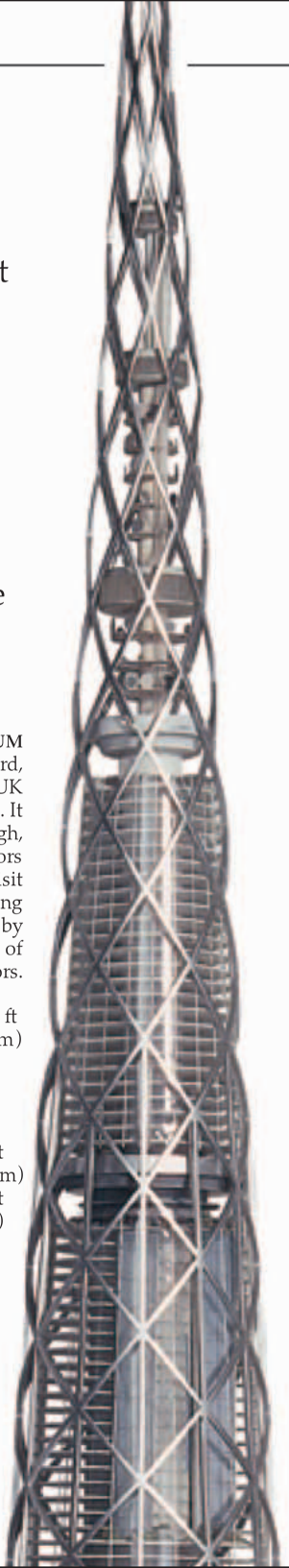
HOTELS OF THE FUTURE
Huge numbers of Japanese commuters often stay in Tokyo's extraordinary space-saving hotels overnight. Each individual sleeps in a capsule that is air-conditioned and equipped with a television and washing facilities.

Honeycomb hotel rooms in Tokyo, Japan



CITY-BUILDING FOR THE NEW MILLENNIUM
One answer to potential overcrowding is to build upward, constructing huge towers. The Millennium Tower, designed by UK architect Norman Foster, was proposed for a site in Tokyo, Japan. It has been planned as a self-contained township 150 stories high, with a population of 50,000. High-speed double-decker elevators will carry 80 people at a time to "sky centers," where they can visit restaurants and shops, or enjoy all forms of entertainment, including the movies or discos. From the sky centers, residents will travel by conventional high-speed elevators to their apartments or places of work on the other floors.





A FUTURE UNDERGROUND
Carrying services below ground is not new – underground trains have been in use for more than a century. To save space in future cities, all vehicles and services could travel below ground.

PETRONAS TOWERS
The 88-story energy-efficient Petronas Towers in Kuala Lumpur, Malaysia, are the world's second-tallest buildings after Taipei 101 in Taiwan, which stands 1,670 ft (509 m) tall. The towers are used as offices, but also have a shopping center, a science center, an art gallery, and a concert hall.

Guest rooms are on a wheel that rotates three times a minute

Restaurant and sports area

Elevator shaft leads to hotel

VACATIONS IN SPACE
By the year 2020 there may be space hotels orbiting the Earth 280 miles (450 km) above its surface. A special shuttle service will carry guests to and from Earth as well as on sightseeing tours to the Moon.

Sky center for communal activities every 30 floors

Apartments and offices occupy other floors

Large glass windows to provide light to every floor

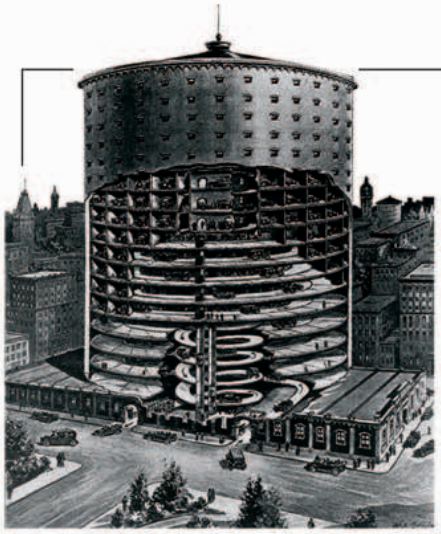
Sky bridge connects floors 41 and 42

Cone shape supported by steel frame

Marina apartments

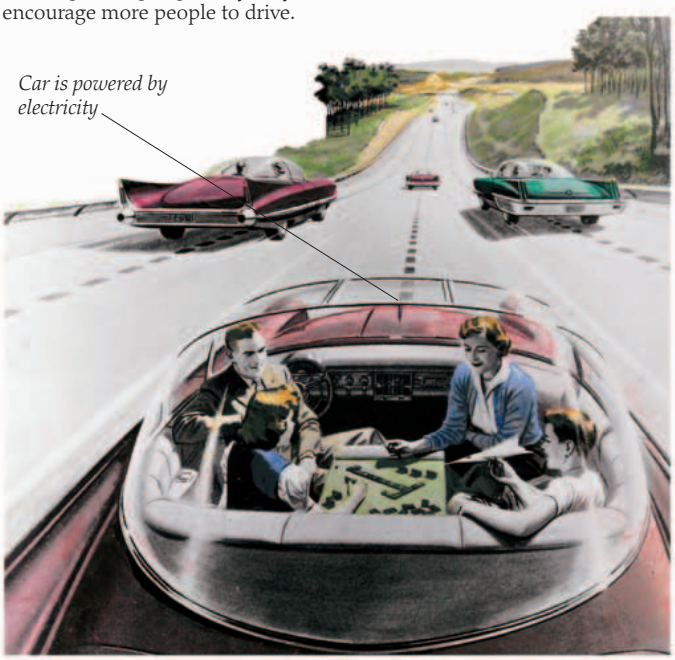
Architectural model of Millennium Tower, Tokyo

Traffic control

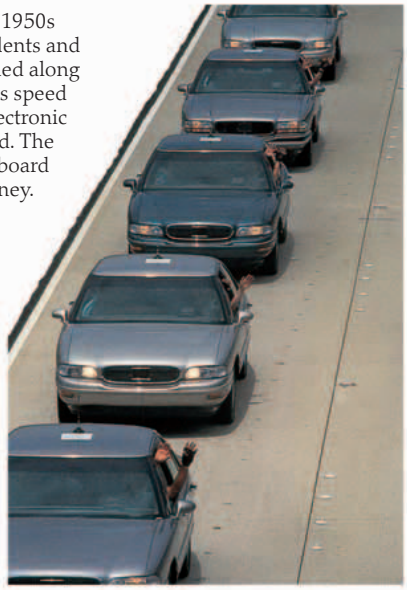


ACCURATE PREDICTION
As early as 1919, it was already obvious that the number of cars in densely populated cities was going to cause parking problems. The suggested solution, a multi-story parking garage, is now a familiar sight. Unfortunately, building more garages may only encourage more people to drive.

THE FREEDOM TO TRAVEL IS VALUED highly, yet it is essential that we reduce fuel consumption, control pollution, and manage our busy roads. In the future, journeys will be planned in advance for optimum efficiency. By displaying position data on a digital map, a satellite-linked navigation system will ensure that drivers know their exact location. They will simply indicate their desired destination, and the car will provide detailed instructions on the best way to get there. A powerful onboard computer will monitor the car's movements, and will take action, such as turning off the engine if erratic driving indicates that the driver is about to fall asleep. On long-distance journeys, it will be possible to drive on an automated highway where the car will travel in a convoy, its speed and steering controlled by the computer. In the air, improved tracking systems will mean that more aircraft can travel safely without crowding or collisions. The Future Air Navigational System (FANS) will allow pilots to switch routes to take advantage of jet streams, which will speed up travel across the world as well as saving on fuel.



ELECTRICAL HIGHWAY
This advertisement from the 1950s suggests a future free of accidents and traffic jams. The car is propelled along an electrical superhighway, its speed and steering controlled by electronic devices embedded in the road. The family just sits back, playing board games and enjoying the journey.

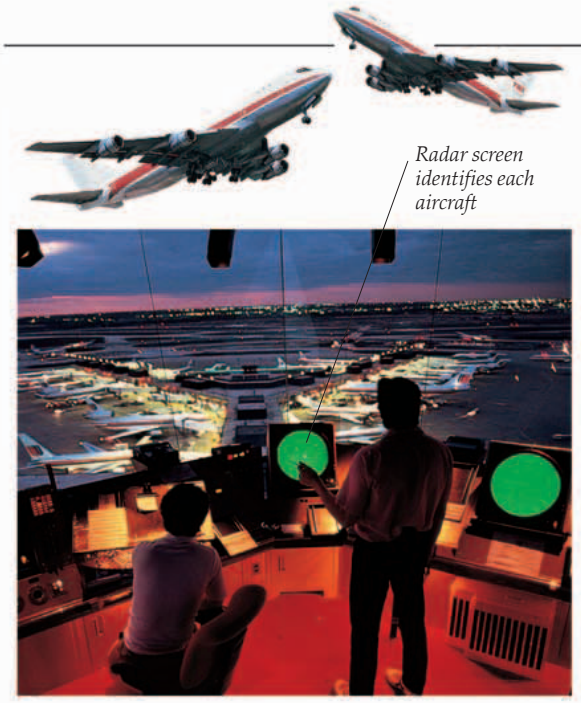


AUTOMATED HIGHWAY
Today the automated highway is becoming a reality. Experiments are taking place with cars that can steer, accelerate, and brake by themselves. They are fitted with computers that pick up signals from magnets set in the road. They are designed to travel in convoys along designated stretches of highways.

Using this computer simulation, researchers can predict the behavior of drivers under different conditions

THE FUTREX MONORAIL
A U.S. company has developed a revolutionary new monorail transport system nicknamed "The Beam." The cars are hung on the side of the rail, rather than on top, so monorails can travel in opposite directions on either side of the beam.

The system is capable of carrying around 12,000 passengers per hour

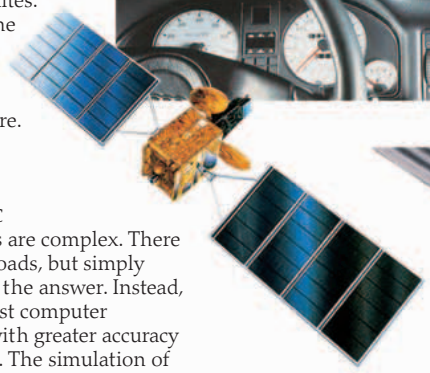


Radar screen identifies each aircraft

BEING GIVEN THE ALL-CLEAR
Like the roads, the skies are becoming overcrowded; serious accidents can even happen while planes taxi to and from the runway. A new generation of radar systems, combined with powerful computers, track and predict aircraft movements in advance, making it easier for traffic controllers to select flight paths. The new safety systems will control the location of all aircraft, whether they are on the ground or in the air.

IN-CAR NAVIGATION SYSTEM
Imagine driving a car that never lets you get lost. There will soon be onboard mapping facilities in all new cars. This system (right) uses a CD-ROM to store maps and receives location signals from global positioning satellites. The driver types in the destination, the computer works out the best route, and a digitized voice provides instructions on how to get there.

Arrow on screen indicates the direction in which to drive



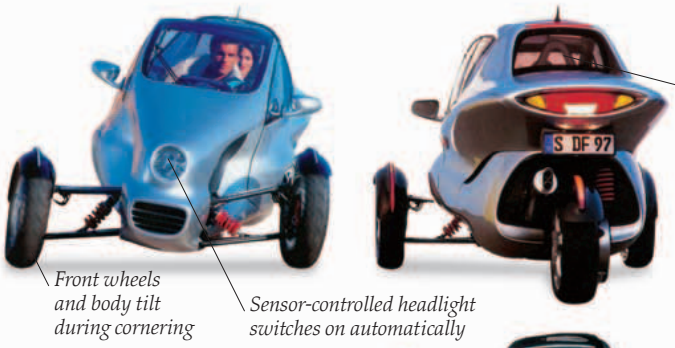
UNJAMMING THE TRAFFIC
The reasons for traffic jams are complex. There are too many cars on the roads, but simply building more roads is not the answer. Instead, planners are using the latest computer technology to determine with greater accuracy the reasons for traffic jams. The simulation of traffic patterns (left) takes into account a variety of factors affecting the actual traffic (right). These include changing weather conditions, different types of vehicles and driving styles, breakdowns, and accidents. This information is studied in order to better plan additional roads, control traffic speeds, and provide alternative routes.

This analysis shows the flow of traffic on a busy highway intersection

Getting around

BEAT THE TRAFFIC
This 1923 illustration shows how future urban congestion will be solved by using "torpedo" cars to carry passengers above the busy streets.

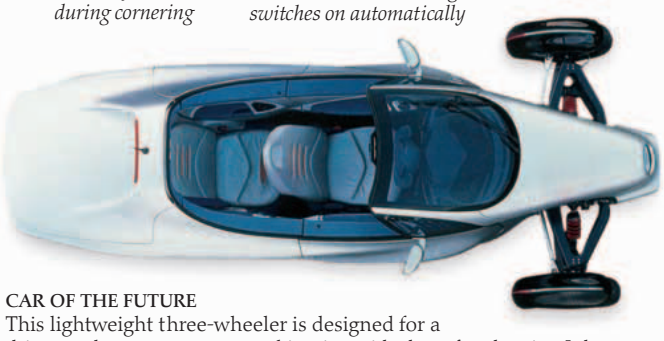
OUR DESIRE TO TRAVEL will not diminish in the 21st century – in fact, it is likely to increase. More people will own cars, so roads will become more congested. We will want to move around the world more quickly, but the skies will be in danger of becoming crowded with aircraft. Attention is now focusing on how to ease these potential problems (pp. 24-25). Train travel will be faster and much more economical, providing passengers and freight with an alternative to jammed highways. And giant airplanes that travel at hypersonic speeds – five times faster than *Concorde* – may one day take passengers around the world in a fraction of the time it takes today.



Computers calculate the optimum tilt angle in relation to speed

Front wheels and body tilt during cornering

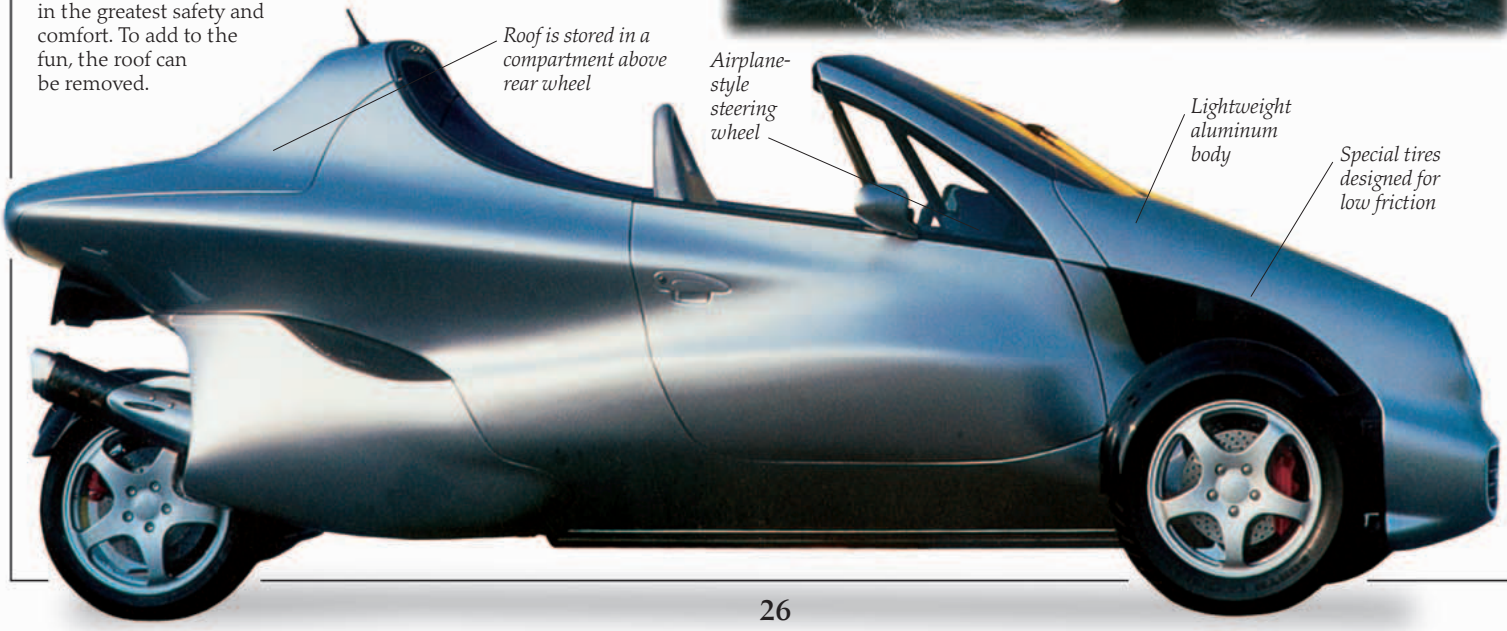
Sensor-controlled headlight switches on automatically



CAR OF THE FUTURE
This lightweight three-wheeler is designed for a driver and one passenger, making it an ideal car for the city. It has an onboard computer that calculates the highest cornering speeds, and the front wheels and body lean when the car is cornering. This provides the maximum speed in the greatest safety and comfort. To add to the fun, the roof can be removed.

Solar panels provide energy

SAILING ON A WING
Ships will probably remain the most reliable means of transporting commercial goods from continent to continent. But shippers are still looking for ways of cutting back on fuel consumption. Some tankers and yachts have already been equipped with computer-controlled wingsails. These unusual-looking sails can save on fuel costs. They are able to survive hurricanes at sea and wind speeds of 100 knots.

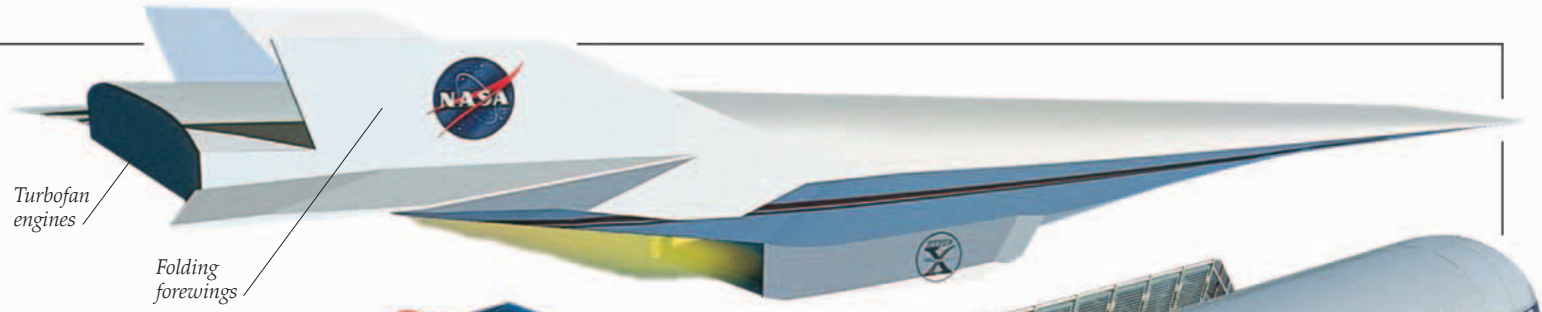


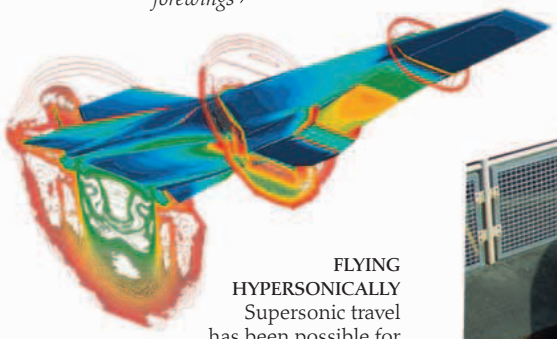
Roof is stored in a compartment above rear wheel

Airplane-style steering wheel

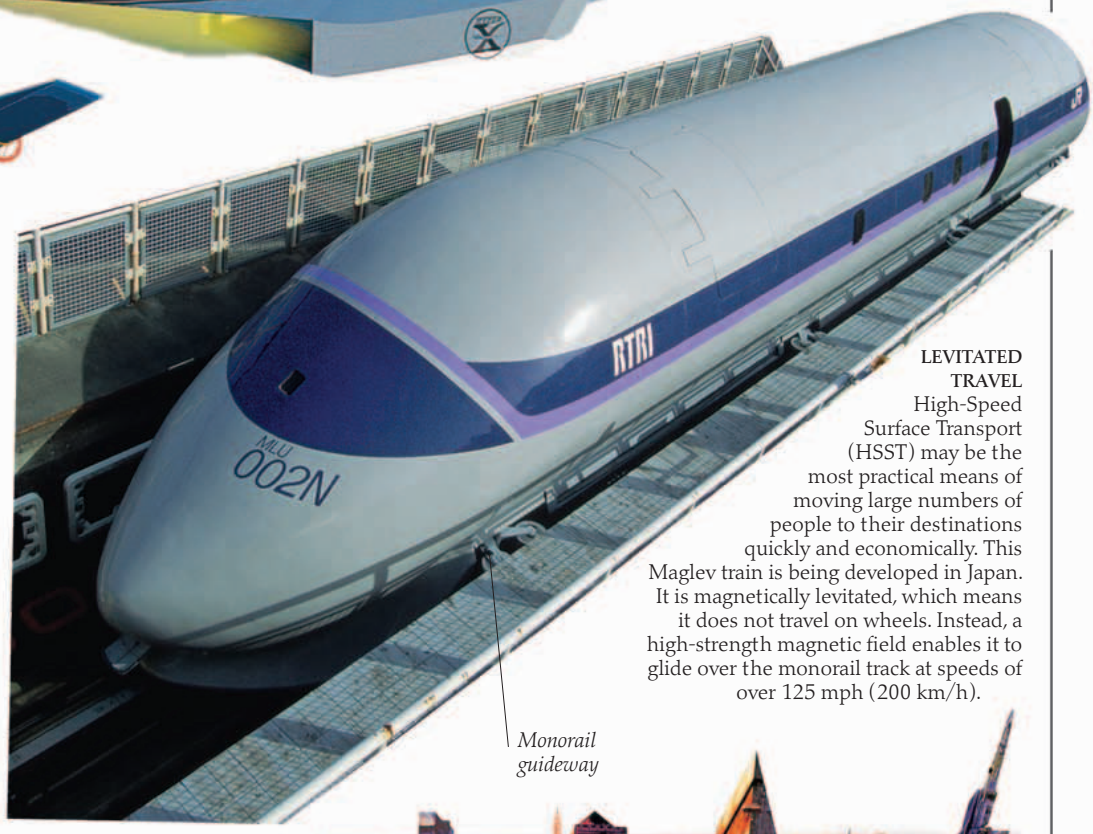
Lightweight aluminum body

Special tires designed for low friction

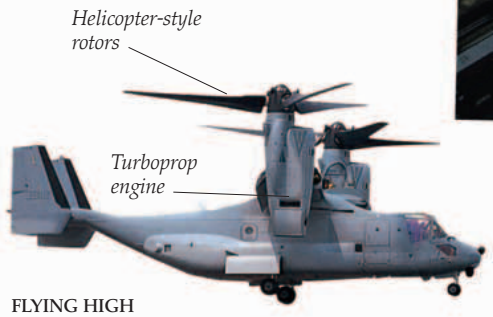




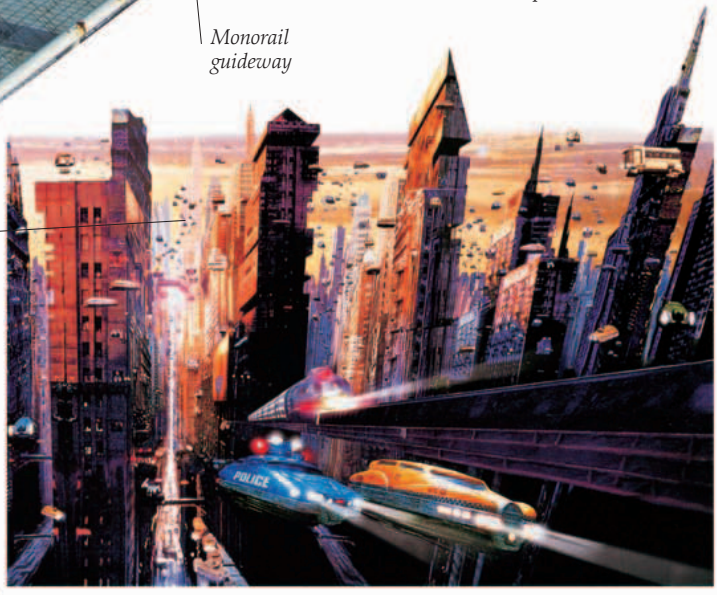
FLYING HYPERSONICALLY
Supersonic travel has been possible for transatlantic passengers since the mid-1970s when the British and French built *Concorde*. NASA is now developing the Hyper-X to fly at hypersonic speeds – five times faster than the speed of sound. It will be unpiloted and launched from a B52 aircraft. Other countries are developing larger and faster versions for the 21st century.



LEVITATED TRAVEL
High-Speed Surface Transport (HSST) may be the most practical means of moving large numbers of people to their destinations quickly and economically. This Maglev train is being developed in Japan. It is magnetically levitated, which means it does not travel on wheels. Instead, a high-strength magnetic field enables it to glide over the monorail track at speeds of over 125 mph (200 km/h).



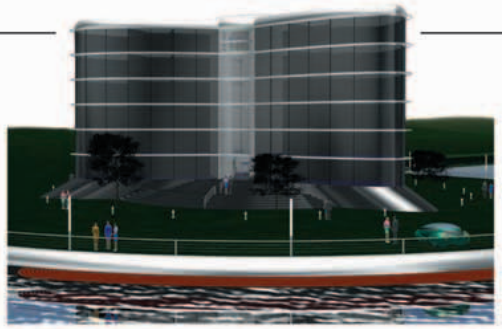
FLYING HIGH
The tilt rotor, used by the military, takes off like a helicopter but flies like a plane. Its wings have helicopter-style rotors, which can be raised into a vertical position for take-off. The tilt rotor would be particularly useful in urban environments because it can take off and land in small spaces, and a passenger version for commercial, short-haul flights will probably become a popular form of transportation in the early 21st century.



TAKING TO THE SKIES
The mass use of private aircraft has never been a practical proposition. But as roads become more and more congested, more people may be forced to take to the skies. Cities of the future may be congested with flying cars, as in the science fiction film *The Fifth Element* (1997).

WHEN IS A CAR NOT A CAR?
Many people think it is time we found a replacement for the gas engine. Concept 2096 is truly a vehicle of the future. The vehicle does not have wheels. Instead, it floats off the ground on cushions of air and is powered by magnets using an electric current. It is driven by a navigational computer, so there is no need for a driver, brakes, or a steering wheel. With a vehicle like this, pollution will be a thing of the past. It will use rechargeable fuel cells, a clean substitute for gas and diesel fuel.

Virtual home in 2020



IDEAL HOME
By the year 2020, some of us might be lucky enough to live in homes with all the latest technology. They will be built from durable materials that require little maintenance. Fully automated, they will react changes in the weather and adjust heating and cooling controls to maintain a pleasant environment.

HOMES OF THE FUTURE will be considerably different from those of the 20th century. They will be energy-efficient and simple to clean and maintain. They will have access to the outside world via a global communications network, making it easy to run a business, do the shopping, and plan a winter vacation, all from the comfort of a living room. There will be an integrated management system, with heating, lighting, and security controls that react to the needs of the occupants. The walls will be constructed from new interactive materials that are able to change appearance at the touch of a button to suit a particular mood, while high-resolution wraparound video screens and holographic projectors will provide fun and entertainment for the whole family.

HOMEWORK HELPER
"Holojectors" (holographic projectors) will be used for fun or as homework helpers. 3-D models could help solve difficult geometry problems.

Scanner in walls of shower connects to health center

POWER SHOWER
A health-and-hygiene station will scan and monitor your well-being while you shower. It will be linked directly to a health center that has a complete record of your family's medical history.

SOMETHING FOR EVERYONE
The dining table will have a multitude of uses. Linked to a communications system, its screens will display newspapers and the latest world news, and allow you to make contact with distant friends and family while you eat.

Interactive screen

It will be possible to take classes via hologram

Interactive on-line book with flexible screen

"IT'S GOOD TO TALK"
Portable telephones will still be used for business and pleasure, but by the year 2020, they will all be videophones. Increased bandwidth will allow more and more digital information to be sent over the airwaves.

High-resolution video image

Nanorobots the size of spiders will roam the carpets, keeping them clean and free of dust

Furniture will be made of special self-cleaning materials

RELAXATION SERVICE
The future family will be able to relax using a therapy couch. Sensitive arms and rollers will gently massage tired body parts, easing away aches and pains. The couch will be linked to a special physiotherapy service, which will give expert advice on health, diet, and exercise.

Screen displays advice

Massage rollers move the length of the couch

Virtual station combines thought control technology with artificial sensory feedback

VIRTUAL REALITY TRAINER
The 2020 home will have its own virtual reality machine. With this, the family will be able to practice dangerous sports such as mountain climbing or bungee jumping, or visit exotic locations on a virtual vacation at the touch of, a button.

WRIST SET
Unlike conventional watches, which only tell the time and date or do simple computing tasks, this wrist set will provide information the wearer desires, for example, the sports scores or traffic reports. Such functional electronic gadgets may even replace traditional decorative jewelry.

Clip-on wristband

Walls of house change image to suit mood

VIRTUAL REALITY HEADSETS
In the future, headsets linked to camcorder technology will be able to record your experiences with stereo sound. Using virtual reality headsets, it will be possible to experience 3-D images for pleasure, learning, or business.

Thought recognition sensors

WORK STATION
Working from home is already a popular alternative for many people. In the future, small work stations will provide full access to everything needed to conduct daily business affairs, from e-mail to video conferencing.

Single-function robots have already been designed

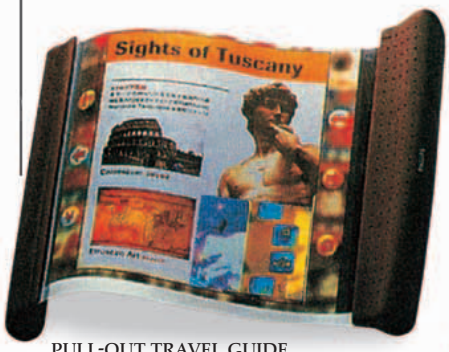
Chair-based work stations will replace the traditional office

ROBOT SERVANTS
Imagine having an addition to the household that always does what it is told. Single-function robots such as vacuum cleaners or lawn trimmers will perform simple tasks around the home. A table that comes to you when it is called will certainly be useful, but it will be better still if it takes away dirty glasses and loads them in the dishwasher.

Easy living

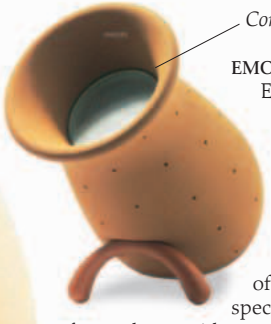
IMAGINE STANDING AT a bus stop when, suddenly, your "hot badge" signals that the person behind you likes the same music you do. It might be all you need to know to start a conversation and become friends. Our everyday lives may soon be changed forever because of clever inventions like this one. On these two pages are some ideas of what technology may offer us in the next century. Friendly robots will learn how to perform simple tasks and develop unique personalities. Some jobs, such as shopping or going to the bank, can already be done from home on the Internet, and soon we will be able to consult a doctor in the same way. Travel will be more fun with electronic travel guides and "ear-ins" that translate foreign languages.

SHOP FROM HOME
Shopping from home has been possible for some time, first through mail-order catalogs and then through television. It is only recently that Internet shopping has become popular, although it is not quite like the 1950s image of the future pictured here.

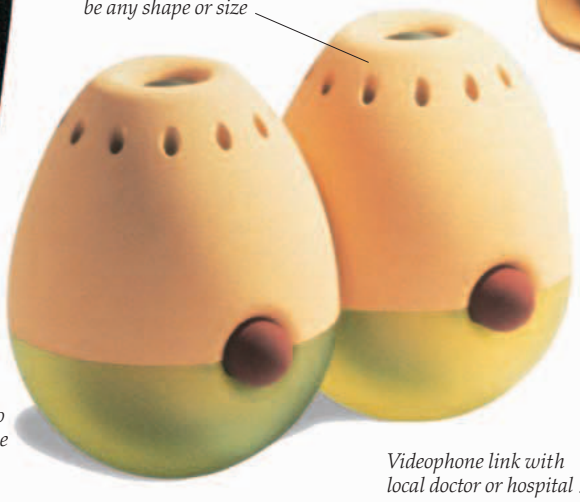


PULL-OUT TRAVEL GUIDE
In the future, finding your way around will be easier with this travel guide. It has a built-in destination planner and provides information about the country you are visiting. The information will be shown on a flexible pull-out screen.

Containers are decorative objects



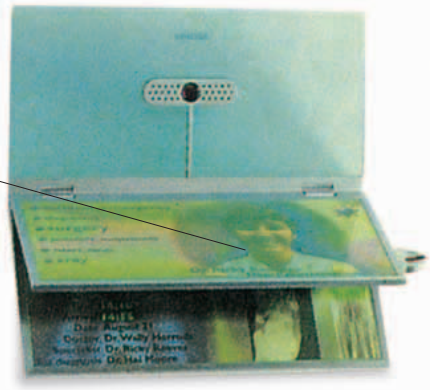
Emotion containers can be any shape or size

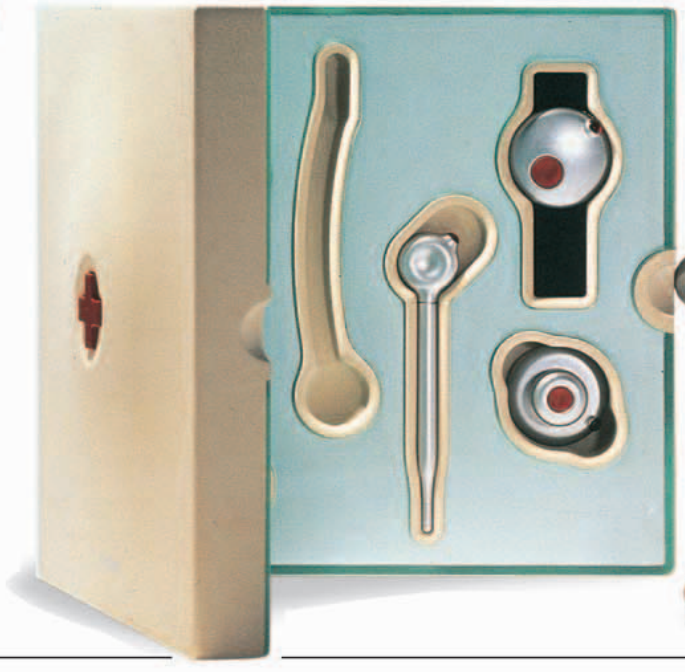


EMOTION CONTAINERS
Emotion containers will be precious gifts. They will be pleasing to look at and made from valuable materials. But they will be much more than that. Each will have a small screen, a loudspeaker, and a scent compartment. The giver of the gift will be able to record a special moment on it, such as a clip from a home video or a baby's first words, for instance. The giver can even include a favorite scent. The moment is captured for the recipient to enjoy.

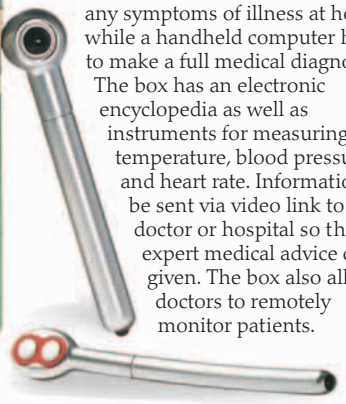
All you have to do is drop the trash in here

Videophone link with local doctor or hospital

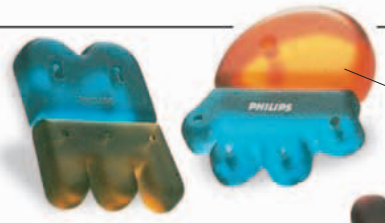




THE HOME MEDICAL BOX
The home medical box will check any symptoms of illness at home, while a handheld computer helps to make a full medical diagnosis. The box has an electronic encyclopedia as well as instruments for measuring temperature, blood pressure, and heart rate. Information can be sent via video link to a local doctor or hospital so that expert medical advice can be given. The box also allows doctors to remotely monitor patients.



INTELLIGENT GARBAGE CAN
Recycling can be a problem, but in the future dealing with trash will be less messy. The intelligent garbage can is designed to sort trash, keep it from smelling, and make it into compact parcels ready for collection and recycling.



Hot badges glow when they "see" a friend

MAKING FRIENDS
Hot badges will brighten up your social life. These short-range communication devices are loaded with personal information. They broadcast your personal profile and receive other badges' broadcasts. If two profiles match, the badges will signal their wearers.

SMART CARDS
Cash will become a thing of the past; carrying smart cards in a wallet will be safer. Fingerprint or voice recognition technology will ensure the card can only be used by its owner. Small credit-card-sized screens will display personal photographs.

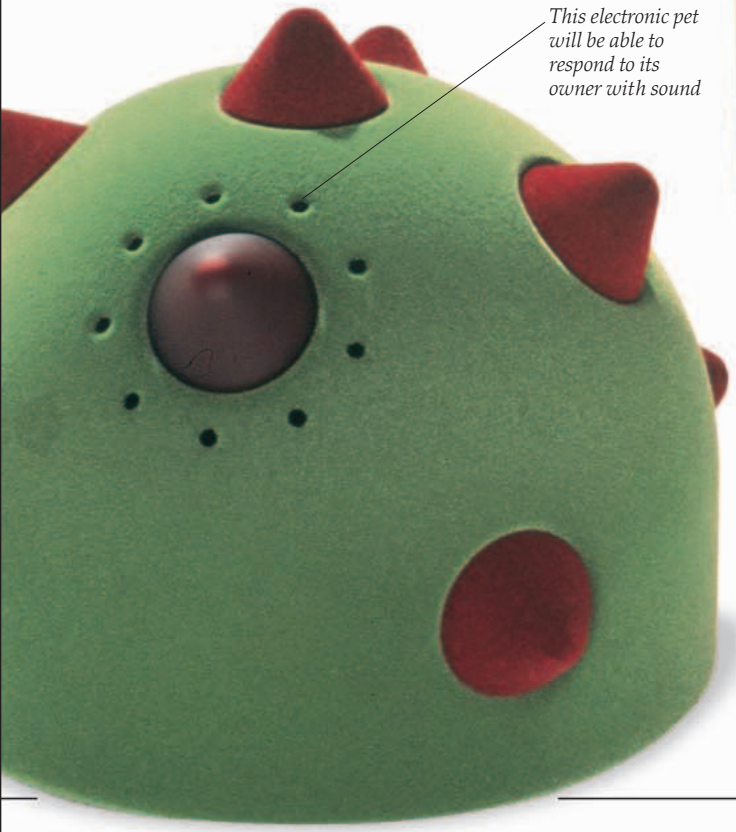
Video screen for photographs

Card carries all personal details

EAR-INS
What if hot badges signal that you like the same music, but it turns out that we speak different languages? This will not matter with "ear-ins." These small devices fit snugly into the human ear and can translate simultaneously from one language to another.

Touchpad

YOUR PERSONAL INTERNET
This gadget is designed for teenagers. It is a communications device that also gives access to entertainment, like music and videos, and information services, such as libraries. It will help with homework projects, but can also be used to communicate with friends.



This electronic pet will be able to respond to its owner with sound

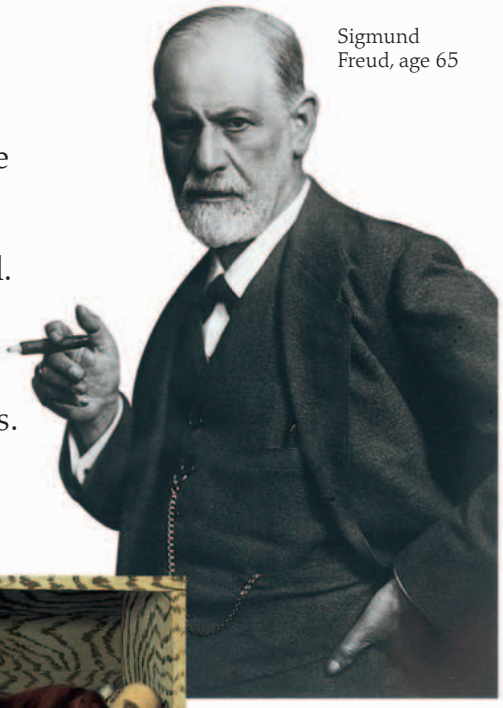
Electronic pets can be any shape

ELECTRONIC PETS
When we think of robots, we tend to think of the functions they can perform. Robots that can do the washing and ironing or teach you how to play tennis have obvious advantages. But we rarely think of robots as cuddly friends. This is where these robots are different. They are designed to be companions rather than servants. They are capable of responding to emotional needs, and react to voice commands as well as touches or gestures. They have sensors, so they can become familiar with their homes. Like animal pets, they like to be loved.

All in the mind

BRAIN POWER
For centuries, scientists and philosophers believed that different mental activities could be attributed to specific regions of the brain, as in this 17th-century illustration. However, it is now clear that the regions often depend on each other. While one area of the brain may be crucial for vision, another may be needed to interpret visual information.

THE BRAIN IS THE MOST COMPLEX organ in the human body – and the least understood. Even with today's sophisticated medical technology, our knowledge of how it works remains limited. Brain waves can be measured using an electroencephalograph (EEG). Through a technique known as biofeedback, it is even possible to control and alter brain wave patterns. These changes in signal can then be monitored by a computer and used to operate electronic devices, such as a television screen. The brain also stores our memories and governs our emotions. Understanding people's thoughts and feelings is still the subject of psychological theories, such as psychoanalysis. However, scientists are also exploring methods for recording life as we experience it by connecting computer chips directly to the brain. Thus, there is the possibility that one day we will record all our thoughts and emotions on a computer chip. A person's experiences will be stored as electronic data for anybody to watch.



Sigmund Freud, age 65

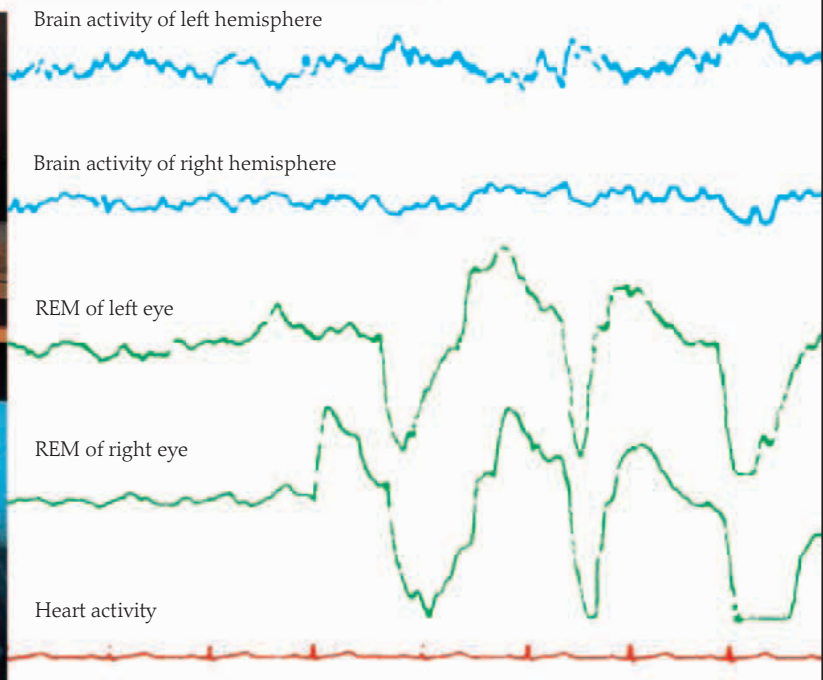
INTERPRETING DREAMS
Sigmund Freud (1856-1939) founded the science of psychoanalysis, a method of analyzing and treating mental illness. He stated that our lives are influenced by both conscious and unconscious thoughts. He believed that through the interpretation of dreams we can gain insight into the unconscious mind.

DREAMS IN ART
Artists have often tried to express the mysteries of the mind through art. Surrealist artist René Magritte (1898-1967) used Freud's theories to explore the unconscious mind through painting.

The Reckless Sleeper (1927)

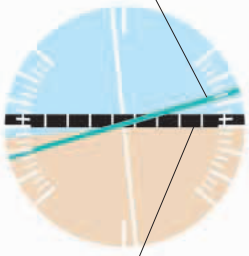
SLEEP PATTERNS
There are two distinct types of sleep: rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep. During REM sleep, there is a great deal of eye, body, and brain activity associated with dreaming. During NREM sleep, eye, body, and brain activity varies. In deep sleep, breathing and heart rate slow down and blood pressure drops. Sleep patterns alternate between periods of REM and NREM.

Electrodes connected to monitoring machines measure brain activity



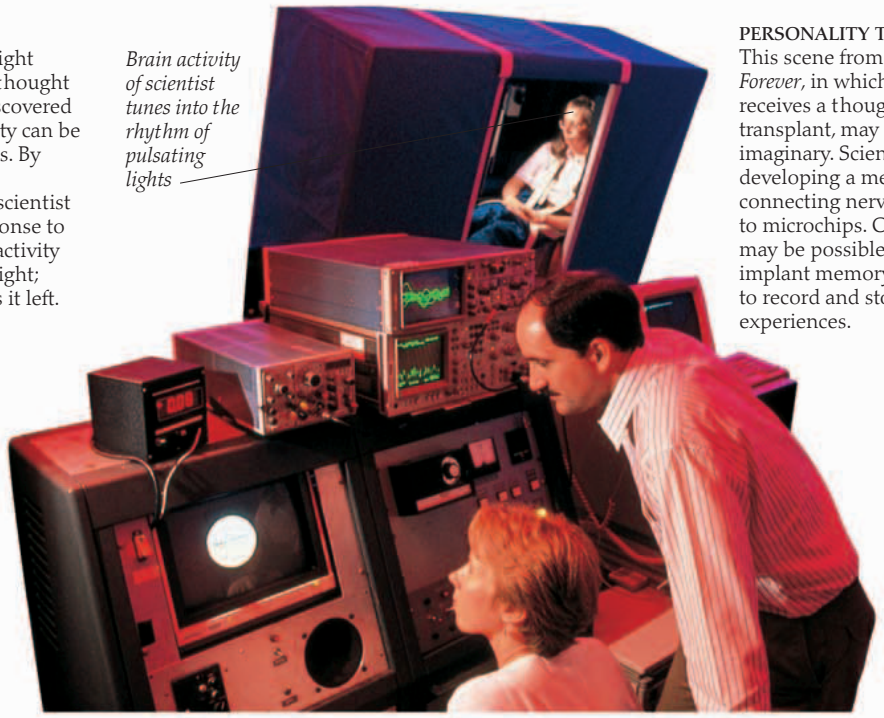
STEERING POWER
This woman is steering a flight simulator by the power of thought alone. Researchers have discovered that patterns of brain activity can be activated by pulsating lights. By using skilled biofeedback techniques, this particular scientist can control her brain's response to the lights. Increased brain activity turns the simulator plane right; reduced brain activity turns it left.

Green line indicates movement of plane against horizon



Scientist controls dial in simulator

Brain activity of scientist tunes into the rhythm of pulsating lights



PERSONALITY TRANSPLANT
This scene from the film *Batman Forever*, in which Jim Carrey receives a thought-wave transplant, may not be entirely imaginary. Scientists are developing a means of connecting nerve endings to microchips. One day, it may be possible to implant memory probes to record and store experiences.

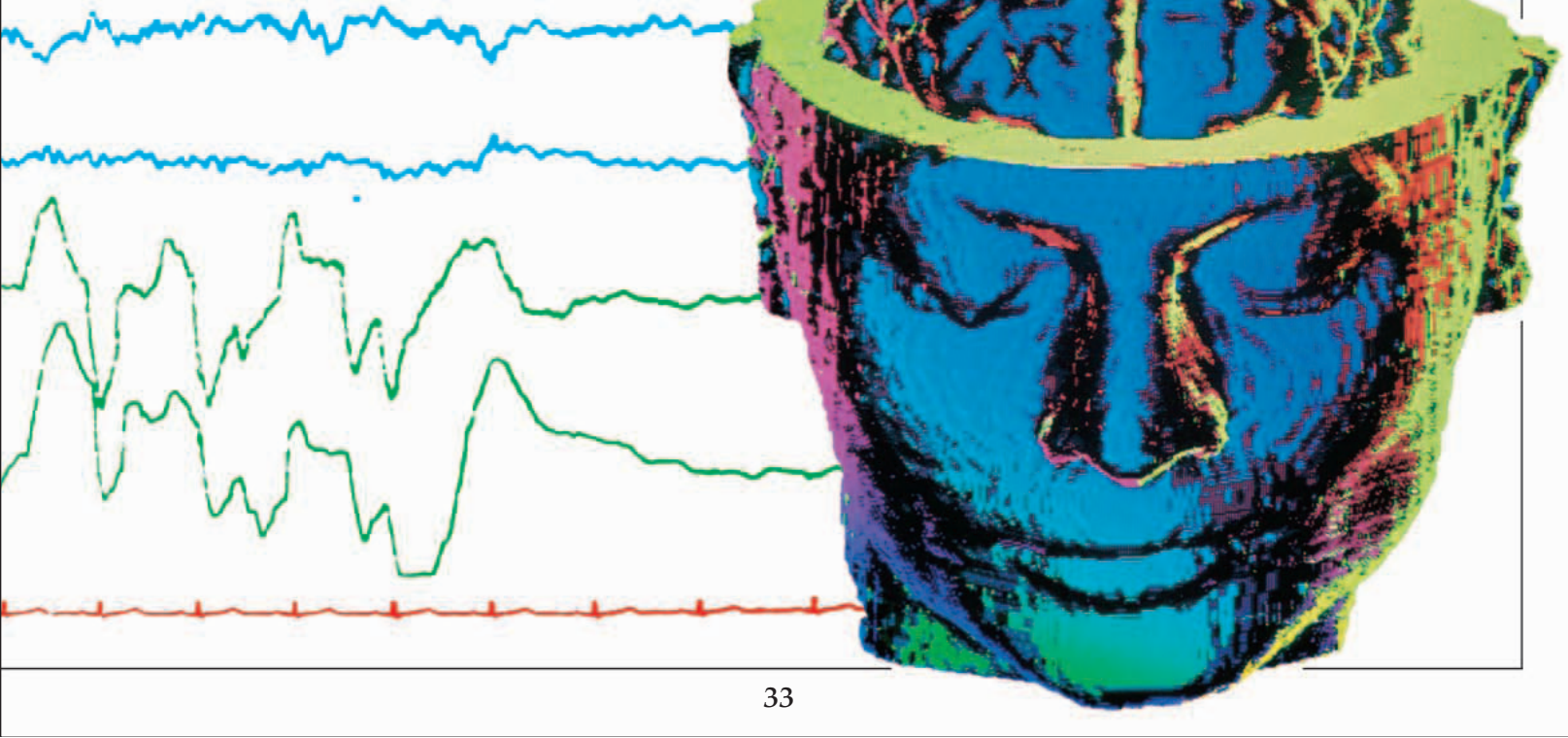
Wearer lights up icon through concentration

MIND OVER MATTER
Japanese scientists have produced a device that can detect changes in the beta waves produced by the mind when it is alert. These changes are picked up, amplified, and sent to a computer, which is linked to a control panel. By learning to control the brain waves, it is possible to operate switches on anything from a television to a central heating system.

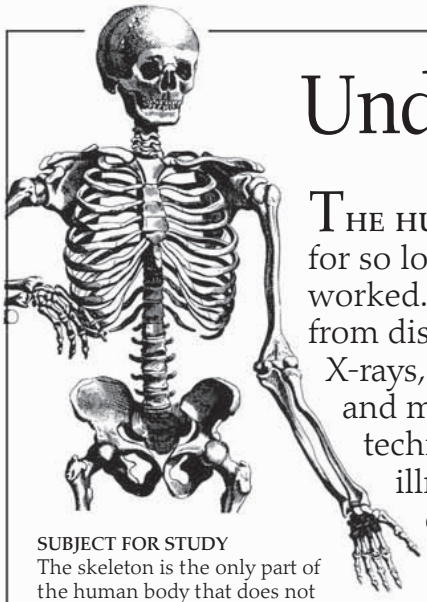
Electrode in goggles picks up changes in the beta waves

Different parts of the brain control different functions

INSIDE THE BRAIN
Today's advanced technology allows us to see right inside our own heads and understand more about what is going on there. This computer-generated view of a head with the "lid" taken off shows the parts of the brain that control most complex functions.

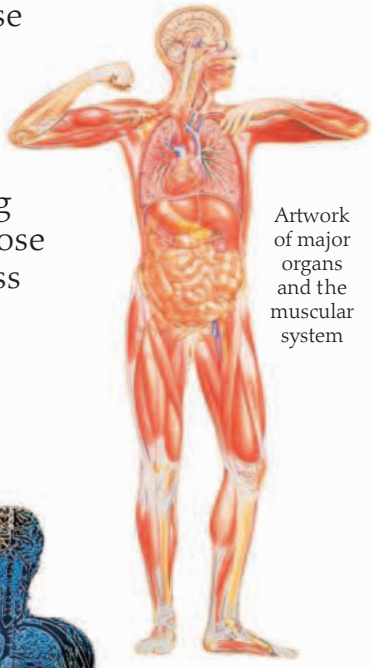


Understanding our bodies



SUBJECT FOR STUDY
The skeleton is the only part of the human body that does not decay quickly after we die. It defines our shape, allows us to walk upright and is the frame that supports our body. To understand how it worked, our ancestors had to cut up dead bodies to examine the bones.

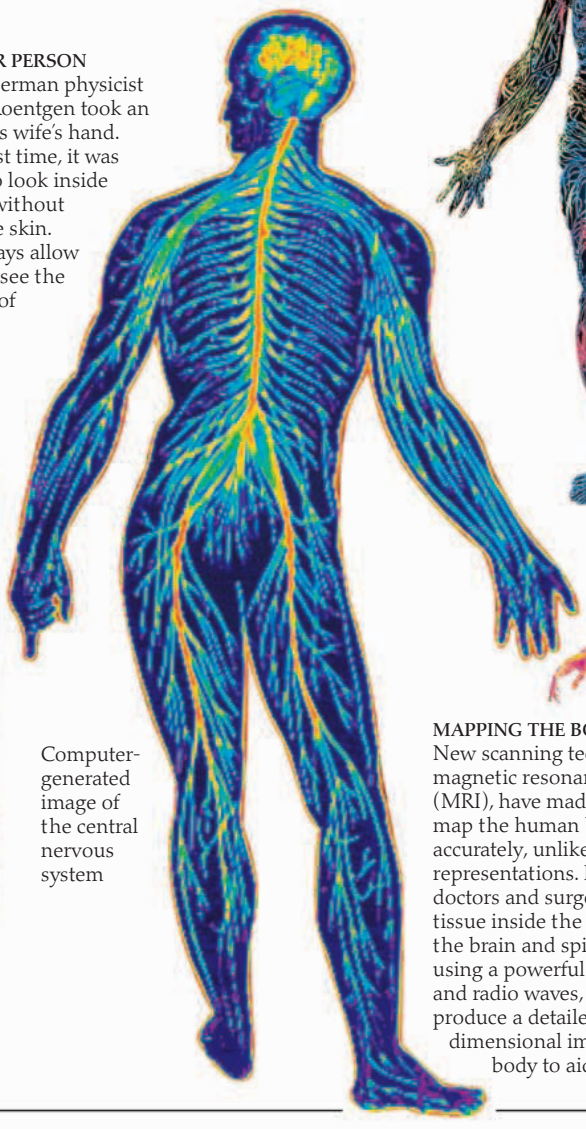
THE HUMAN BODY HAS ALWAYS been mysterious because for so long it was impossible to see exactly how it worked. Anatomists drew the first accurate diagrams from dissected corpses. Then, with the invention of X-rays, it became possible to see through living skin and muscle to the skeleton. Today, doctors use imaging technology to help them monitor patients and diagnose illnesses. Ultrasound is used to observe the progress of a growing fetus inside the womb. Magnetic resonance imaging (MRI) can build three-dimensional images of the interior of the body, allowing doctors to detect diseases. Advances in technology even show us the invisible! Electron microscopes allow us to look into a cell and see the structure of DNA. In the future, we will have a complete record of our genetic makeup.



Artwork of major organs and the muscular system

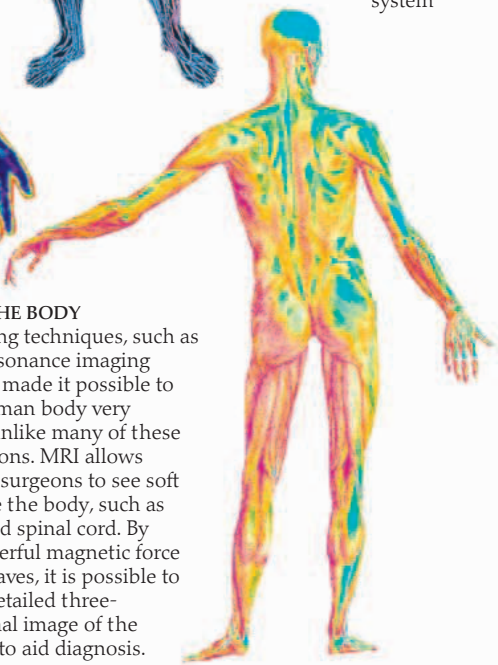
THE INNER PERSON
In 1895, German physicist Wilhelm Roentgen took an X-ray of his wife's hand. For the first time, it was possible to look inside the body without cutting the skin. Today, X-rays allow doctors to see the condition of bones and ligaments.

A computer version of the traditional view of the venous system – the veins of the body – as one continuous vessel



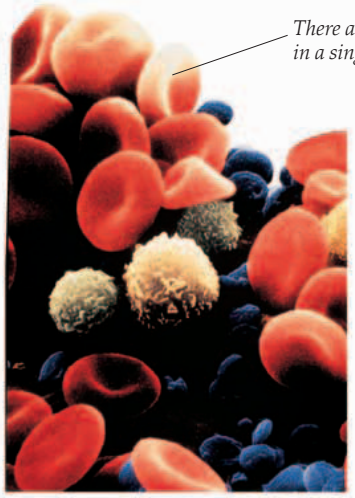
Computer-generated image of the central nervous system

Computer-enhanced view of the musculoskeletal system



TAKING A LOOK WITH SOUND
The previously hidden world of the womb is made visible through ultrasound. By using ultrasonic waves, it is possible to form images of a fetus growing inside its mother's womb. Ultrasound is also used to examine internal organs.

MAPPING THE BODY
New scanning techniques, such as magnetic resonance imaging (MRI), have made it possible to map the human body very accurately, unlike many of these representations. MRI allows doctors and surgeons to see soft tissue inside the body, such as the brain and spinal cord. By using a powerful magnetic force and radio waves, it is possible to produce a detailed three-dimensional image of the body to aid diagnosis.



There are millions of cells in a single drop of blood

LOOKING CLOSER
For centuries, microscopes have permitted scientists to look at minute particles invisible to the naked eye. Today, microbiologists use powerful electron microscopes to study cells, enabling them to gain a better understanding of the essential processes of life. This highly magnified image of a blood sample was created using a scanning electron microscope. It shows three common types of blood cells – red (erythrocytes), white (lymphocytes), and blue (platelets).

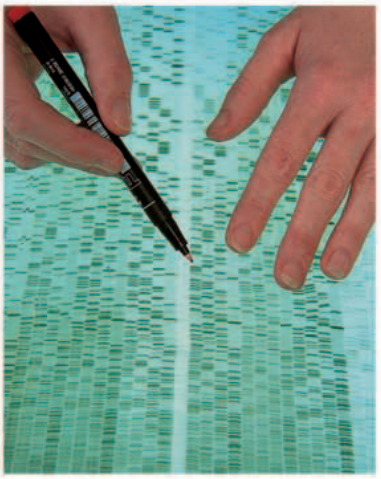
THE CODE OF LIFE
Deoxyribonucleic acid (DNA) holds the very code of life itself. It is found in the nucleus of every cell and carries genetic information about an individual. The structure of DNA consists of two slender spiral strands that twist around each other to form a shape called a double helix. The strands are held together by compounds known as bases. With this knowledge, scientists can manipulate the building blocks of life itself.

White blood cells do not attack nanorobots, as they are made from a neutral material

NANOROBOTS
The notion of engineering on a minuscule scale was first discussed in the late 1950s. Today, it is becoming a reality. Using high-powered electron microscopes, scientists can examine and manipulate things at the atomic level. They are developing nanorobots – micro-machines that will be small enough to travel through the bloodstream. They will repair or remove diseased tissue at the molecular level. The nanorobots shown in this illustration are destroying diseased tissue inside a human blood vessel.

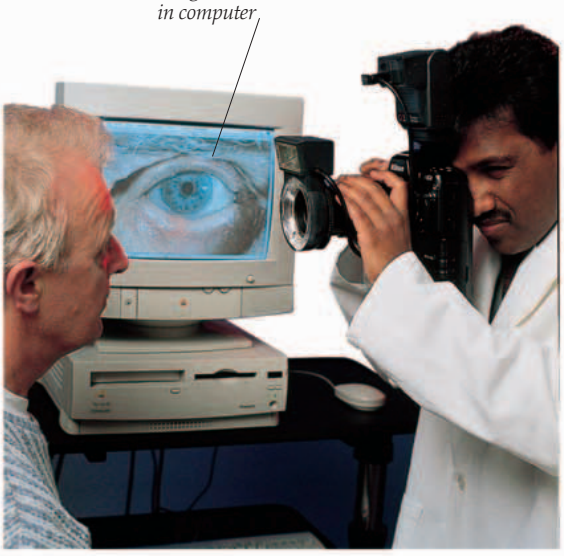
Nanorobot's spinning blades destroy a tumor

Nanorobot attacks a blood clot



UNIQUE FINGERPRINTS
In 1984, DNA was internationally recognized as a legal means of identification. Within each person's DNA molecules is a sequence of information unique to that individual (except for identical twins). Forensic scientists are able to identify a chemical sequence (above) to determine whether DNA samples are from the same person. The sequence can be taken from a tiny amount of evidence, such as a single strand of hair or a drop of blood discovered at the scene of a crime.

Image is stored in computer



INSTANT INFORMATION
Using a digital camera, a doctor takes a photograph of a patient's eye for his medical records. The image can then be displayed on a computer screen – and also stored for future reference. Soon, computerized medical records will be drawn up for every individual. Patients visiting the doctor's office or the hospital will have their medical records immediately available. Eventually, a patient's entire medical history, along with his or her genetic code, will be carried everywhere by the patient, stored on a smart card (pp. 58-59).

Bases are joined together in complementary pairs

Sequence of bases makes up the cell's genetic code

Several thousand base pairs make up a gene

Model of a DNA double helix

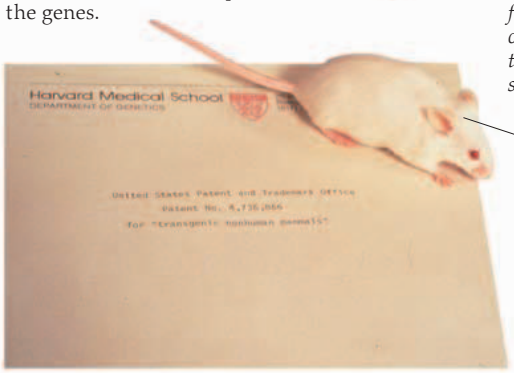
Genetic engineering

ONE OF THE MOST SIGNIFICANT legacies of the 20th century will be the development of our ability to manipulate life through genetic engineering. The human race is poised on the edge of being able to make fundamental changes to the living organisms that share our planet. What would normally take millions of years to develop through the process of natural selection may soon be achieved in a laboratory overnight. One day, geneticists may be able to remove traits from human beings that are considered undesirable for social or medical reasons. They could then replace them with more acceptable characteristics. But this kind of genetic engineering will not only change human biology – it will alter society itself.

CHEMICAL CODES
The DNA molecule is composed of units called nucleotides that form complicated sequences. Enzymes are used to cut sequences to change something genetically. Understanding how an enzyme works allows us to manipulate the genes.

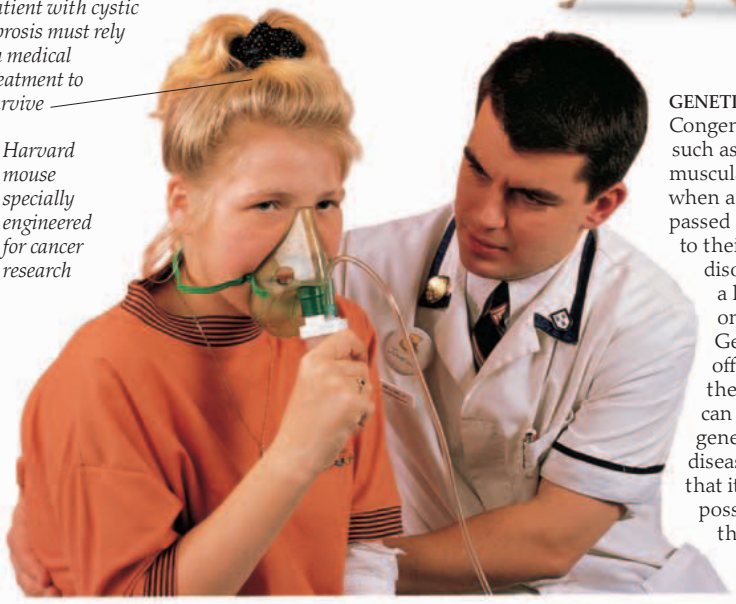
MONSTER MYTH
Some people fear that genetic engineering will produce new monsters like the Chimera of ancient mythology, which was part lion, part goat, and part snake.

PEST CONTROL
By genetically modifying a virus with a toxin taken from a North African scorpion, it is possible to produce a much more effective pesticide for a worm called the cabbage looper. The modified virus destroys loopers 25 percent faster.



Harvard mouse specially engineered for cancer research

ONE OF A KIND
Genetic engineering may result in research or business organizations owning life forms. This mouse, genetically engineered for cancer research at Harvard University, became the world's first patented mammal in 1988. Some geneticists argue that if they create a unique living organism, they should have rights over its use. However, an international ethical debate has stalled further patents.

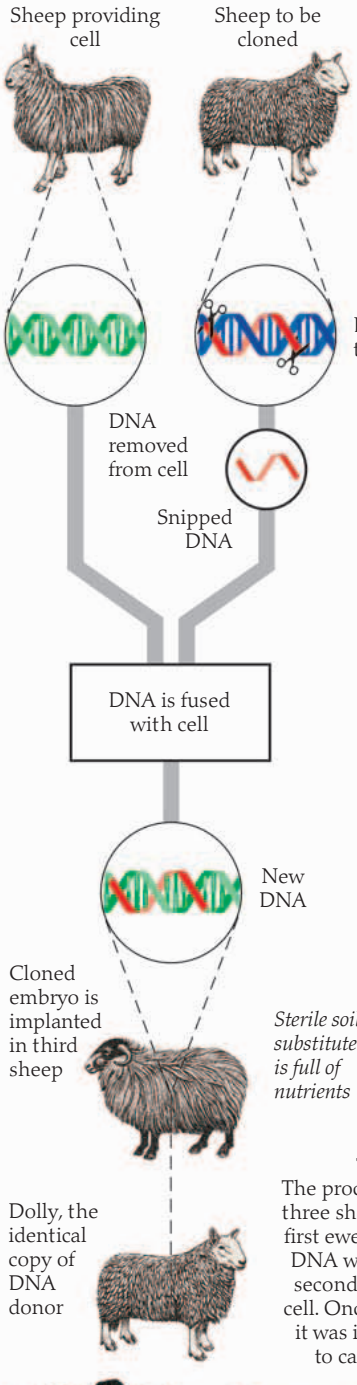


Patient with cystic fibrosis must rely on medical treatment to survive

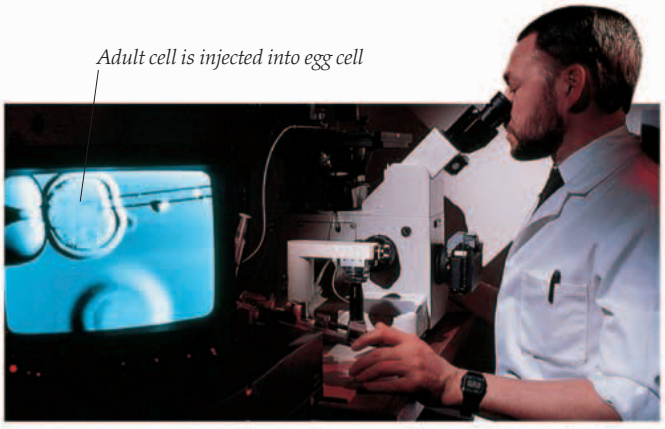
GENETIC THERAPY
Congenital disorders, such as cystic fibrosis or muscular dystrophy, occur when a defective gene is passed on from parents to their children. These disorders can result in a lifelong dependence on medical treatment. Genetic engineering offers some hope for the future. Geneticists can now isolate the genes that carry these diseases. It is hoped that it will soon be possible to replace the defective genes with healthy ones.

Cloning animals and plants

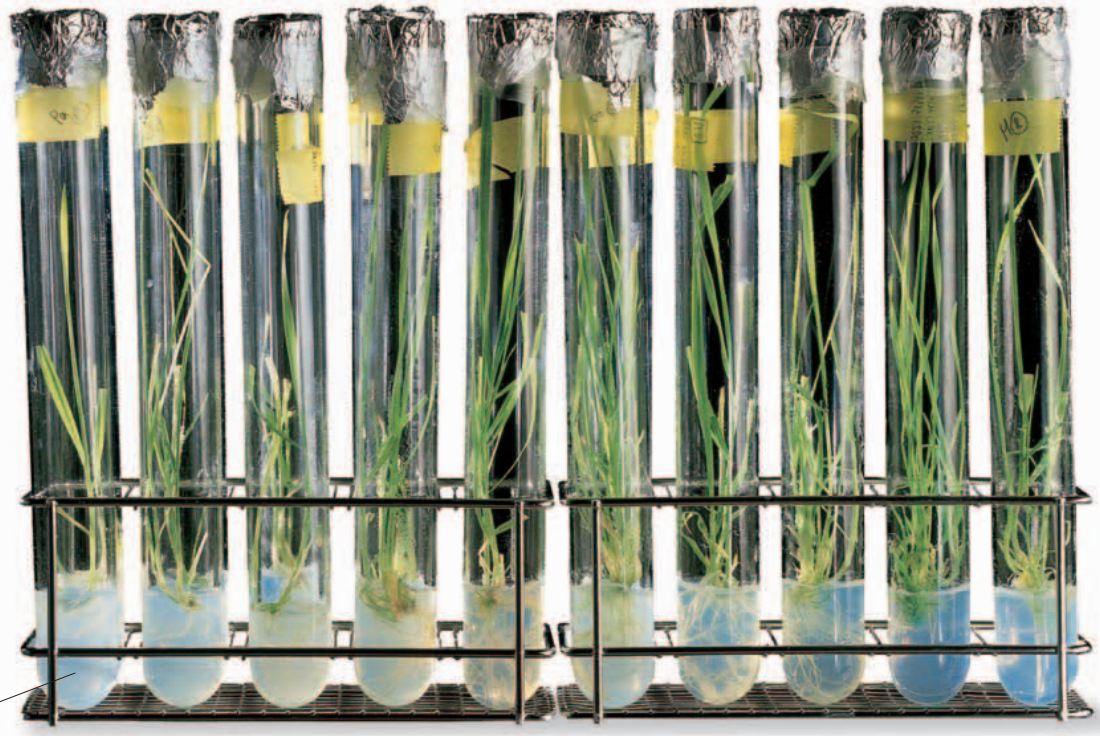
One of the most incredible, yet troubling, developments of genetic science is the ability to clone animals and plants. A clone is an exact genetic copy of its DNA donor. In 1997, the world was introduced to Dolly the sheep, the first mammal to be cloned from a cell of another adult. Geneticists have already cloned human embryos for medical research. If their techniques are perfected, it may soon be possible to clone human organs and tissue for transplant. However, cloning whole human beings is a controversial issue.



THE BIRTH OF DOLLY
The process of creating Dolly involved three sheep. A cell was taken from the first ewe, and its genes were removed. DNA was then taken from a cell of a second ewe and fused with the first cell. Once the embryo was developed, it was implanted into a third sheep, to carry and give birth to Dolly.



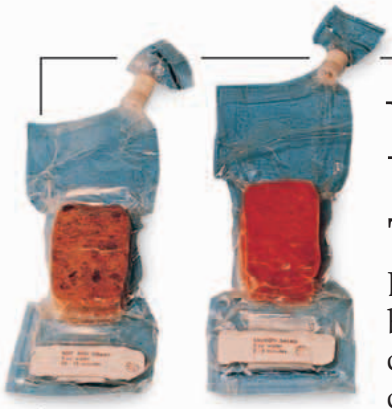
SPARK OF LIFE
There are a number of ways of transferring DNA from one cell to another. In Dolly's case, a cell was injected into an egg that had its nucleus removed (above). A spark of electricity fused the cells and promoted growth. Other methods include using bacteria to carry DNA or firing tiny gene-carrying particles into the egg.



PLANT REVOLUTION
Genetic modification has been employed in the farming industry to increase crop yields, improve pest resistance, or boost a crop's ability to thrive in a hostile environment. These cereal plants (above) are clones grown from the single cell of a plant that was genetically modified to produce the desired characteristics.


Dolly the sheep

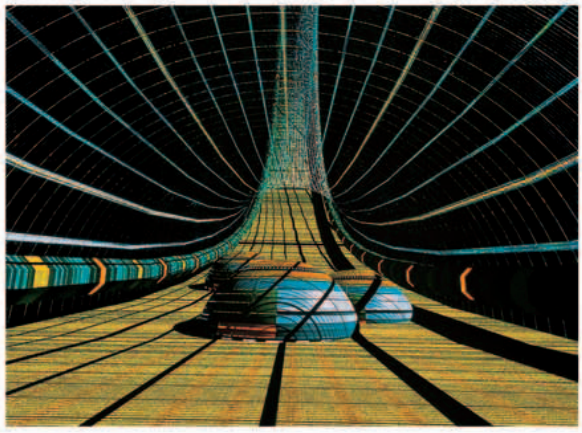
COUNTLESS CLONES
Cattle have been successfully cloned in the United States, which would permit the mass reproduction of unlimited numbers of identical cows. Cloning cattle would enable farmers to maximize the benefits of desirable traits, such as high milk yields and tender meat. Cows could also be genetically engineered to produce special proteins in their milk for people with specific dietary needs.



FOOD IN SPACE
There is endless fascination with the food that space travelers eat. In the 1960s, astronauts survived on a diet of dehydrated food and tablets that contained nutritional supplements. Although they were convenient to carry into space, they were not pleasant to eat.

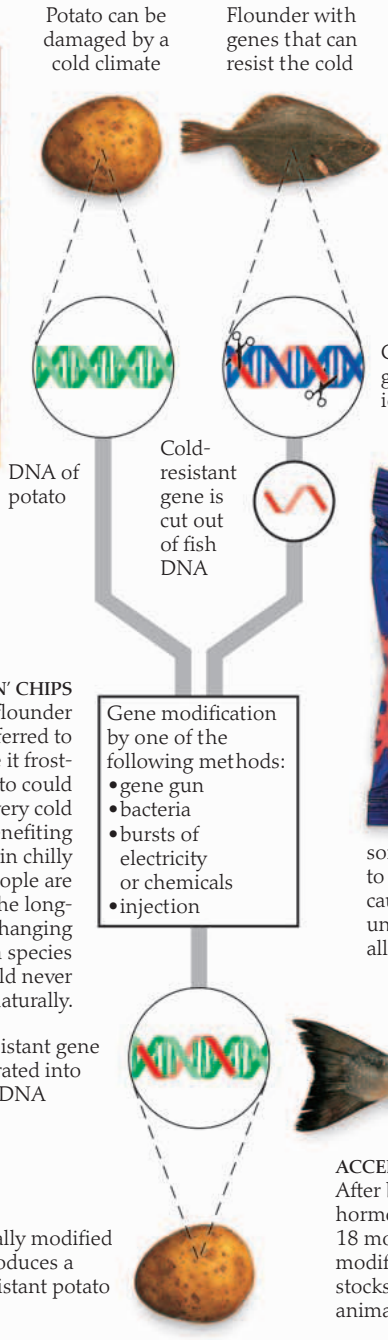
Foods of the future?

THE DEMAND FOR FOOD increases daily as the world's population grows. But drought and crop failures have not been eliminated, and pests have become increasingly resistant to insecticides. Meanwhile, sophisticated consumers are demanding fresh food year-round, but they are also concerned about the possible side effects of the chemicals used to increase crop yields. By studying the DNA of plants and animals, scientists hope to revolutionize agriculture. Although there are substantial benefits, the genetic engineering of food remains controversial. Some scientists are concerned that, if they manipulate nature, it may be impossible to reverse any mistakes.



FUTURE FOOD IN SPACE
If one day we choose to live in space, it will be essential to grow food there. This artist's conception of a farming spaceship, shaped like a giant wheel, demonstrates how crops could be grown on a space station. Centrifugal force substitutes for gravity, and the growing crops release oxygen, replenishing the ship's supply.

FUTURE PEST CONTROL
In recent years large amounts of chemical fertilizers, herbicides, and pesticides have been used to protect plants and encourage growth. By genetically modifying crops to be pest-resistant and hardy, it may be possible to eliminate the need for crop spraying.



FISH 'N' CHIPS
A gene from a flounder could be transferred to a potato to make it frost-resistant. The potato could be grown in very cold conditions, benefiting societies living in chilly climates. But people are worried about the long-term effects of exchanging genes between species that could never interbreed naturally.

Peanuts can cause a fatal allergic reaction

ALLERGY-FREE NUTS
Most food allergies are slight, and result in no more than a mild rash or stomachache. But some reactions are very severe. The allergic reaction to peanuts, for example, can be particularly serious, causing severe illness or even death. Research is now under way to manipulate the genes of nuts so that all risk of allergic reaction is removed.

SWEET TOOTH
Those of us who find it hard to resist a slice of chocolate cake may be able to eat as much as we like in the future. Tomorrow's treats will be genetically engineered to be less fattening, so we can have our cake without having the fat.

ACCELERATED GROWTH
After being genetically modified to produce a growth hormone, this fish is large enough for eating after just 18 months instead of the usual three years. Genetic modification could be the answer to depleting fish stocks. But along with similar experiments on other animals, it raises many serious ethical questions.

A BETTER DEAL FOR ALL?
The shelves in supermarkets may soon be filled with genetically modified fruit and vegetables. They will be made to taste better and be more nutritious. They will be longer-lasting, so there will be far less spoilage, which will make them more plentiful and cheaper to buy. Genes that have a negative effect on a certain type of food will be removed and replaced with beneficial genes. And certain fruits and vegetables may also be genetically engineered to defend themselves against harmful viruses, fungi, and insects so they will no longer need to be sprayed with chemical pesticides.

Changing bodies

BODY CHIPS
Scientists are developing a method of connecting human nerve cells to a silicon chip. This could counter the effects of brain damage. Already, some forms of blindness have been overcome using semiconductor retinal implants to stimulate the optic nerve.

OUR BODIES ARE fragile and complex, vulnerable to disease, and easily damaged. In recent years, medical advances, along with the development of new drugs and materials, have allowed surgeons to replace body parts that are damaged, diseased, or simply worn out. Successful organ transplants mean that people can now survive diseases that twenty years ago would have killed them. Prosthetics (artificial parts) are being developed that give the person wearing them high levels of control, comfort, reliability, and agility. Scientists are also experimenting with implants to combine human cells and microchips, creating physical links between the human body and the latest computer technology. The potential for this work is enormous. One day, implanted machines and computers may mean that the human body will function more efficiently and last longer.

Polyethylene finger joints for arthritis

Titanium and polyethylene elbow

Anti epilepsy unit

Pacemaker can download information

Mother-of-pearl from an oyster shell

Electronic pain relief

Silicon chip controls the mind

Cyborgs are part human, part machine

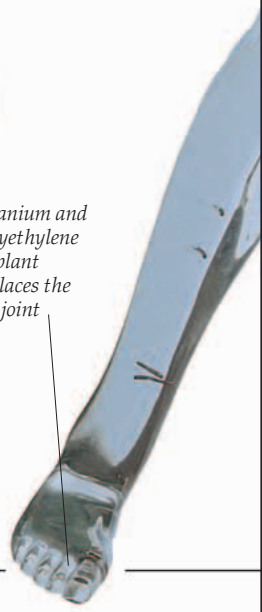
WIRED MAN
Fictional cyborgs, such as Captain Picard from *Star Trek* (right), with their enhanced strength and superhuman sensory organs, may soon become a reality. In the future, the boundaries between humans and machines will become blurred with the creation of real cyborgs, like the "Wired Man" (above).

REGENERATING BONES
Instead of replacing a damaged limb with a prosthetic, human bone can now be regenerated using mother-of-pearl shell mixed with bone or blood cells (left). When implanted, it stimulates the growth of new bone.

FUTURE TRANSPLANTS
Organ transplants are a regular procedure, even among young children. This baby (right) became the youngest person in the world to receive an organ transplant when she was only five days old. Scientists are experimenting with genetically modified animal organs to overcome donor shortages.

Skin is grown in fibrin gel

NEW SKIN
New skin can be made artificially by placing skin cells in a nutrient-rich gel. The replicating skin cells multiply rapidly – it takes only three weeks to grow into 3.5 sq. ft (1 sq. m.) of new skin. The artificial skin is used on patients who need skin grafts, perhaps after being badly burned.



Titanium and polyethylene implant replaces the toe joint

Artificial eye

Silicone rubber replaces damaged nose

Silicone rubber replaces external ear

Polymethylmethacrylate (PMMA) used for gums and teeth

Artificial larynx allows speech

Long-lasting ceramic-coated shoulder joint

Titanium nails hold fractured bones together

Cardiac pacemaker regulates heartbeat

Bone staples pull the bone together as they warm up

Aortic valve made from PMMA

Aortic valve made from polytetrafluoroethene (PTFE)

Stainless steel cylinder unblocks artery

Titanium device fuses two vertebrae together

Artificial cobalt-chromium hip with ceramic head

Titanium replacement, with a chrome head and polyethylene cup, is light and flexible

Stainless steel cylinder unblocks large blood vessels

Flexible polyester tubes bypass damaged veins

Polyethylene and cobalt alloy provide smooth movement in this artificial knee joint

Bone plates made from carbon fiber encourage bone growth

Titanium and polyethylene make a strong and wear-resistant ankle

Pneumatic cylinders allow natural walking at different speeds

Running shoe fits securely on artificial limb

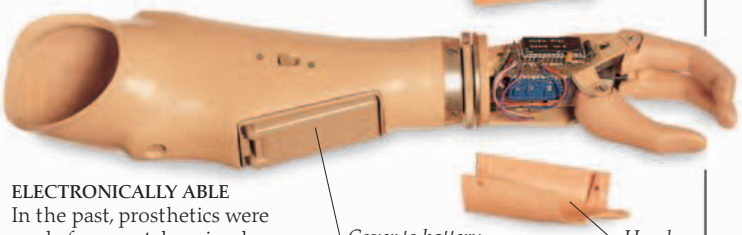
THE BIONIC HUMAN BEING

All the prosthetics or other additions visible in this resin body are made from lightweight, flexible, and long-lasting materials. They are used to replace many different parts of the body that may have been damaged by disease, a traumatic accident, or old age. Ceramic combined with cobalt chromium replaces the worn-out, brittle joints of the elderly, and broken bones can be held in place by pins while natural healing takes place. When blood vessels become blocked or lose their elasticity, they can be bypassed with artificial vessels. And damaged soft tissue can be replaced by silicone. Scientists are constantly finding new medical uses for the most unlikely materials.

HELPING TO HEAR

Some forms of deafness can be helped by using electronics. Implants are attached to the bone behind the ear. Electrodes from the implant reach the cochlea, the part of the inner ear that allows us to hear. Impulses then travel in the normal way through the nerve pathways, sending signals to the brain, which interprets them as sound.

Hand cover



Cover to battery compartment

Hand cover

ELECTRONICALLY ABLE

In the past, prosthetics were made from metal or simply carved out of wood. They were uncomfortable and awkward to use. Today, most artificial limbs use electronic circuits. This arm is operated by tensing the muscles in the stump of the limb. This produces tiny electrical signals that are detected and amplified by sensors. In the future, an electronic motor could be controlled by nerve signals from the stump.

Prosthetic cover

Wearer can take part in everyday activities

REVOLUTIONARY LEG

This artificial limb has a built-in knee socket. The socket contains a computer chip and pneumatic cylinders. These allow the wearer to walk without having to concentrate on each step. The limb is so advanced and flexible that the wearer can enjoy all kinds of physical activity, such as jogging and cycling.

Robots and robotics

SINCE THE FIRST AUTOMATED production lines were put into operation in the 1950s, it has been obvious that many routine jobs can be carried out effectively by mechanical means. Robots can free people from difficult or dangerous tasks such as bomb disposal or welding. Robots can eliminate the need for human workers for tasks that may be boring or repetitive. It often costs an employer less to maintain a robot than to employ a person.

Today's advanced robots are mobile and equipped with television cameras for sight and electronic sensors for touch. Recent developments include robots that can walk, balance themselves if they start to fall, and recognize faces. Some organizations have been researching robotics for several years with the goal of seeing how this technology can be applied to practical use in the home. In the future, a mechanical housekeeper may cook our meals and do all the chores.

Humanoid shape considered more "friendly"

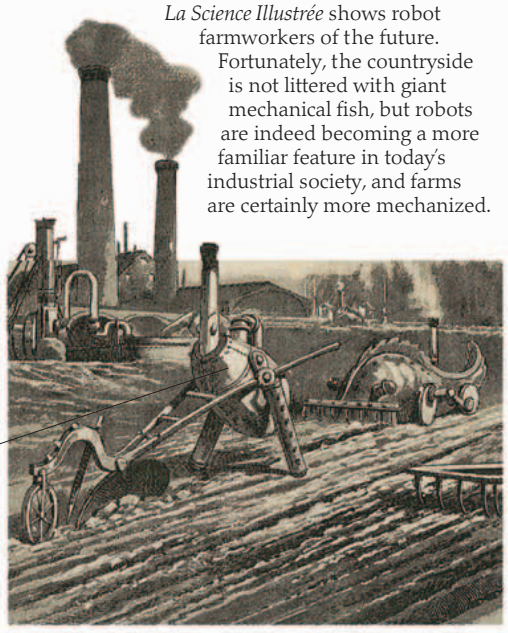
MANNY THE ROBOT
Robot builders have begun to build robots that look and move something like people. These robots vary in design and size, but there are already several that are humanoid. This one, nicknamed Manny, was developed to test protective clothing, such as spacesuits, firefighting gear, and clothing worn in hazardous environments – for example, when dealing with chemicals.

Joints are fully articulated

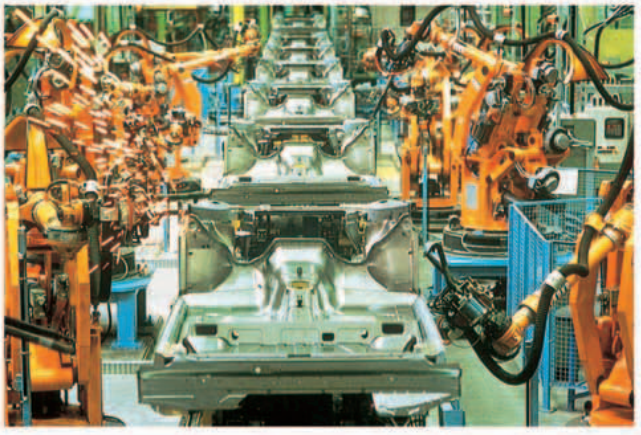
Ability to balance delicate objects

System set up to simulate sweating and breathing

SLAVES IN THE FIELDS
Mechanical workers have long been thought of as a means of escaping from the drudgery of repetitive or unpleasant work. This illustration from an 1896 edition of *La Science Illustrée* shows robot farmworkers of the future. Fortunately, the countryside is not littered with giant mechanical fish, but robots are indeed becoming a more familiar feature in today's industrial society, and farms are certainly more mechanized.



The Czech word "robot" originally referred to slavelike mechanical farmworkers



AUTOMATION IN INDUSTRY
Robots do not get bored. They can do repetitive tasks accurately and consistently for hours on end. Industrial computer-controlled robots are used in car production to carry out a variety of tasks, such as welding, drilling, and the paint-spraying of body parts. A robot is programmed to carry out a particular task, such as welding a car door, while a computer tracks its movements. Afterward, the computer takes over completely, instructing the robot to move in exactly the same pattern over and over again.

ROBOTS IN SPACE
A Remote Manipulator System (RMS) arm was developed for use by astronauts in space. It was used to move some equipment from the space shuttle *Endeavour* while the astronauts serviced the Hubble Space Telescope in 1993.

Sports robot is programmed to follow partner's movements

RMS arm was extended from cargo bay door of shuttle

Astronaut on RMS arm

Can use sensors in its arms to shake hands with people

Sensors in hands detect the ball

BALL PARTNER
A Japanese electronics company has developed a robot that can play catch. It does this by reacting to voice commands, identifying colors, and even recognizing human faces. The makers plan to develop robots that will serve the human population in the 21st century. Although this particular robot is programmed only to play catch, it is hoped that later models will be able to work in factories, hospitals, or the home.

Robot contains the latest microchip technology

Hinged joints permit robot to walk on uneven surfaces

Video camera

Foot contains sensors

ATTILA, THE ROBOT INSECT
This insect robot can move across rough terrain, negotiating small obstacles using its own logic. Its ability to perform simple tasks may make it useful for on-the-spot repairs inside machinery.

Internal battery lasts 15 minutes

BOMB DISPOSAL UNIT
This radio-controlled bomb disposal robot is removing a briefcase that may hold a bomb. The robot is controlled by an operator who can "see" its movements from a safe distance by using the onboard video camera.

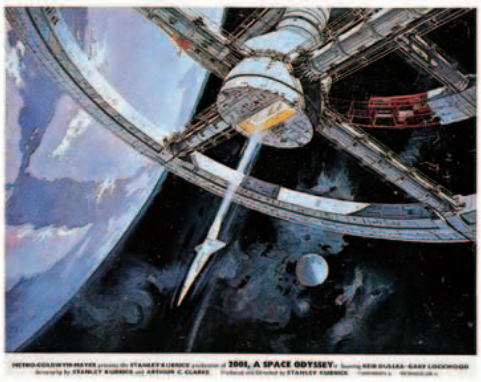
Fire extinguishers operate if bomb explodes

CLIMBING ROBOT
This humanoid robot is capable of deciding how to move across a variety of surfaces, climb stairs, and recover its balance if pushed. The robot, dubbed "Honda-sapien" by its creators, is able to decide for itself when to step over an obstacle and when to walk around it. The robot is 6 ft (2 m) tall and weighs 460 lb (210 kg).

Stays upright when walking up a slope

Honda-sapien is the first robot in the world that can climb stairs

Machines that think

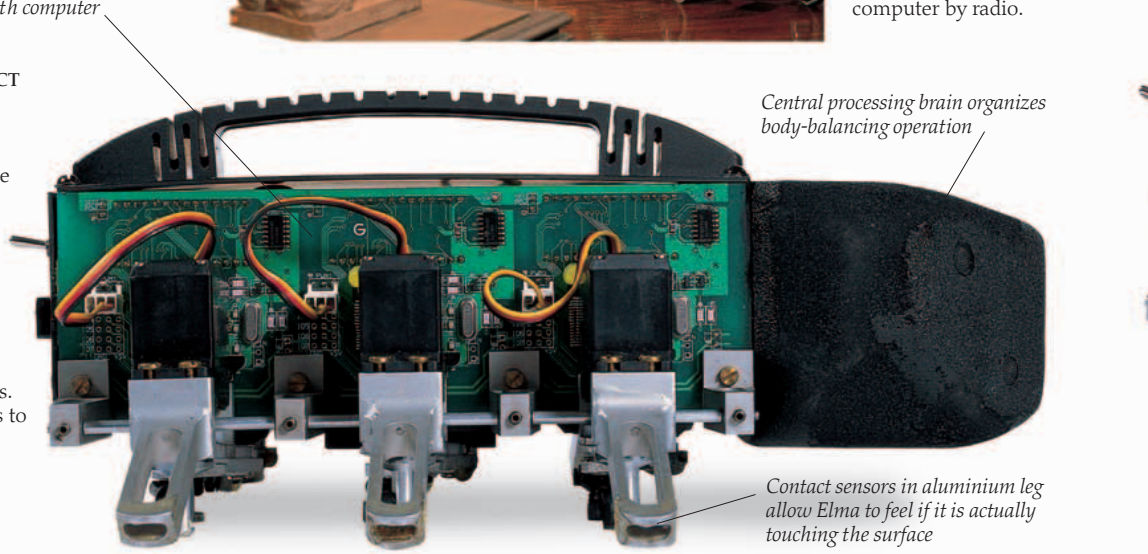


ARTIFICIAL INTELLIGENCE TAKES OVER
The science fiction film *2001: A Space Odyssey*, based on the book by Arthur C. Clarke (b.1917), is a story ahead of its time. Today's supercomputers do not yet have the capabilities of the mad computer HAL, which controls the Jupiter-bound spaceship in the film, but it is possible that they will in the future.

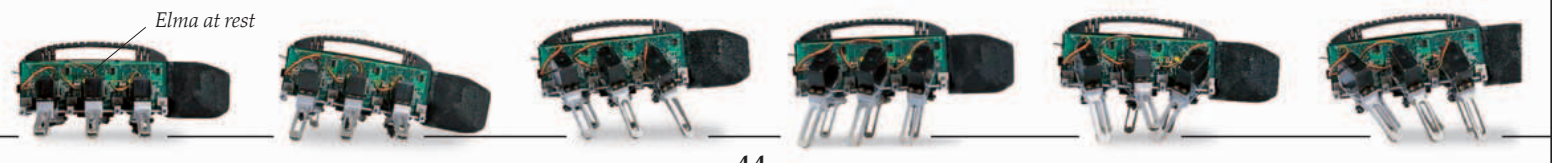
MANY PEOPLE BELIEVE that by the middle of the 21st century the world will be populated by "smart" robots, which will be able to make their own judgments and decisions. These robots will be intelligent, independent, and able to communicate with each other. But they will specialize in specific functions, so a robot that can travel at great speeds, for example, will not also be able to play championship chess. However, their skills, overall range of knowledge, and ability to intercommunicate will provide them with great power. Some scientists now predict that robots will become so advanced that they will be able to think for themselves. Robots may one day offer us a life free from drudgery, but such a future is not without risk of creating machines that may take on lives of their own.

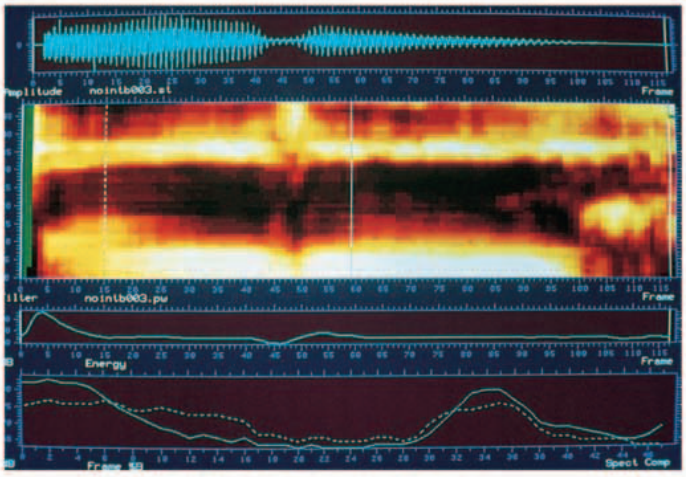
IN DEEP (BLUE) TROUBLE
In 1997, for the first time, IBM chess supercomputer Deeper Blue beat grandmaster Gary Kasparov in a six-game chess match. Kasparov had played a less sophisticated version of the machine before and won, but in Kasparov's own words, this time the computer "suddenly played like a god." Deeper Blue may be capable of analyzing 200 million moves per second and seeing 20 moves ahead, but it cannot run any other software or perform other tasks while playing.

WATCH ROBOT
The Cybermotion SR2 is a security robot used by the Los Angeles County Museum to detect intruders or hazards such as gas, fire, or steam. SR2 navigates the museum without cables or tracks, using a built-in electronic map. It uses sonar to avoid bumping into any of the exhibits, and it communicates with a central computer by radio.



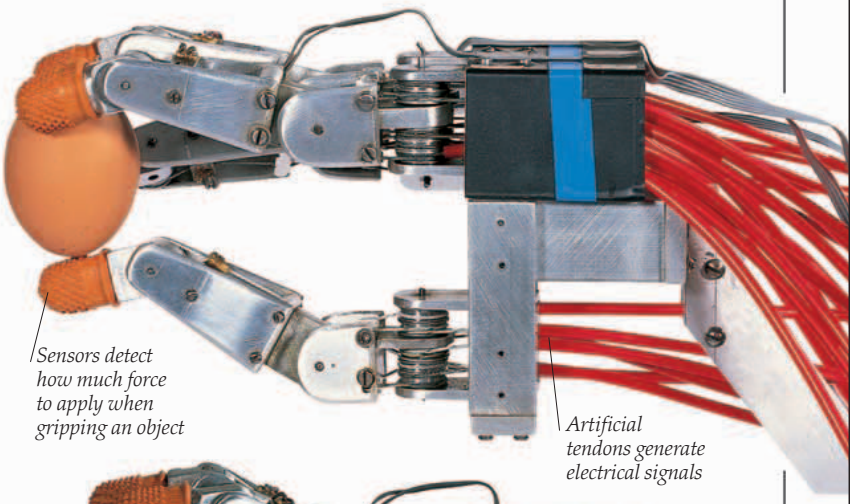
ELMA, A ROBOT WITH INSTINCT
Robots ruled by intelligence rather than instructions are being designed by roboticists. Elma, a robot insect built by the Department of Cybernetics at Reading University, England, was constructed solely to learn how to walk. Elma has six independent legs, each of which is operated by its own motor. Elma was pre-programmed by its creators to try out different leg movements. The aim of the experiment was to see if it could move over a surface without falling by coordinating each of its leg movements independently (pp. 46-47).





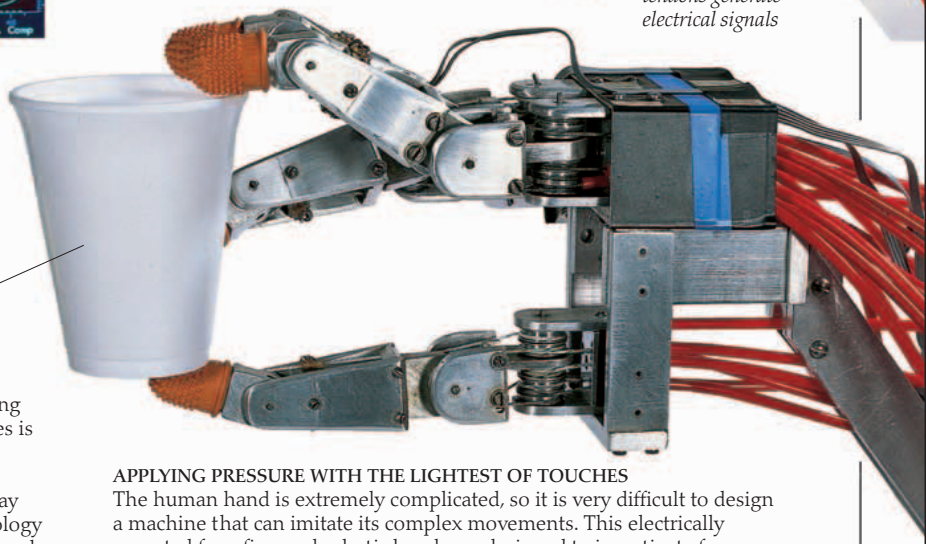
VOICE RECOGNITION
Computer interfaces still rely heavily on the keyboard and the mouse. This is set to change, as scientists have already begun work on new systems that will allow computers to recognize human voice patterns and understand verbal instructions. The computer graphics seen here represent the speech-synthesized word "baby."

ROBOT SERVANTS?
A friendly machine doing all the household chores is a popular but unlikely vision of robots in the future. We are a long way from having the technology to create a multi-functional robot with the ability to carry out household duties. Even the simple task of making a cup of tea and delivering it to you in bed is beyond the capabilities of current robots.



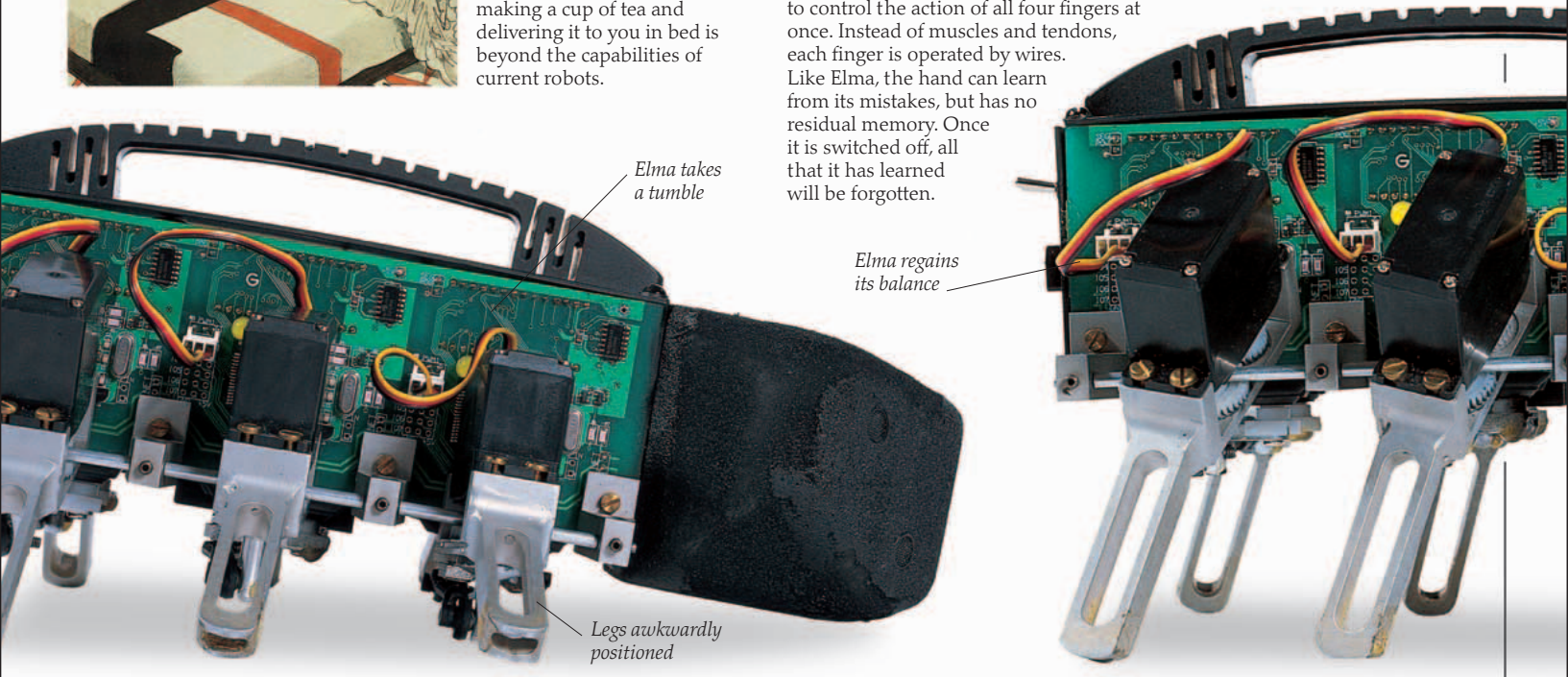
Sensors detect how much force to apply when gripping an object

Artificial tendons generate electrical signals



Robot can grip a variety of objects

APPLYING PRESSURE WITH THE LIGHTEST OF TOUCHES
The human hand is extremely complicated, so it is very difficult to design a machine that can imitate its complex movements. This electrically operated four-fingered robotic hand was designed to investigate force control. The rubber fingertips contain tiny pressure sensors, which can detect how much force is required to grip an object. Information from the sensors is fed to a microprocessor, which is intelligent enough to control the action of all four fingers at once. Instead of muscles and tendons, each finger is operated by wires. Like Elma, the hand can learn from its mistakes, but has no residual memory. Once it is switched off, all that it has learned will be forgotten.



Elma takes a tumble

Elma regains its balance

Legs awkwardly positioned

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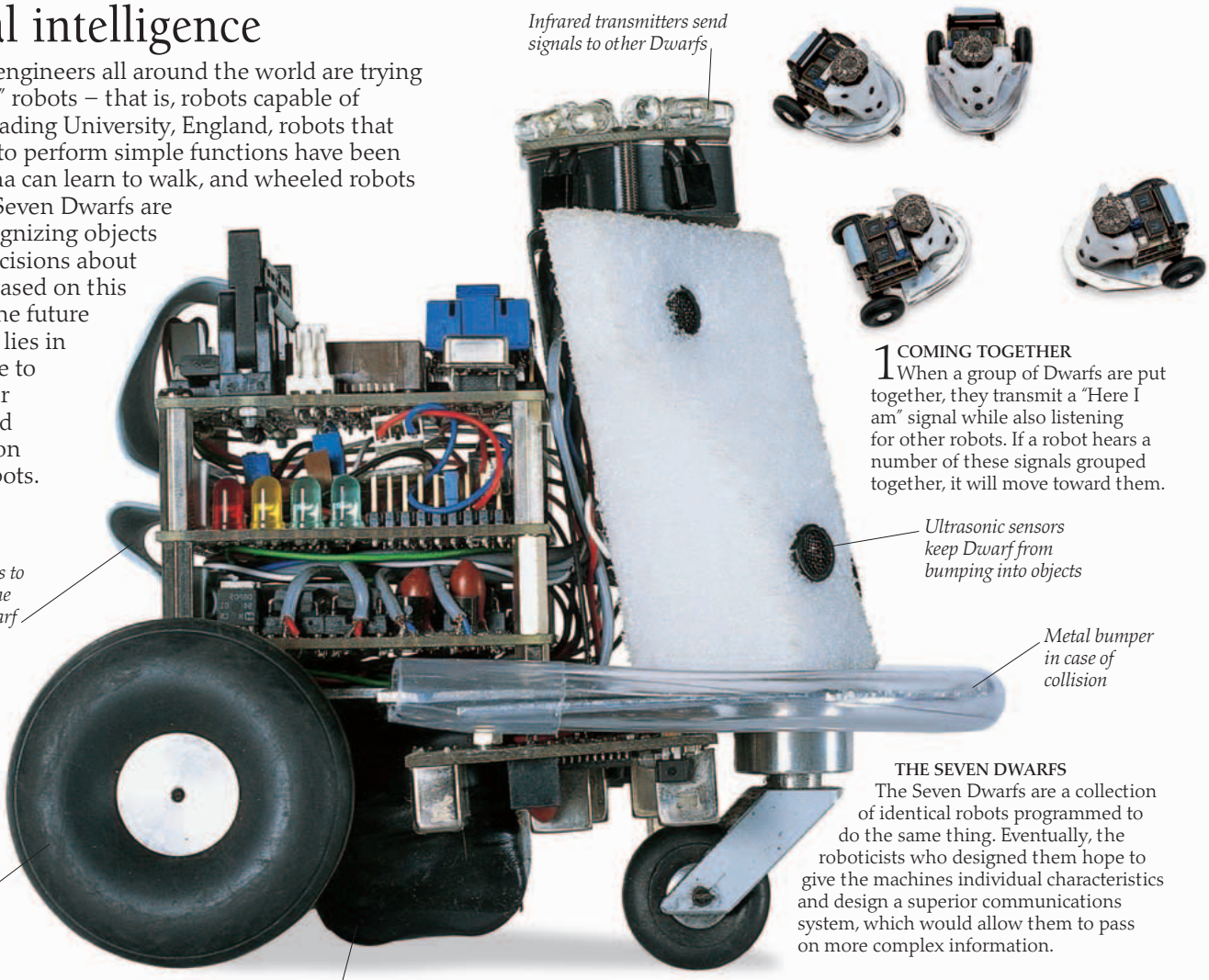
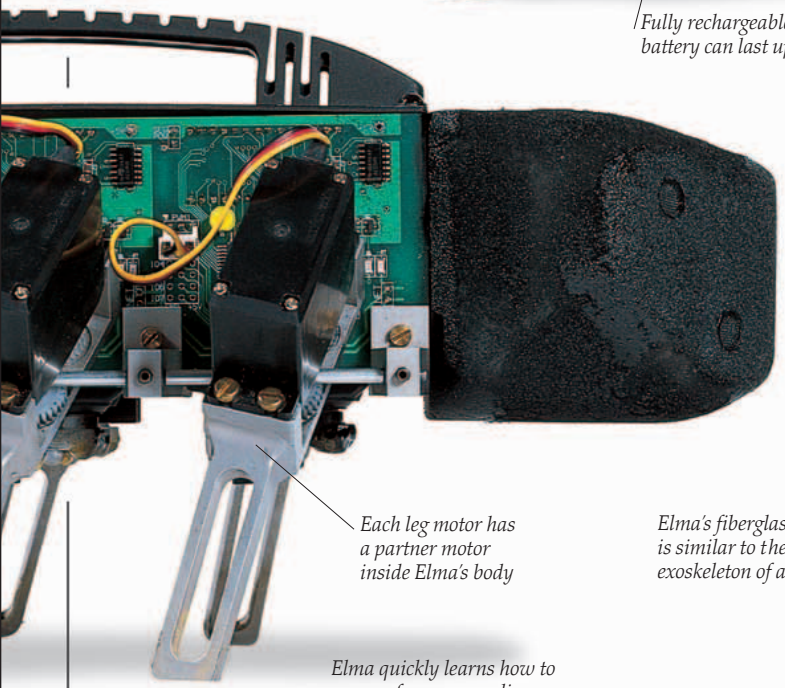
Artificial intelligence

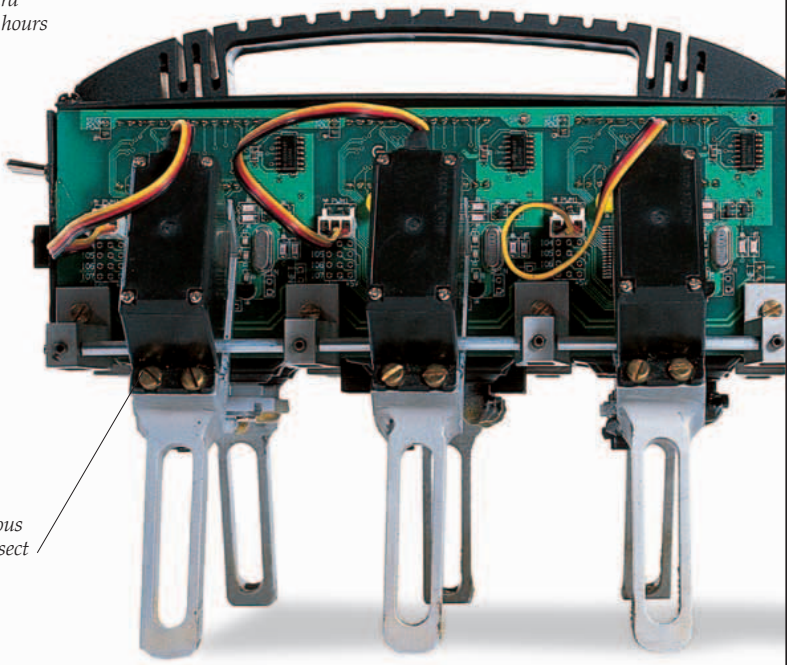
Scientists and engineers all around the world are trying to build "smart" robots – that is, robots capable of learning. At Reading University, England, robots that can learn how to perform simple functions have been developed. Elma can learn to walk, and wheeled robots known as the Seven Dwarfs are capable of recognizing objects and making decisions about how to move based on this information. The future for robots now lies in their being able to learn from their experiences and pass information on to other robots.



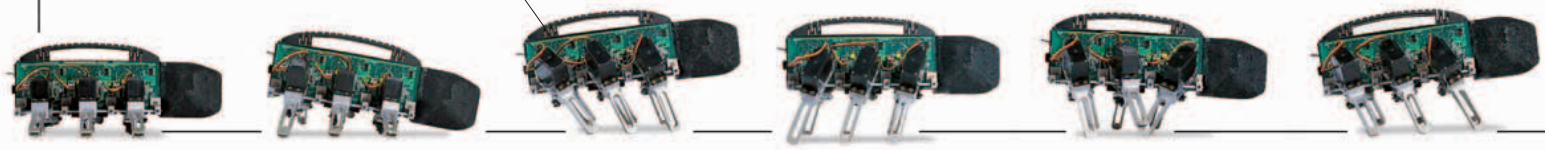
1 COMING TOGETHER
When a group of Dwarfs are put together, they transmit a "Here I am" signal while also listening for other robots. If a robot hears a number of these signals grouped together, it will move toward them.

THE SEVEN DWARFS
The Seven Dwarfs are a collection of identical robots programmed to do the same thing. Eventually, the roboticists who designed them hope to give the machines individual characteristics and design a superior communications system, which would allow them to pass on more complex information.



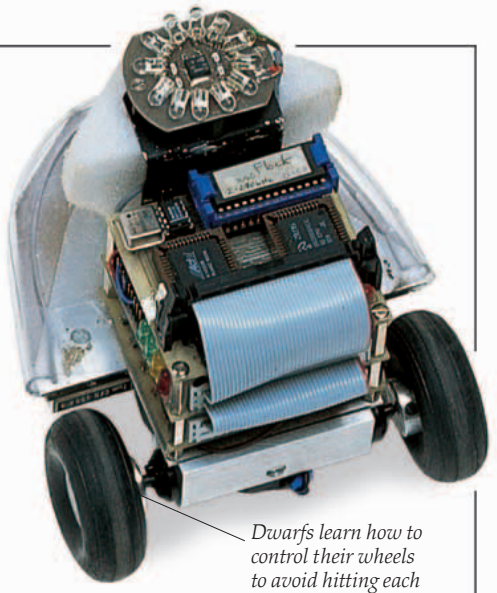


Elma quickly learns how to recover from a nose dive



2 COMMUNICATION
The Dwarfs learn to avoid bumping into things, including each other. But they are also programmed to flock toward each other. They communicate efficiently by transmitting and receiving infrared signals.

3 GETTING TOGETHER?
The Dwarfs move about, flocking and avoiding each other. When one finds itself with a clear, open space ahead of it, it is programmed to transmit a signal that means "Follow me." The other Dwarfs are programmed to follow and turn to do so.

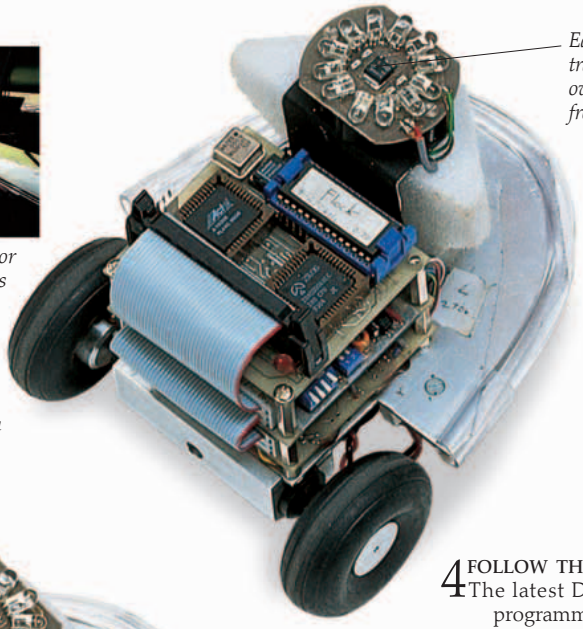


Dwarfs learn how to control their wheels to avoid hitting each other and other objects

Future operators will be able to control truck from anywhere

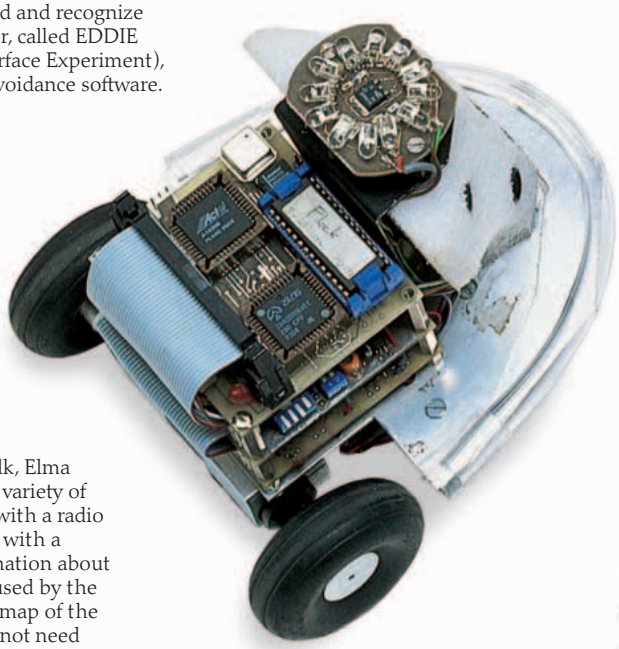
Computer operator monitors progress of Navlab

Navlab can travel at speeds of up to 37 mph (60 km/h)



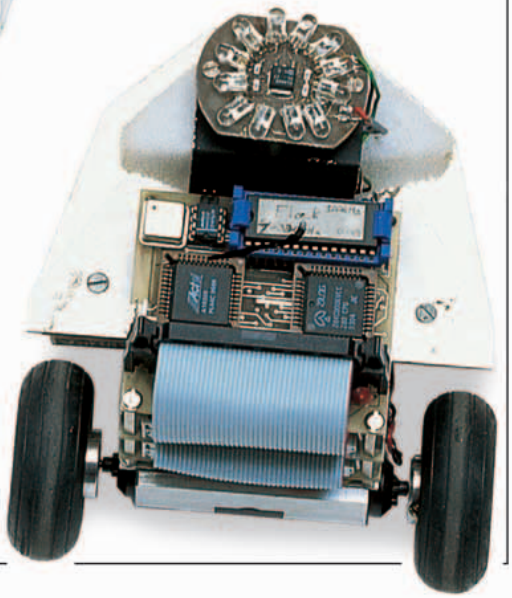
Each Dwarf transmits its own unique frequency

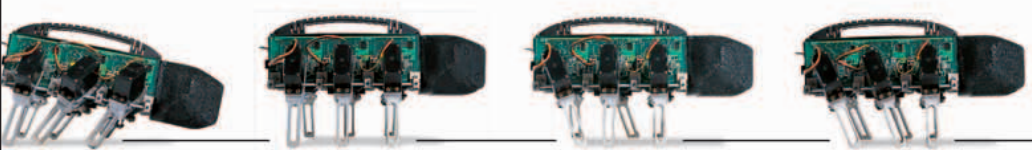
NAVLAB II
The Navlab II is a self-driving truck. It is controlled by a computer called ALVINN (Autonomous Land Vehicle in a Neural Network). The computer is "taught" how to drive by a human instructor. Through video cameras and a laser range finder, ALVINN can monitor the road and recognize markings and junctions. Another computer, called EDDIE (Efficient Decentralized Database and Interface Experiment), provides additional collision-avoidance software.



4 FOLLOW THE LEADER
The latest Dwarfs are programmed to give preference to a leader signal over a group signal. Sometimes more than one leader signal is transmitted at a time, and the group will split, with individual Dwarfs following the nearest signal. When a leader reaches another group, it reverts to using the"Here I am" signal.

THE FUTURE FOR ROBOTS LIKE ELMA
It is hoped that, having learned how to walk, Elma and robots like it will be able to navigate a variety of different surfaces. Now, Elma is equipped with a radio link that allows it to communicate directly with a computer so it can send and receive information about its environment. This information can be used by the computer to produce a three-dimensional map of the terrain. In the future, robots like Elma will not need computers, as they will be entirely self-sufficient.





SEEING THE WORLD THROUGH TWO-COLOR GLASSES
Before virtual reality, there was three-dimensional cinema. In the 1950s, members of a 3-D movie audience were each given a pair of cardboard glasses. These were essential – without them the film would look unfocused. Filmmakers designed shots to impress the audience by directing the action toward them. People would duck as objects seemed to fly out from the screen!

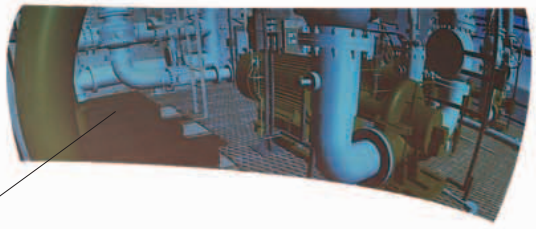
Glasses had lenses of different colors

Virtual reality

THE EDGES BETWEEN reality and virtual reality are becoming blurred. It is already possible to "experience" an exciting activity such as skiing down a mountain. As computers become more powerful, the virtual experience will become even more real. You will feel the wind in your hair, the frost on your eyebrows, and the gentle heat of the sun on your face, as well as the shudder through your ski boots as you race down the mountain. Virtual reality also has practical uses. It provides us with very beneficial medical applications. Not only can it be used to teach surgical techniques, surgeons are already able to carry out procedures with it, using robotic arms. Imagine the benefits of a surgeon in Australia being able to perform an operation on a patient in Mexico! In the future, virtual reality will be used to train people in many activities, from truck driving and engineering to mountain climbing and atomic physics.

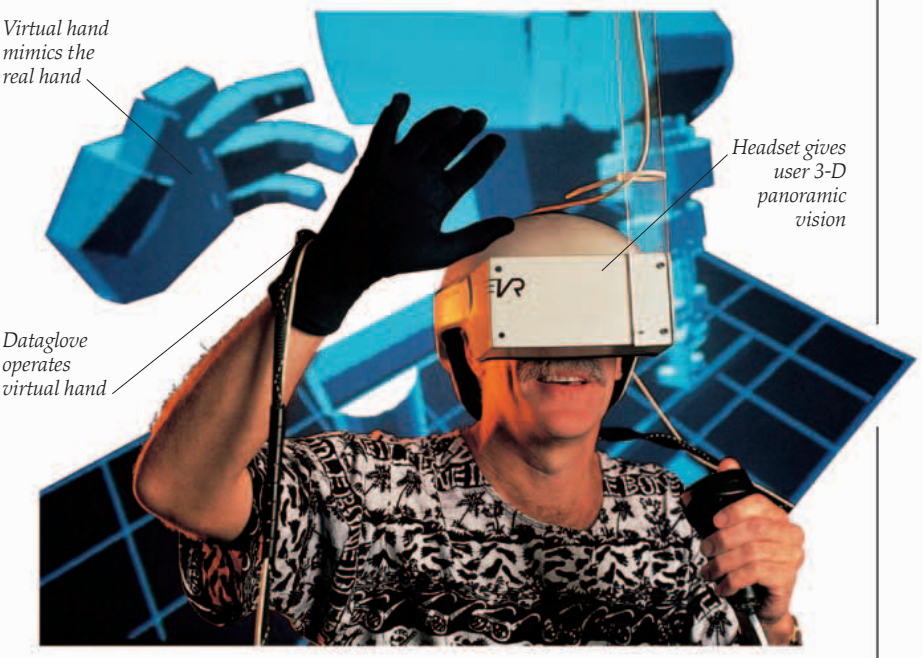
VIRTUAL ENGINEERING
Virtual reality is an effective design tool. It allows manufacturers to model products with a computer instead of having to build expensive prototypes. The people in this picture are viewing a virtual oil rig. A bank of powerful computers, performing a billion operations per second, allows them to be guided through a three-dimensional virtual space to view the oil rig from any angle. The wraparound screen and quadraphonic sound effects complete the spectacle.

"Flychair" has controls that allow the person sitting in it to decide how to "travel" around the oil rig

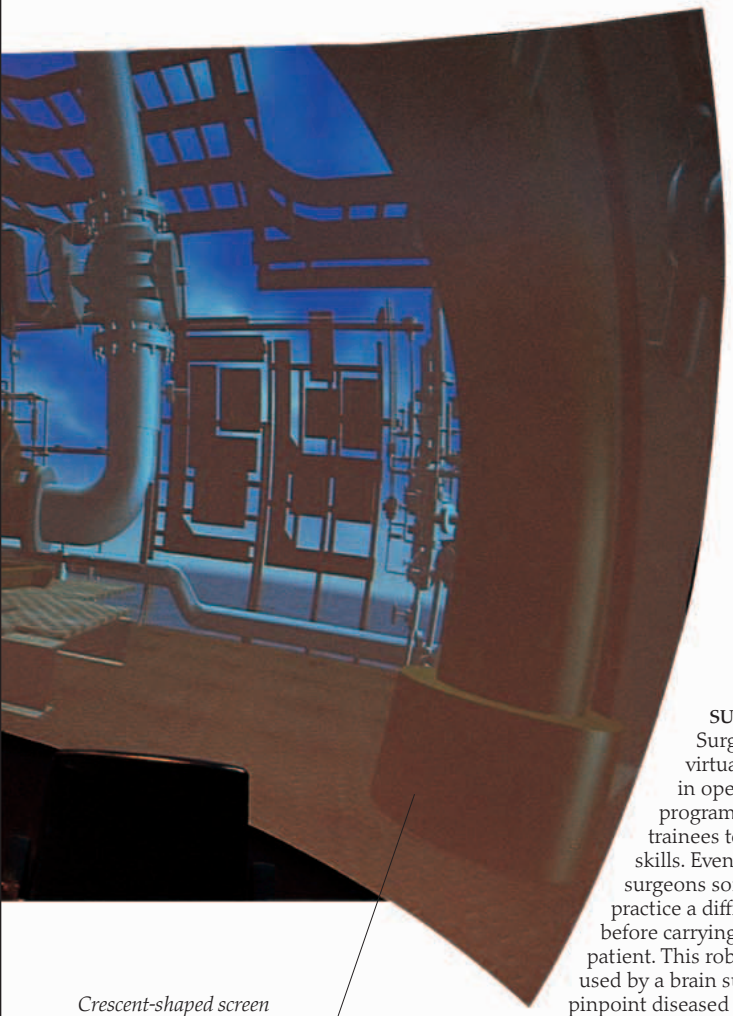


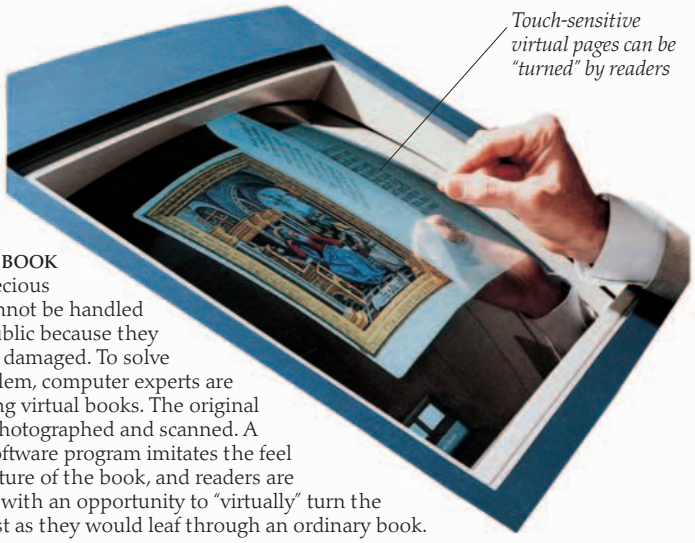
It is possible to examine complicated machinery in great detail

VIRTUAL ENTERTAINMENT
As yet, virtual reality has not been fully developed for use in the home. Instead, people have "virtual rides" in entertainment centers. Here, they watch surfers riding the waves in remarkable and nerve-wracking three-dimensional reality. In the 21st century, all this will change, with virtual reality machines in the home (pp. 28-29) and special virtual sensory suits that will allow you to experience the ride itself.



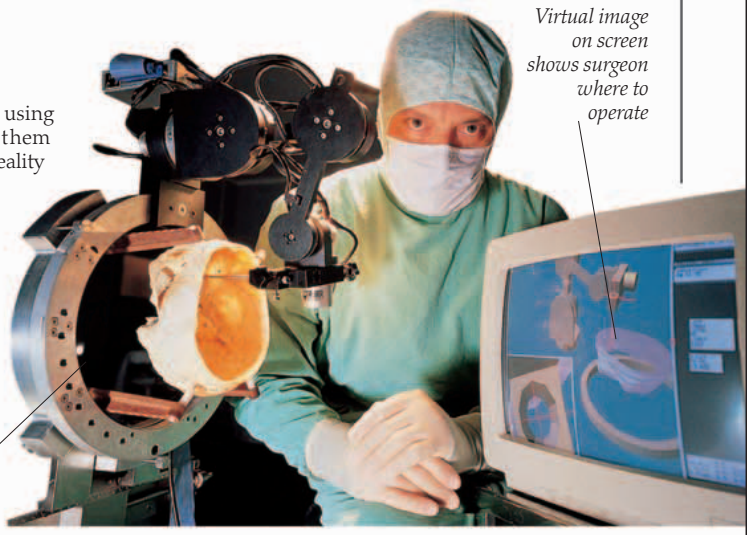
VIRTUAL CONTROL
This visor and glove allow the wearer to interact with a virtual experience. The glove on his hand provides feedback, allowing him the sensation of touch. He is programming a virtual reality system that will be used to control a real robot sent into dangerous situations, such as the ocean floor or a reactor core in a nuclear power station.





VIRTUAL BOOK
Many precious books cannot be handled by the public because they could get damaged. To solve this problem, computer experts are developing virtual books. The original book is photographed and scanned. A special software program imitates the feel and structure of the book, and readers are provided with an opportunity to "virtually" turn the pages, just as they would leaf through an ordinary book.

SURGICAL ARM
Surgeons are already using virtual reality to assist them in operations. Virtual reality programs can be used by trainees to develop their skills. Even experienced surgeons sometimes need to practice a difficult procedure before carrying it out on the patient. This robot can be used by a brain surgeon to pinpoint diseased areas of the brain, such as tumors.



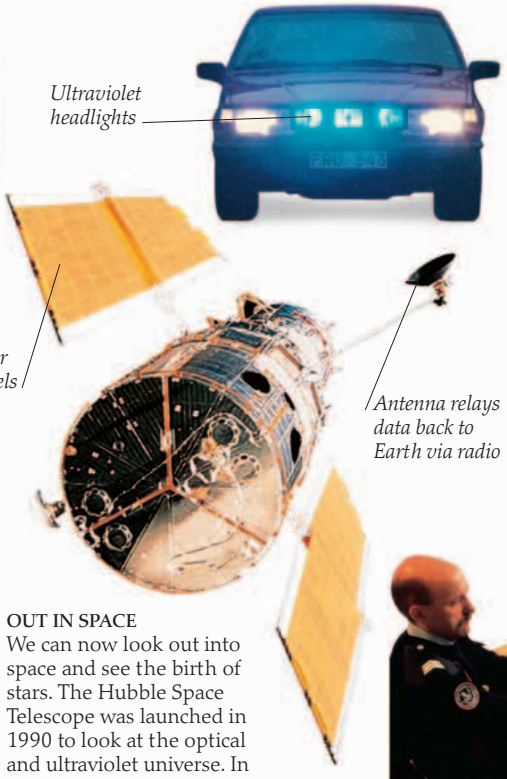
Seeing the invisible

X-RAY SPECS
Children had fun with these pretend X-ray specs (or gogs), launched in the 1950s. They could use their imagination to pretend they were spies or secret agents, capable of seeing through the walls of buildings, or even through skin to their own skeleton. If one day in the future X-ray specs do become a reality, they would certainly be used by everyone.

With the naked eye we can see the world around us, and with a little assistance we can see it more clearly. Eyeglasses help those with poor sight, microscopes allow us to see minute detail, and telescopes permit us to see far into the distance. But there are still many things that remain invisible to us. Visible light is just one small area in a huge electromagnetic spectrum that moves from gamma and cosmic rays through X-rays, ultraviolet radiation, infrared, and microwave, to radio waves. Each of these parts of the spectrum allows us to see the world, and the universe, in slightly different ways. Some are familiar, but others are just being discovered. X-rays have been used in medicine for more than a century. Radar was first used in World War II to locate enemy aircraft and ships. Today, ultraviolet light can be used to help drivers to see better at night, while space telescopes are sending back spectacular images from deepest space.

View of road ahead with ordinary headlights

View of road ahead with ultraviolet headlights

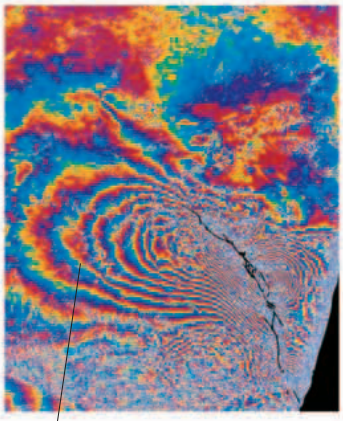


VISION ON
It is hardly surprising that most road accidents occur at night. In poor visibility, a driver has far less warning of a hazard ahead, and therefore less time to avoid it. Brighter headlights are not practical because they dazzle oncoming traffic. But ultraviolet light, invisible to the human eye, can be used. It reflects off fluorescent material, warning the driver in time to stop.

OUT IN SPACE
We can now look out into space and see the birth of stars. The Hubble Space Telescope was launched in 1990 to look at the optical and ultraviolet universe. In 1995, it sent back the first high-quality images of the Eagle Nebula (left), a huge cloud of gas and dust 7,000 light-years from Earth.

Columns of hydrogen gas act as incubators for new stars

SECURITY CHECK
Customs officials at airports and ports throughout the world use X-ray machines to check the contents of luggage. With new technology, larger and more sophisticated machines have been designed that are capable of checking the entire contents of vehicles, such as this truck (right). Previously it could take anywhere up to 24 hours to carry out a security check – now it can be done in a matter of minutes.



Colored bands show Shockwaves of earthquake

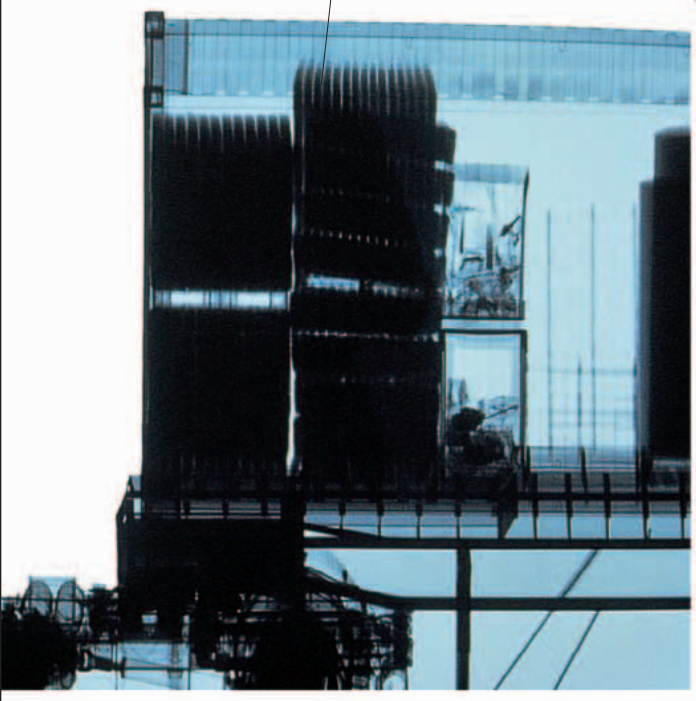
VIEW FROM SPACE
This color-enhanced image of an earthquake was taken by the *ERS-1* satellite. It is the first view of an earthquake from space and shows how the ground was displaced in California in 1992. The closer the color bands are, the greater the ground displacement.

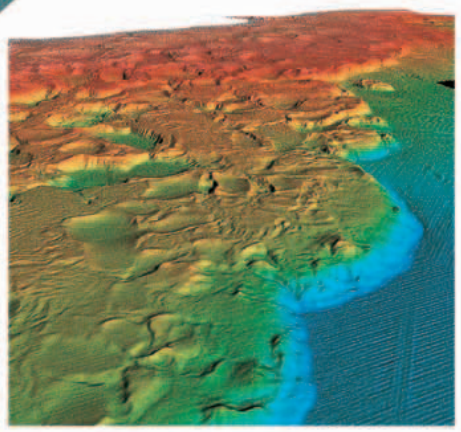
Pilot's cabin

STEALTH FIGHTER
It is difficult to make something as large as an airplane disappear, but that is what Lockheed attempted to do with their F-117 Stealth Fighter. Its angular shape deflects radar beams, making it difficult to spot and almost impossible for guided missiles to attack. Although the fighter can be cloaked from radar, it is not invisible to other detection devices, such as thermal imaging.

Angular shape deflects radar beams

Security officials can see through 11 in (28 cm) of steel, revealing any secret cargo





OCEAN FLOOR
This sonar image taken of the sea bed in the Gulf of Mexico was made by ships recording sound echoes from the ocean floor. The different colors show the various depths. Buried rock sediment, deposited from the Mississippi River, creates a crater landscape that resembles the surface of the moon.

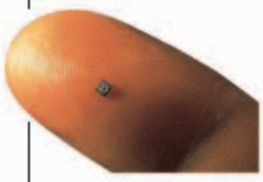
Infrared goggles give soldier ability to see in the dark

TOMORROW'S KILLING MACHINE
Camouflage has been used to help soldiers and their weaponry blend into the background. However, the use of radar, ultra-sensitive listening devices, and thermal imaging makes it increasingly difficult for soldiers to "disappear." Military scientists are developing new cloaking devices so that soldiers and their equipment can hide from enemy targets.

Heads-up display (HUD) projects tactical information into eyepiece

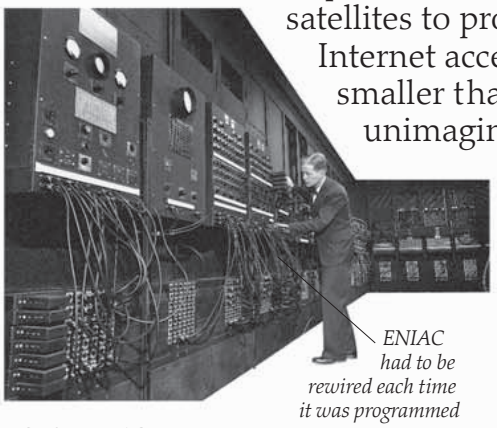
"Smart" weapon includes a laser to pick out target

Getting smaller



IN MINIATURE
The integrated circuit is an essential feature of modern technology. It replaced the diverse separate components of early electronics. Many thousands of individual transistors can be carried on a tiny chip of silicon, changing the look and the way electronics can be applied.

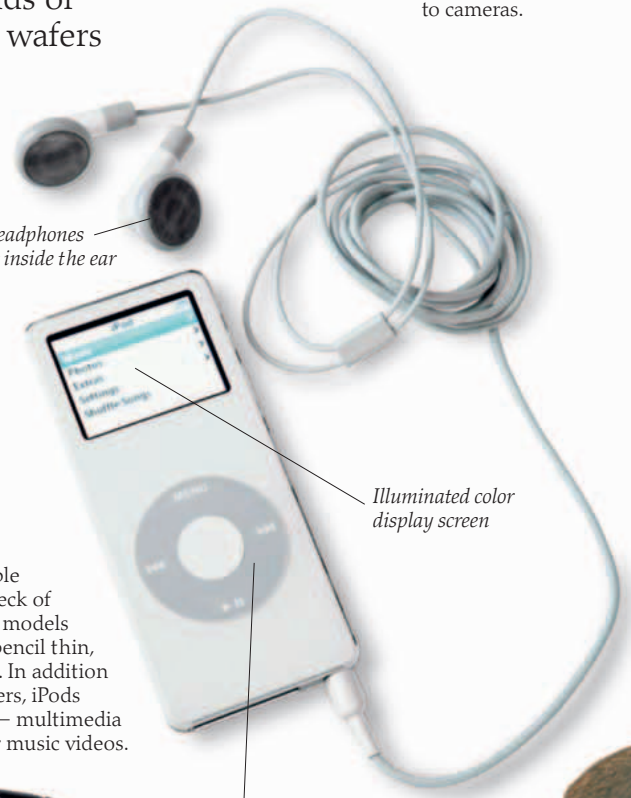
THE INVENTION OF THE TRANSISTOR in 1947, and its successor the integrated circuit in 1959, have transformed our world. Previously, cumbersome electron tubes in radios and television sets generated a lot of heat and had to be housed in large containers. Today, thousands of electrical components are etched onto tiny wafers of silicon to make microprocessors. This technology has spawned a computer industry that only a few years ago was unimaginable, with powerful hand-held computers that can be linked to satellites to provide e-mail and Internet access. In the past, a radio smaller than a mouse seemed unimaginable, but now one exists. In the future, components will get even smaller still.



ENIAC had to be rewired each time it was programmed

MONSTER MACHINE
Before the introduction of transistors and integrated circuits, scientists relied upon valve technology for their electronic computers. This meant that computers were extremely large and not very powerful. One of the first computers, ENIAC, weighed 30 tons and occupied a whole room.

POWER SUPPLY
These tiny, lightweight batteries can be used to power a whole range of electronic equipment, from watches to cameras.



Headphones fit inside the ear

Illuminated color display screen

Click wheel to access menus, play, pause, or rewind

MUSIC ON THE MOVE
The first iPods designed by Apple Computers were the size of a deck of playing cards. The latest "nano" models are less than half the size and pencil thin, but still hold up to 1,000 songs. In addition to acting as a digital audio players, iPods also carry photos and podcasts – multimedia files, such as audio programs or music videos.

Menu displayed on screen as icons

BLACKBERRY
In less than 50 years computers have reduced in size so that now they can fit into the palm of your hand. The BlackBerry combines a cell phone, a personal organizer, a wireless Internet browser, a digital walkie-talkie, and a mini-laptop computer and can send and receive e-mails from just about anywhere – all as you walk along the street.

USB STICK
The size of a pack of chewing gum, a USB stick can hold a huge amount of data, which can be easily transferred between electronic devices. This type of USB stick is inserted into the USB port on a computer and is recognized by the computer as a removable hard disk drive.

USB connection

VIDEO CAMERAS
Since they first appeared in the 1980s, video cameras, or camcorders, have been increasing in popularity. People take them all over – to school plays or sports events, to family gatherings, and on vacation. The latest camcorders are digital, with full-color screens so you can view as you record and replay film clips.

Liquid crystal display (LCD) screen

POCKET-SIZED TELEVISIONS
In the early days of television, all the working components were housed in a large, cumbersome wooden box. Today, integrated circuits allow us to package a television into a much smaller container. This television is small enough to slip inside a pocket.

Zoom lens

DIGITAL CAMERAS
Digital cameras record images directly onto a flash card, which is downloaded onto a computer for viewing. The images are easy to store and edit, so if you do not like a photograph, you can change it! This camera is less than 1 in (2 cm) thick and weighs only 5 oz (149 g).

Color screen displays text and images

Headset fits over the ear

BLUETOOTH HEADSET
This mini device sets up a short-range wireless connection with your cell phone, so you can leave your phone in your pocket as you talk.

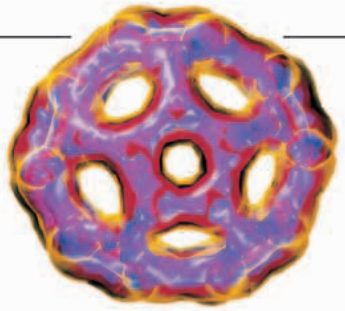
ESSENTIAL COMMUNICATION
Early cell telephones were impractical, cumbersome, and required heavy batteries. Today's slimline cells are increasingly popular, and small enough to be carried inside a shirt pocket.
To cater to the increase in demand for airspace, the human voice is digitized before it is transmitted.

High resolution LCD screen

Thumb controls (right hand)

Thumb controls (left hand)

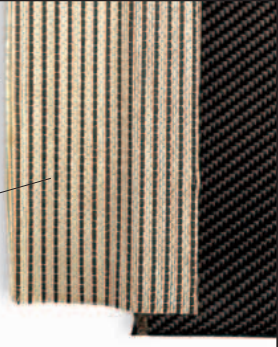
PORTABLE VIDEOGAMES
You no longer need to go to a video arcade or sit in front of a TV to play 3-D computer games. A new breed of tiny console fits realistic games right in the palm of your hand. On this portable Sony PlayStation, you can also play movies, listen to music, and surf the Internet.



BUCKYBALLS
Buckyballs are tiny spherical structures made up of 60 carbon atoms. They may become the building blocks of a new kind of engineering at a molecular level – creating nanomachines (pp. 34-35).

Lighter than air

Carbon cotton feels rougher than normal cotton



NEW MATERIALS ARE being developed all the time. The invention of plastic in the early 20th century revolutionized our world, and plastic became the lightweight alternative to traditional materials such as wood, metal, and glass. There are now hundreds of different types of plastic, and others are being developed. Plastics are very adaptable and can be used to make anything from durable toys to pliable contact lenses. However, most plastics are not biodegradable, so millions of tons of wasted plastic cannot be disposed of safely. New materials and processes may provide solutions, but in the meantime, scientists are developing more environmentally friendly materials for the next millennium. Some lightweight synthetics are stronger than steel, yet they can be woven into clothing. Foamed metals use fewer raw materials, making them lighter but still just as strong.

Pull a carbon thread as hard as you like – you can't break it

HEAT-RESISTANT TILES IN SPACE
Silica tiles line the underside of the space shuttle *Columbia*. The heat-dissipating tiles are made from a high-quality sand, and are used to protect the shuttle from the extreme temperatures as it re-enters the Earth's atmosphere.

LIGHTWEIGHT FRAME
Designed by Lotus Cars, this lightweight automobile chassis is a remarkable piece of engineering. It only weighs 149 lbs (68 kg) – half the usual steel equivalent – and can be easily lifted by two men. It is made from an alloy that is sensitive to heat. Instead of welding, the metal joints are held together by a powerful glue.

Rivets keep joints from coming apart

Bonded chassis is both lightweight and strong

Lightweight steel subframe

Space-age glue holds chassis parts together

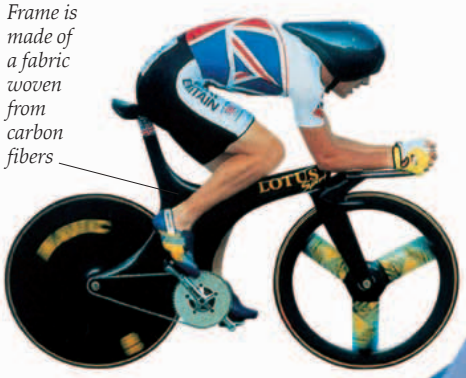
Lotus Elise

HIGH-TECH FIBER
This material may look like cotton, but it is, in fact, carbon fiber. Unlike cotton, the thread of this lightweight fiber is almost impossible to break. It can be used in a whole range of products, from high-tech fighter planes to bicycle parts and golf clubs.

IN THE HEAT OF THE MOMENT
Kevlar is a synthetic material similar to nylon, yet it is five times stronger than steel, more flexible than carbon fiber, and resistant to high temperatures. It can be woven into jackets to make them bulletproof. The textile can stand temperatures as high as 752°F (400°C), making it much tougher than standard firefighting clothing.

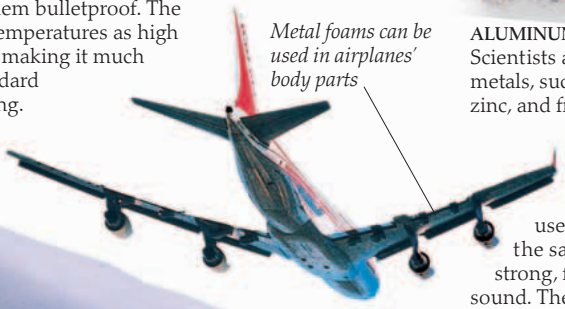
ALUMINUM FOAM
Scientists are taking ordinary metals, such as aluminum and zinc, and frothing them up to create metal foams for all kinds of uses. Foamed metals are full of holes, so they use less material to fill the same space. They are strong, fireproof, and absorb sound. They already form parts of spacecraft, and will soon be used in airplanes. As they are lighter than ordinary metal, they reduce fuel consumption.

Frame is made of a fabric woven from carbon fibers



RIDE TO VICTORY
A racing bicycle must be light, strong, and aerodynamic. In 1992, a frame made from carbon fiber helped British athlete Chris Boardman win a gold medal at the Barcelona Olympics.

Metal foams can be used in airplanes' body parts



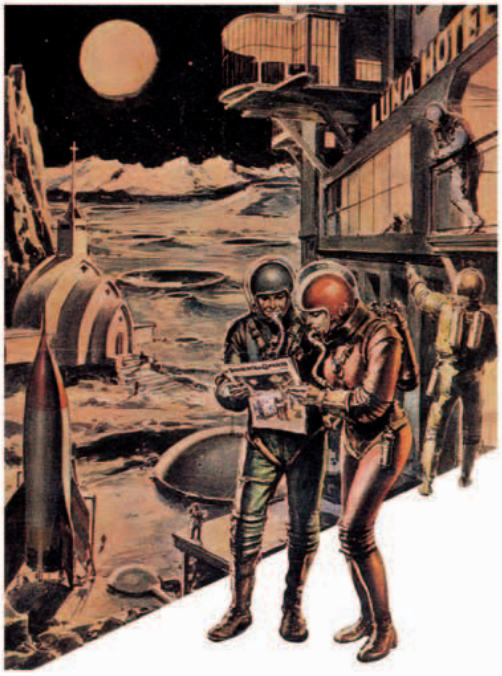
SEAgel is water-soluble at temperatures above 50°F (10°C)

SEAgel claims to be the first "lighter-than-air" solid

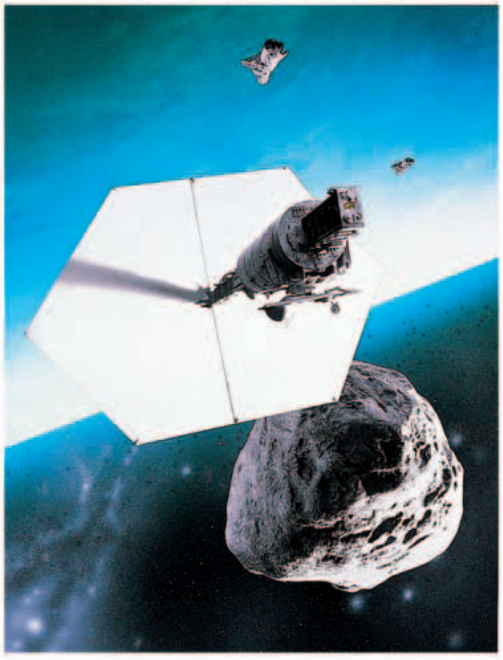
REVOLUTIONARY MATERIAL
Safe Emulsion Agar gel, or SEAgel, is an extremely lightweight solid – so light that it can balance on top of soap bubbles! It is produced from agar, which is derived from seaweed and is usually used as a thickening agent for food. Unlike plastic, SEAgel is biodegradable, soluble in water, and will not harm the environment. It could be used as an insulator, or to replace plastic as a packing material.

New frontiers

THROUGHOUT HISTORY, HUMANS have been driven to explore the far reaches of the globe in search of valuable minerals and new forms of life. Now that there are few areas of the world left unexplored, our sights have risen beyond our own planet and into space itself. Only a few centuries ago wooden ships powered by the wind traveled across the oceans into uncharted territories. In an echo of this recent history, we will in the future send spaceships powered by the solar wind to explore space. We will colonize planets and perhaps discover other forms of life. But we cannot rely on Earth to provide the materials to build and power these missions. Asteroids will be mined for resources, and huge solar power satellites will be built to generate electricity. Only then can colonies be established on the moon and nearby planets.

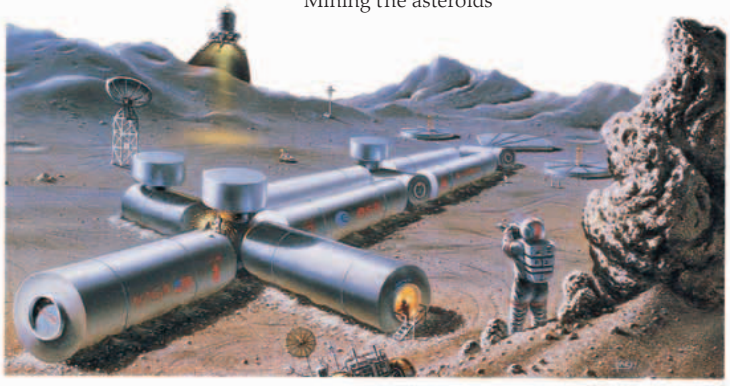


FLY ME TO THE MOON
Vacations in space first captured people's imagination in the 1950s, when we were on the brink of sending the first human being into orbit. In the 21st century, there will be bases on the moon, probably with busy lunar hotels.

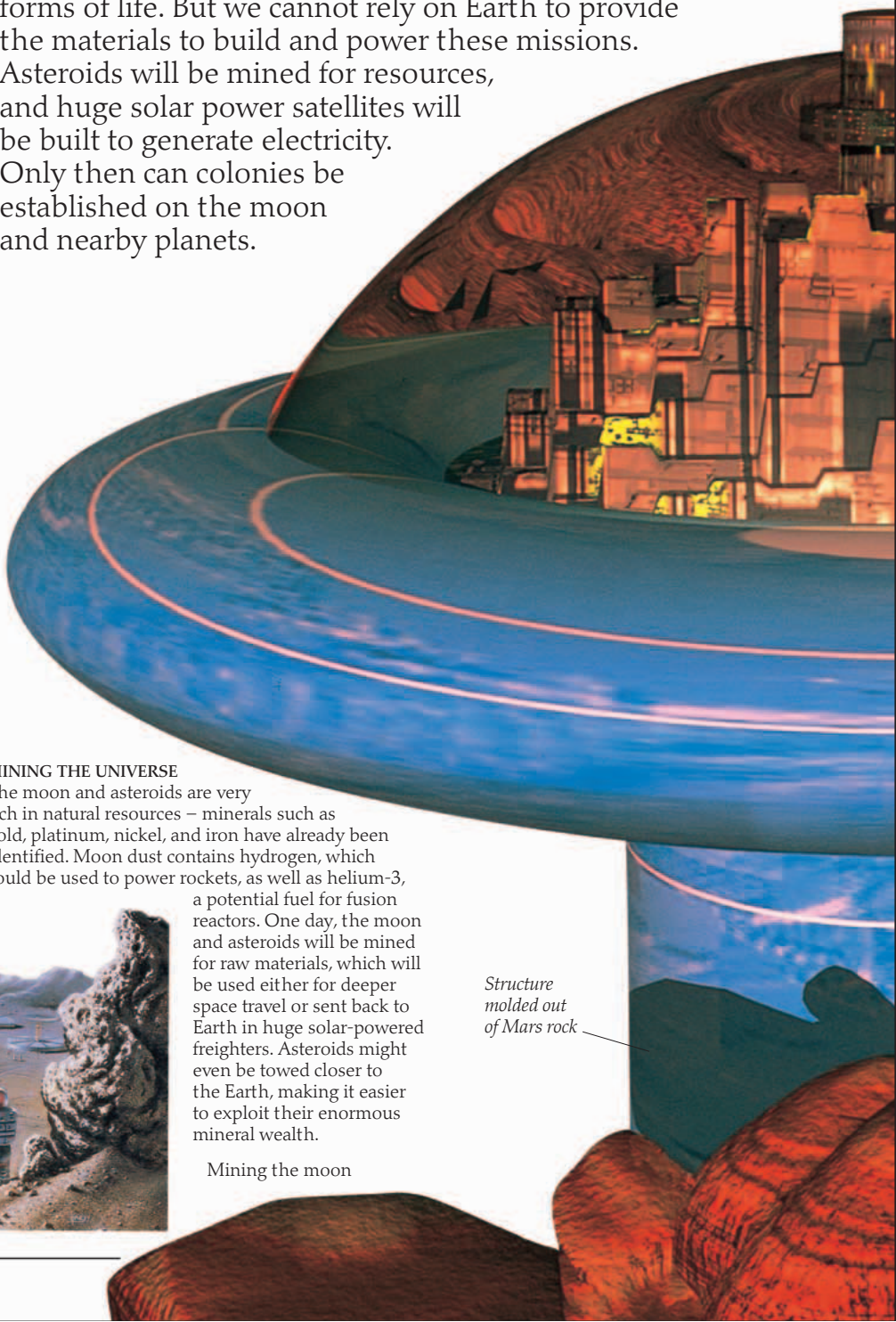


Mining the asteroids

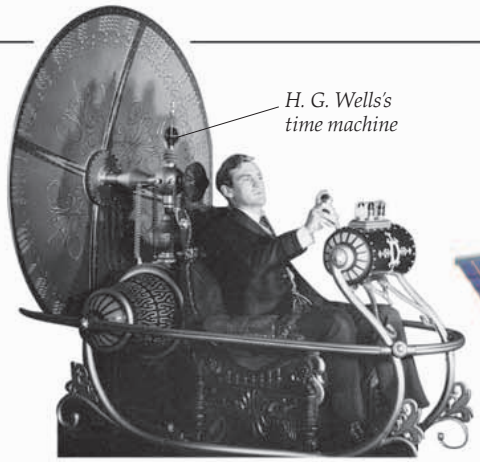
MINING THE UNIVERSE
The moon and asteroids are very rich in natural resources – minerals such as gold, platinum, nickel, and iron have already been identified. Moon dust contains hydrogen, which could be used to power rockets, as well as helium-3, a potential fuel for fusion reactors. One day, the moon and asteroids will be mined for raw materials, which will be used either for deeper space travel or sent back to Earth in huge solar-powered freighters. Asteroids might even be towed closer to the Earth, making it easier to exploit their enormous mineral wealth.



Mining the moon



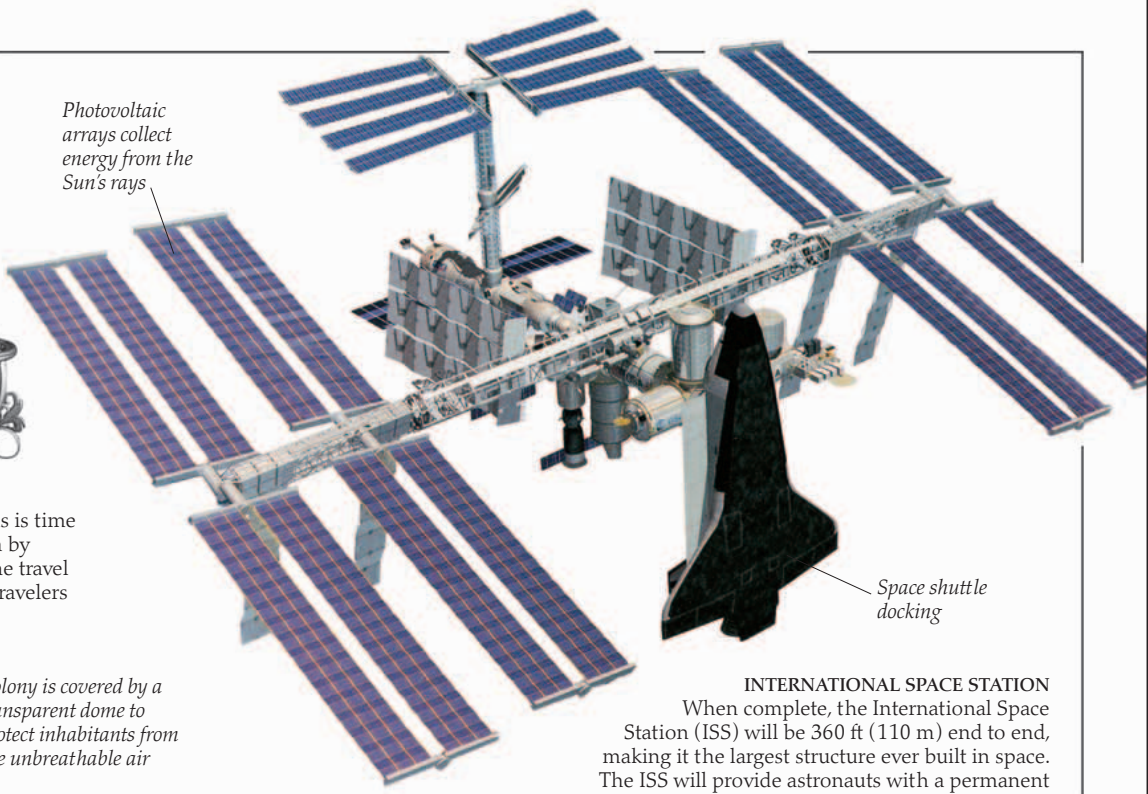
Structure molded out of Mars rock



H. G. Wells's time machine

TIME TRAVEL
Another area that has taxed our imaginations is time travel. It is often a subject for works of fiction by novelists such as H. G. Wells. Logically, if time travel were to become a reality in the future, time travelers would actually be visiting us right now!

Photovoltaic arrays collect energy from the Sun's rays

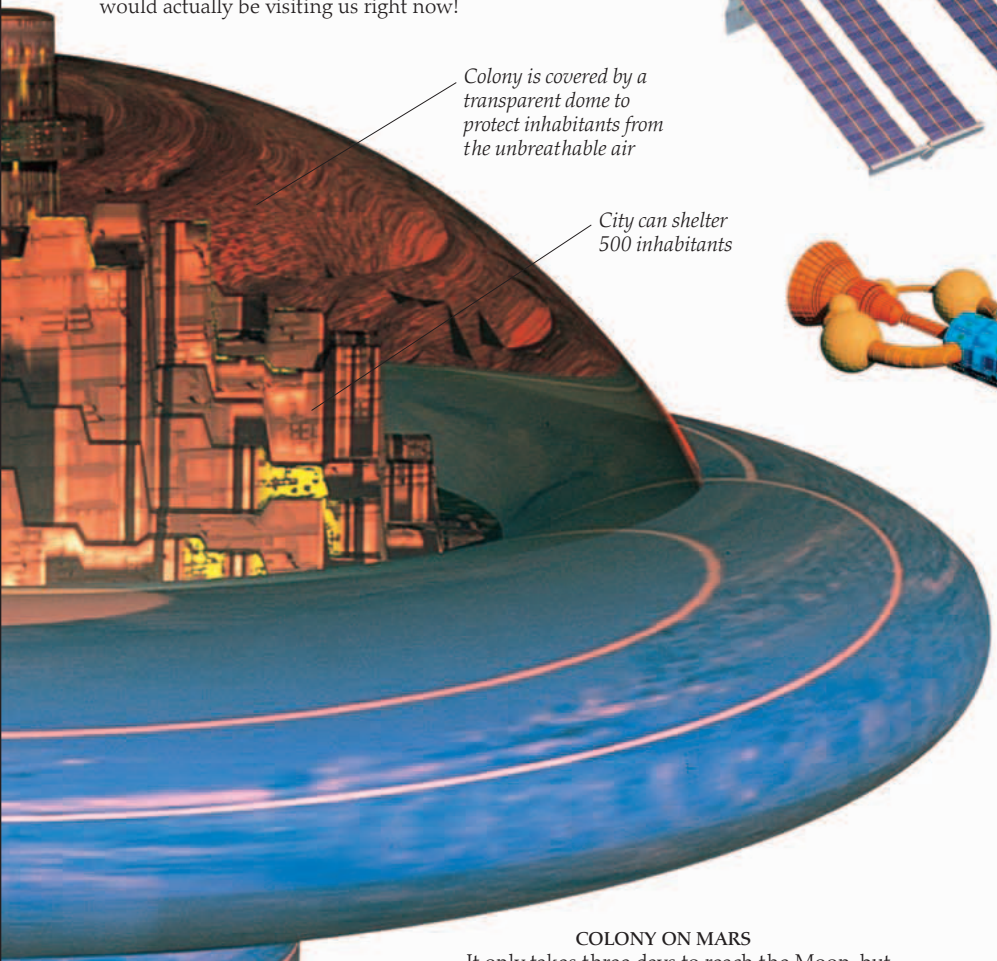


Space shuttle docking

INTERNATIONAL SPACE STATION
When complete, the International Space Station (ISS) will be 360 ft (110 m) end to end, making it the largest structure ever built in space. The ISS will provide astronauts with a permanent base in Earth orbit for long periods of time. Its laboratories will be used for scientific research into new materials and processes and also to study the effects of long-term space flight.

Colony is covered by a transparent dome to protect inhabitants from the unbreathable air

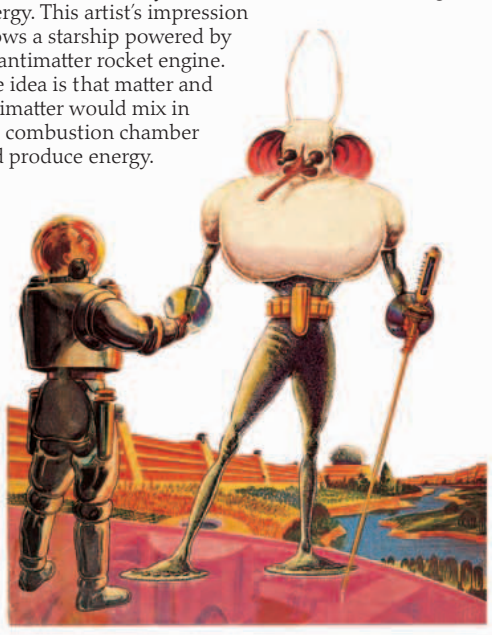
City can shelter 500 inhabitants



ANTIMATTER TRAVEL
For every particle that exists, there is a corresponding antiparticle that is identical in every way except for its opposite electrical charge. When matter and antimatter meet, they annihilate each other, creating energy. This artist's impression shows a starship powered by an antimatter rocket engine. The idea is that matter and antimatter would mix in the combustion chamber and produce energy.

COLONY ON MARS
It only takes three days to reach the Moon, but it would take six months to reach Mars. Because the planet is so far away, it will be necessary to process fuel for the return journey home when the ship reaches Mars. Giant protective domes like this will need to be built to contain whole cities of people in a specially regulated atmosphere.

City is built in a crater on Pavonis Mons, an extinct volcano



IS THERE ANYBODY OUT THERE?
The idea of aliens invading Earth has preoccupied science fiction writers and filmmakers. For many years, people were convinced there was life on Mars. Given the size of the universe, the chances of other life forms existing out there is high, but whether they will look like humans, insects, plants, or amoebas is anybody's guess.

Living in the future

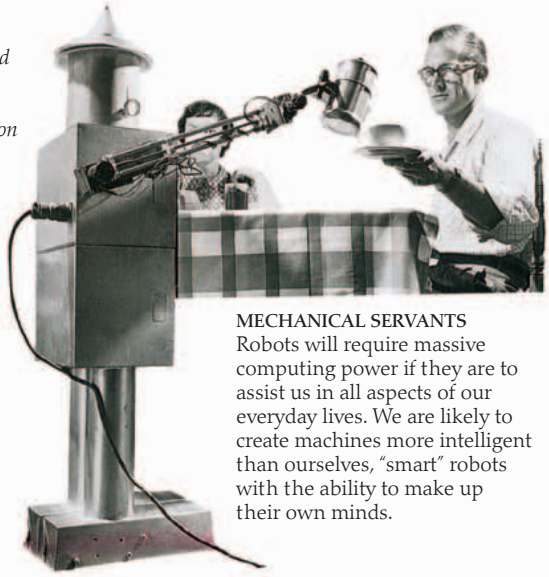
CITIES OF THE FUTURE
The dream of cities in space may soon become a reality. Ice discovered at the moon's polar regions could be used to manufacture fuel and oxygen. This will provide the raw materials to build the first small space colonies.

ALL AROUND US developments are taking place that will dramatically affect our lives. Molecular scientists are uncovering the fundamental processes of life itself. The inherited characteristics of our descendants may one day be in the hands of genetic engineers. If research into robotics is successful, we may share our planet with intelligent machines. New materials are being developed all the time. Our future may not even be on this planet. Wherever it is, and whatever it is like, it is yours to find out about, take part in, and enjoy!

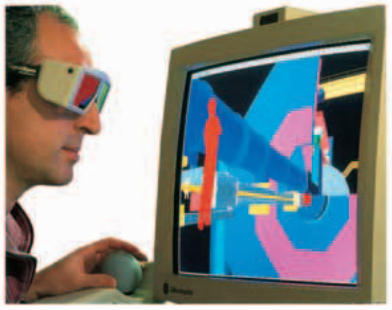
GROWING POPULATION
Growth in the world's population increases demand on resources. International cooperation will be needed to ensure fair distribution and manage the environment.

Smart card microchip will carry information

"SMART" CARDS
Your full personal history could soon be recorded on a smart card. Combining a driver's license, a passport, medical records, financial status, and employment and criminal records, it will be used for all transactions.



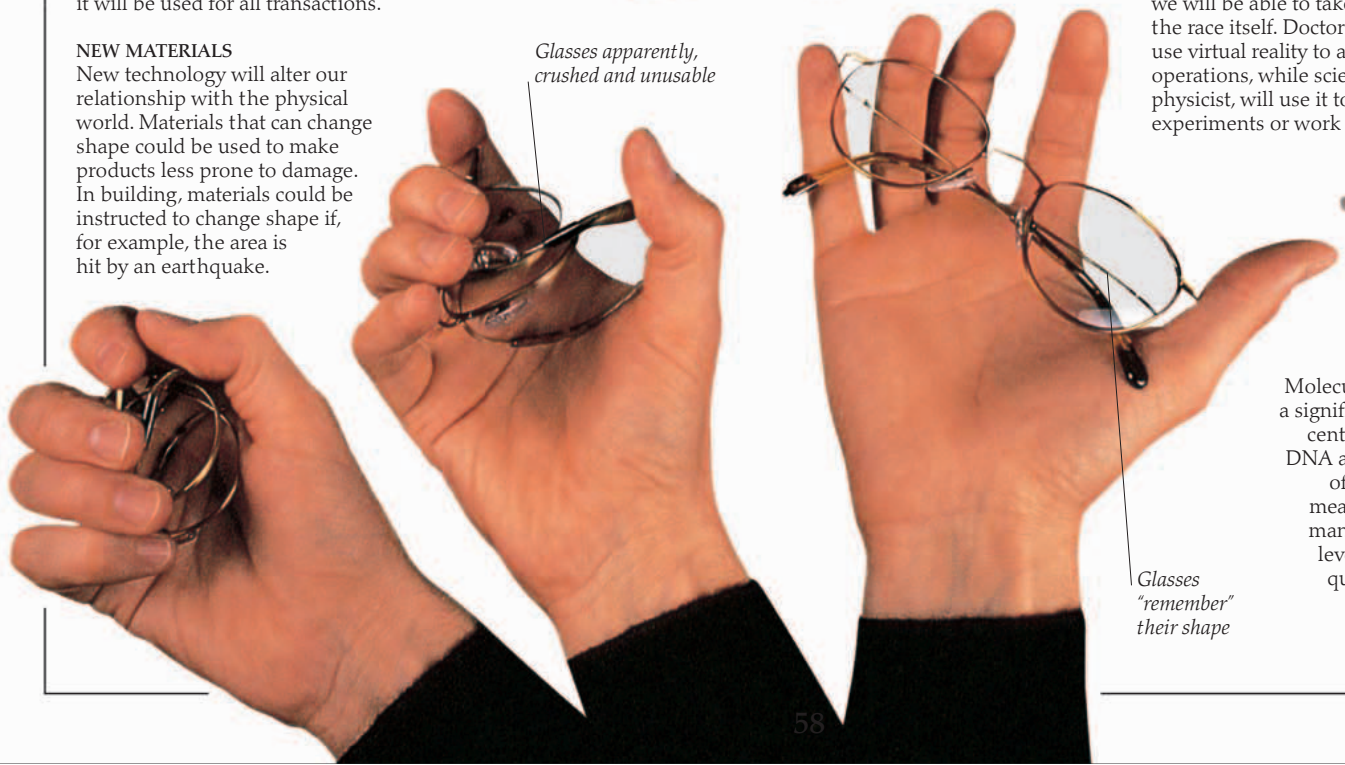
MECHANICAL SERVANTS
Robots will require massive computing power if they are to assist us in all aspects of our everyday lives. We are likely to create machines more intelligent than ourselves, "smart" robots with the ability to make up their own minds.



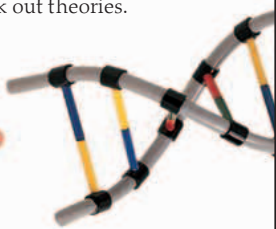
VIRTUAL REALITY
Virtual reality is destined to make a significant impact on the way we live. We are now able to watch motor racing from the stands. In the future, we will be able to take "virtual" part in the race itself. Doctors will routinely use virtual reality to assist with their operations, while scientists, like this physicist, will use it to design experiments or work out theories.

NEW MATERIALS
New technology will alter our relationship with the physical world. Materials that can change shape could be used to make products less prone to damage. In building, materials could be instructed to change shape if, for example, the area is hit by an earthquake.

Glasses apparently, crushed and unusable

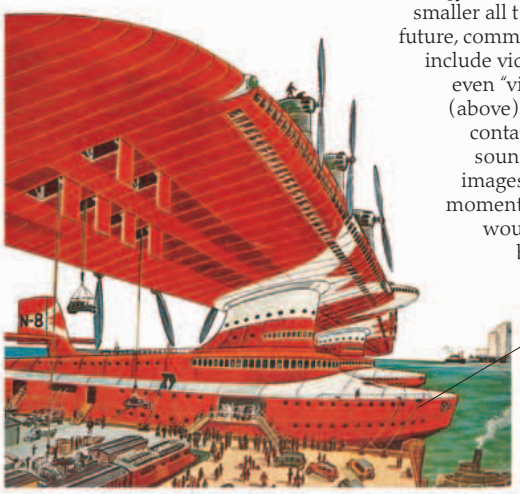


Glasses "remember" their shape



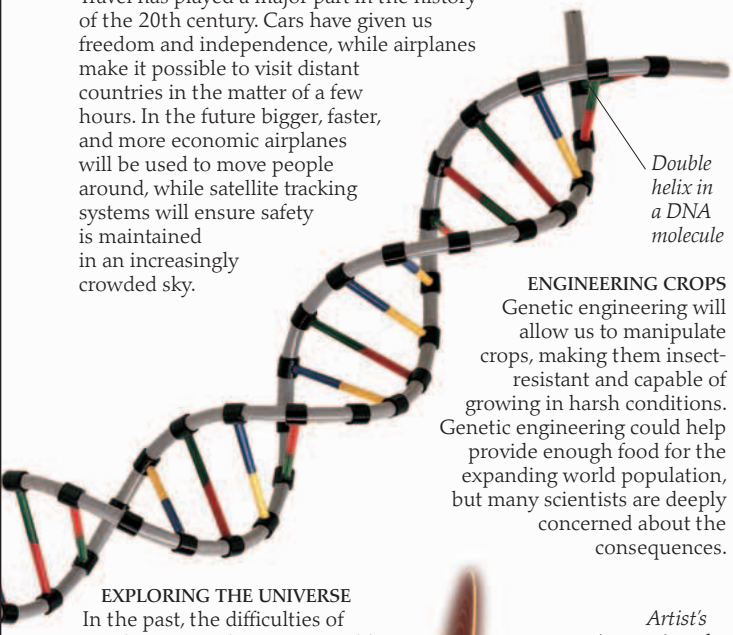
DESIGNING LIFE
Molecular biology will play a significant role in the next century. The discovery of DNA and the development of genetic engineering mean that we are able to manipulate life at a basic level. But this raises the question of how much we should interfere.

COMMUNICATIONS
With Internet access and better technology, the world is getting smaller all the time. In the future, communications will include videophones and even "video postcards" (above). The cards will contain an extract of sounds and moving images. The captured moments and message would be activated by the receiver.



Liner can fly across the surface of the ocean

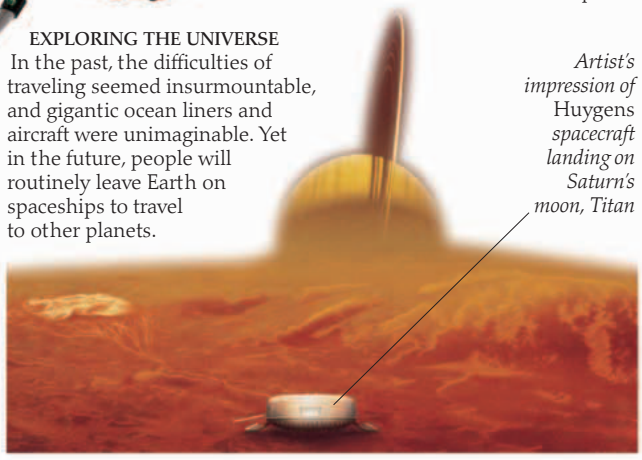
TRANSPORTATION
Travel has played a major part in the history of the 20th century. Cars have given us freedom and independence, while airplanes make it possible to visit distant countries in the matter of a few hours. In the future bigger, faster, and more economic airplanes will be used to move people around, while satellite tracking systems will ensure safety is maintained in an increasingly crowded sky.



Double helix in a DNA molecule

ENGINEERING CROPS
Genetic engineering will allow us to manipulate crops, making them insect-resistant and capable of growing in harsh conditions. Genetic engineering could help provide enough food for the expanding world population, but many scientists are deeply concerned about the consequences.

EXPLORING THE UNIVERSE
In the past, the difficulties of traveling seemed insurmountable, and gigantic ocean liners and aircraft were unimaginable. Yet in the future, people will routinely leave Earth on spaceships to travel to other planets.



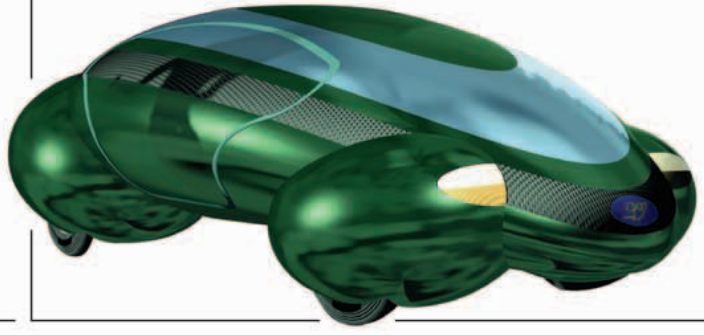
Artist's impression of Huygens *spacecraft landing on Saturn's moon, Titan*

Calendar of the future

Imagine traveling in a time machine into the middle of the 21st century. What do you think life will be like then? By examining current developments, it is possible to make predictions about the future. Many of these predictions may happen and some may not, but those marked with asterisks could happen at any time.

2008	Widespread use of solar cells for residential power supply
2008	Full personal medical records stored on smart card
2008	Electronic notebook as readable as paper
2008	Tactile sensors comparable to human sensation
2009	Firefighting robots that can find and rescue people
2010	Smart clothes that can alter their thermal properties
2010	Presidents and governments of many countries elected by people voting on the Internet
2010	Wristwatch-sized cell phones
2010	Voice-activated products throughout the home to control computers, lights, and other appliances
2011	Multilayer solar cells with efficiency greater than 50 percent
2011	Robotic security and fire guards
2011	Housework robots to fetch, carry, clean, and organize
2012	In-home recycling and water-treatment systems
2014	Nanorobots roaming in blood vessels under own power
2014	Robotic pets
2014	Electronic shopping dominant
2019	First human landing on Mars
2020	3-D video-conferencing
2020	Genetic links of all diseases identified
2020	Artificial lungs, kidneys, and brain cells
2020	Cars that drive themselves on smart highways
2025	Deep underground cities in Japan
2025	New forms of plants and animals from genetic engineering
2025	Artificial liver
2025	Extension of lifespan to over 100
2025	Flying-wing planes carry passengers at 600 mph (960 km/h)
2030	More robots than people in developed countries
2035	Fully functioning artificial eyes and legs
**	Collapse of the world's fisheries
**	Asteroid hits Earth
**	Unknown long-term side effects of medications discovered
**	Viruses become immune to all known treatments
**	International financial collapse
**	Major information disruption
**	Nanotechnology takes off
**	Energy revolution
**	Collapse of the United Nations
**	Terrorism rises beyond the capability of government systems
**	First unambiguous contact with extraterrestrial life
**	Human mutation
**	Worldwide epidemic
**	Time travel invented

Video watch



Self-driving car of the future

Did you know?

FASCINATING FACTS

If ocean levels rise significantly as a result of global warming, many coral islands will vanish beneath the sea, and some major cities, such as New York and London, will disappear underwater.

Scientists are trying to develop plants that could produce plastic. Today, all plastic is entirely man-made.

Camels could help cure sick humans in the future. Not only are camels able to survive harsh conditions, but they are also highly resistant to many deadly viruses. Scientists in the Middle East are hoping to use camel antibodies to make effective new drugs for humans.

Landfills are filling rapidly. In Marseilles, France, the city council is planning to use robots with special sensors to sort trash so that more of it can be recycled.

Scientists predict that by the year 2010, transistors will be so small that 2,000 of them will be able to fit across the width of the average human hair.

A company has formed to market vacations in space. The first space tourist has already been into orbit. As long ago as the 1970s, an American airline accepted reservations for flights to the Moon in 2000. Former president Ronald Reagan was one of the first to sign up.

The Next Generation Space Telescope

In the future, space telescopes may be able to see right back to the Big Bang. The Next Generation Space Telescope (also called the James Webb Space Telescope), to be launched by 2011, will look into space and study how galaxies and stars first formed after the birth of the Universe.

Work is about to start on an enormous wind farm on the Isle of Lewis off the west coast of Scotland. It is going to be the largest wind farm in Europe, capable of producing the same amount of electricity as a nuclear power station.

Research has shown that plants grow better when they are stroked regularly, so a new machine has been invented that strokes seedlings as they germinate, helping them to produce stronger and healthier plants.

In the next 10 years, large computers will work so fast that wire connections will no longer work with them. Only light rays will move fast enough to carry the data.

By 2020, it is predicted that four people out of ten could be working in their homes instead of offices. They will link to their colleagues and via the Internet.

Wind farm

Dennis Tito (left), the first space tourist

The first manned mission to Mars could take place as soon as 2019, when the planet will be favorably positioned.

A brightly colored, child-friendly robot named Pebbles has been developed in Canada to help children who have to spend a long time in the hospital keep up with their schoolwork. Pebbles has a monitor and enables children to have direct two-way visual communication with their teachers and classmates.

Scientists hope that within 10 years computerized telescopes will be able to locate any large asteroids that may be heading for Earth. They are trying to develop rockets or lasers powerful enough to destroy asteroids before they hit us.

Tigers, a species at risk of extinction

Half of the world's species of plants and animals could die out completely in the next 50 years. The main threat to their survival comes from loss of natural habitat, caused partly by global warming and pollution, and partly by people clearing land for farming, forestry, or the mining of oil and minerals.

QUESTIONS AND ANSWERS

Q Is there any evidence of intelligent life somewhere in space?

A So far there has been no evidence of intelligent life in space. When pulsars were discovered in 1968, astronomers called them "little green men" because they didn't know what they were, but no one believed they were signals from aliens.

Q Will computers continue to become faster and more powerful?

A Computers are becoming more powerful all the time. IBM's ASCI white supercomputer, until recently the fastest computer in the world, takes one second to do what it would take a person 10 million years to do on a calculator.

Q Will houses ever be able to take care of themselves?

A Some scientists believe that one day we couid bring buildings to life; for example, we could have walls that breathe in clean air and breathe out stale air. We could make homes think, too, and call in to ask them to do things for us before we arrive home.

Flying cars in the 1997 movie *Fifth Element*

Q Will it ever be possible to rewire the human brain so it works better?

A A leading scientist has predicted that later in this century we could have the option of inserting silicon chips in our brains in order to rewire them and change the way we think and learn. Scientists have already succeeded in growing live nerves on computer chips.

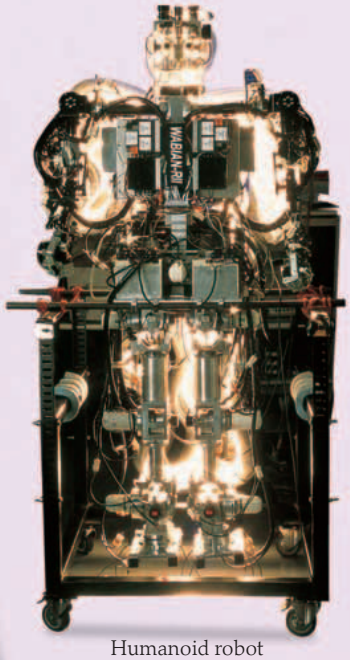
Q Is there anywhere left to explore besides outer space?

A This century, a permanent global network of observatories is being set up on the sea floor to explore the depths of the oceans and what lies beneath them.

Undersea volcanic vent

Q Will we ever have cars that fly?

A The flying car is still a dream. It would need wings (impractical in traffic), the speed of a jet, and room for take-off. In the 1970s, a German firm made a prototype heli-car, but it never went into production.



Humanoid robot

Q Could robots ever rule the world?

A At the moment, all robots have to be programmed, but scientists are working on robots that can move and think independently. Some people worry that such machines may overtake humans.

Q Will there ever be such a thing as a virtual human body?

A A computer-generated virtual heart has been created by a team of scientists as part of a global project to build a whole virtual human body. The idea is to test new drugs on the virtual heart before testing them on people. Today, only one in eight drugs in clinical trials is ever approved. In the future, a virtual body could help tailor drug treatments to a patient's individual needs.

Q Will people have remote-control computers in their homes one day?

A Soon you may be controling your computer from your sofa. Instead of using a keyboard or mouse, you will click on a remote control to activate a DVD or music file. This technology already exists but is not widely available.

In the future, most elderly people may be as active as this water-skier.

Q How long will people be able to live in the future?

A In 2002, there were 76,000 people aged 100 and over in the United States. By 2150, the average human lifespan may reach 200 years if genetic scientists pinpoint how to halt or slow down the process of aging. Improved fitness and health will be strong contributing factors.

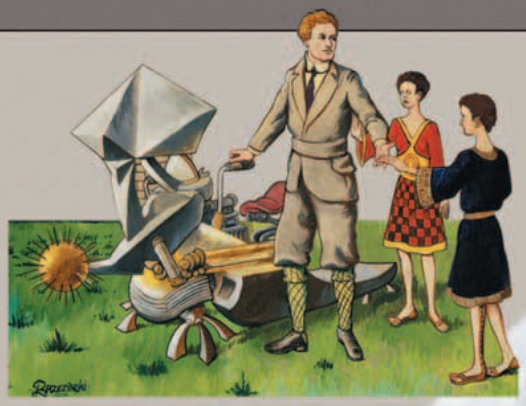


Illustration of H.G. Wells's time machine by Anton Brazezinske

Who's who?

ANY NEW INVENTION OR EXPLOIT has to be dreamed of before it can be attempted in reality. Scientists and visionaries who put forward imaginative ideas about the future—whether as science fiction or science fact—are often proved wrong, but they also help shape the way in which the world evolves.

SCIENCE FICTION WRITERS

Jules Verne's conception of a flying machine

JULES VERNE
Nineteenth-century French author Jules Verne wrote fantasy novels that included powered flight and journeys to the Moon. These imaginative tales were immensely influential, inspiring young scientists and inventors to attempt to make them reality.

H.G. WELLS
Most of H.G. Wells's science fiction was written in the 1890s. In *The Time Machine*, he explored the idea of time travel, something that still fascinates theoretical scientists today. In *The War of the Worlds*, he described the Earth being invaded by aliens.

SIR ARTHUR C. CLARKE
Writer Arthur C. Clarke was the first person to imagine using satellites to create a global communications network. His fictional inventions include HAL, a computer that develops a mind and a will of its own.

Radio telescope dishes communicating with satellites

VISIONARIES

BUCKMINSTER FULLER
Visionary architect "Bucky" Fuller invented the geodesic dome, the strongest, cheapest, most easily built structure ever devised. Eager to save the resources of "Spaceship Earth," he dreamed of housing 5,000 people in geodesic spheres that would float in the air, and of putting domes over whole cities to make them more energy efficient.

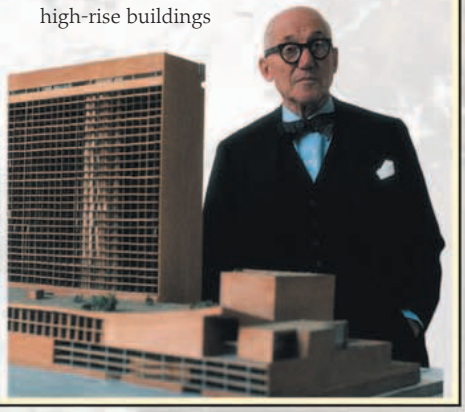
Buckminster Fuller in front of a geodesic dome

Computers are now used almost everywhere.

MARSHALL MCLUHAN
In the 1960s, Canadian thinker Marshall McLuhan was one of the first people to understand the impact that new electronic communications were having. He wrote that the world was becoming a "global village" in which people in different countries were like neighbors, sharing the same gossip and the same experiences.

LE CORBUSIER
From the 1920s onward, French architect Le Corbusier developed a vision of a new kind of city for the modern age. Its buildings were to be rationally designed "machines for living," made of standard prefabricated parts and laid out in rigorously planned communities. He saw this as an ideal blueprint for city dwellings.

Le Corbusier with model high-rise buildings



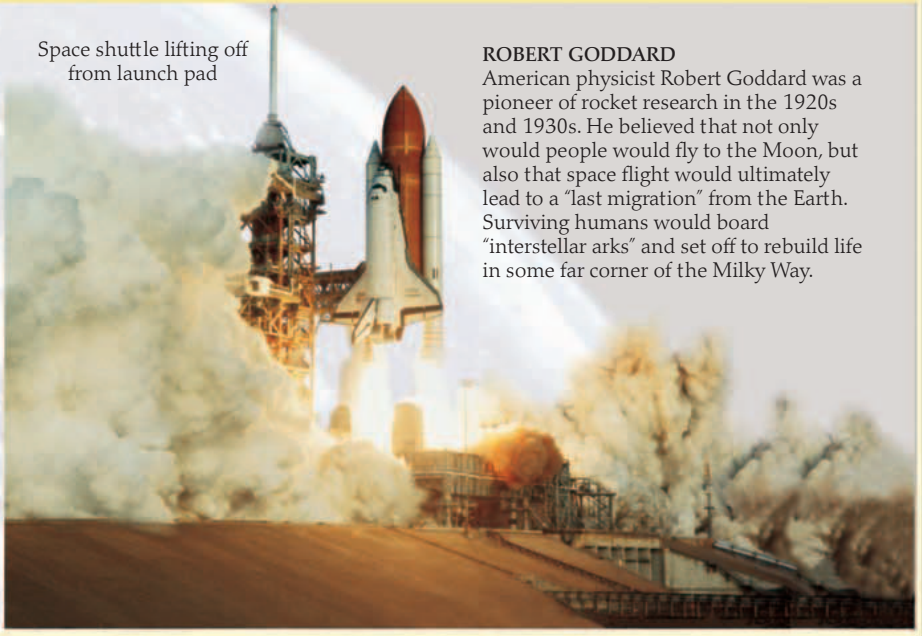
SCIENTISTS

Stephen Hawking

STEPHEN HAWKING
English physicist Stephen Hawking, author of *A Brief History of Time*, has said that humans may send intelligent machines, capable of reproducing themselves, to colonize the planets of other stars.

JAMES LOVELOCK
Environmental scientist James Lovelock sees the Earth not as a rock but as a living system that he calls "Gaia." In his ideal vision of the future, humans accept their place as part of Gaia rather than trying to conquer it.

Space shuttle lifting off from launch pad



ROBERT GODDARD
American physicist Robert Goddard was a pioneer of rocket research in the 1920s and 1930s. He believed that not only would people would fly to the Moon, but also that space flight would ultimately lead to a "last migration" from the Earth. Surviving humans would board "interstellar arks" and set off to rebuild life in some far corner of the Milky Way.

FAILED PREDICTIONS

MOVING PAVEMENTS
In H.G. Wells's science fiction novel *When the Sleeper Wakes*, a city of the future has moving pavements that carry people along without walking. This idea never caught on in towns but did find a use in airports.

FUTURE HOUSEWORK
In 1950, a magazine predicted that by the year 2000, we would be able to do our cleaning with a garden hose, since everything would be plastic, and, therefore, waterproof.

PLENTY OF LEISURE
In the 1960s, futurologists predicted that by 2000, hard work would be a thing of the past, with the average person going into an office or factory for just three hours a day.

A 1960s vision of the future: the movie *2001: A Space Odyssey*

The wings could fold away and be towed behind the car when driving on the road.

Molt Taylor's Aerocar

WORLD WITHOUT WHEELS
In 1975, Arthur C. Clarke said that the wheel would be redundant by 2000 because cars would float on air.

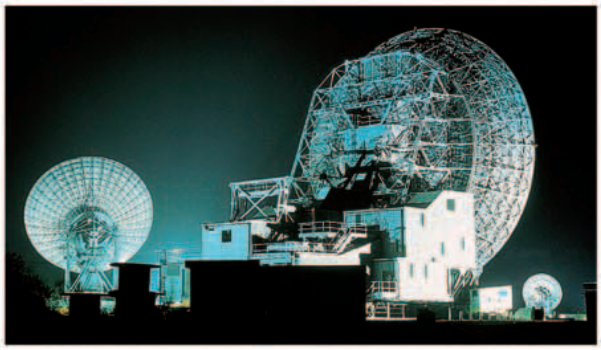
SOLAR POWER
In 1981, science fiction writer Isaac Asimov said that by 2000 there would be power stations in orbit around the Earth, using solar energy to generate electricity.

AIR-CARS
In 1924, automobile manufacturer Henry Ford predicted that one day aircraft would be as common as cars. In the 1950s, Molt Taylor tried to market the Aerocar, an aircraft that would turn into a car to drive on the road, but the idea of an aircraft in every garage remains a dream.

PEACE FOREVER
In 1900, T. Baron Russell predicted that by 2000, war would have died out.

WORKING ON THE MOON
In 1982, NASA predicted that by the year 2000 there would be at least 1,000 people working on the Moon. In fact, no human has set foot on the Moon since 1972.

SAFE NUCLEAR ENERGY
It was once widely believed that nuclear energy would provide all our electricity cleanly, cheaply, and, above all, safely. In 1955, energy officials predicted that the United States would have 1,000 nuclear plants by the year 2000. In fact, there were only about 100.



EARTH STATION
The British Telecom Earth Station in Cornwall, England, is the largest operational satellite station on Earth. Its massive dishes send and receive TV pictures from all over the world and handle thousands of international phone, fax, and video calls. At the multimedia visitor center, visitors can find out all about the latest developments in satellite technology and can even operate a satellite dish.

Find out more

WATCH FOR REPORTS OF the latest developments in science and technology in newspapers, science magazines, and television programs. For more detailed information, it is worth visiting science museums. Many of these have excellent interactive displays, and some of the larger ones even have exhibits devoted to the future. There are also theme parks dedicated to technology and visions of the future. Here are some suggestions for interesting places to visit, as well as a list of useful Web sites that can provide more information.

INTERACTIVE SCIENCE MUSEUMS
Many museums encourage a "hands-on" approach to science. La Cite des Sciences et de l'Industrie in Paris is a vast science museum with many interactive displays. Children are greeted at the entrance by a friendly robot and there is a children's zone, called La Cité des Enfants, where children can try things out for themselves and discover how they work.

Robot at La Cité des Sciences, Paris

Space exhibit at La Cité des Sciences

INFORMATION TECHNOLOGY
The, Explora section of La Cité des Sciences et de l'Industrie has many exhibits on the development and future of information technology. While there, visitors can also pilot an airplane, step inside a camera, visit the Ariane rocket, and take a trip through the human body.

Places to Visit

EXPLORATORIUM, SAN FRANCISCO, CALIFORNIA
An experimental, hands-on museum designed to interest visitors of every age. Many exhibits can be touched, looked through, picked up, and tinkered with.

LIBERTY SCIENCE CENTER, JERSEY CITY, NEW JERSEY
Learn about electricity, wind, technology, and matter with interactive exhibits.

ORLANDO SCIENCE CENTER, ORLANDO, FLORIDA
See how electricity and magnetism combine in the Science City: Power Station exhibit or examine physical laws of nature in the Physics Park exhibit.

VIRTUAL REALITY
Futuroscope, near Poitiers, France, is a huge futuristic theme park devoted to the moving image, with about 20 different giant screens. Here visitors can experience the latest virtual reality technology, watching 3-D films while sitting on moving seats. The latest attractions include encountering cyber bugs, being sucked into whirlpools, and experiencing a dive down to the lost city of Atlantis.

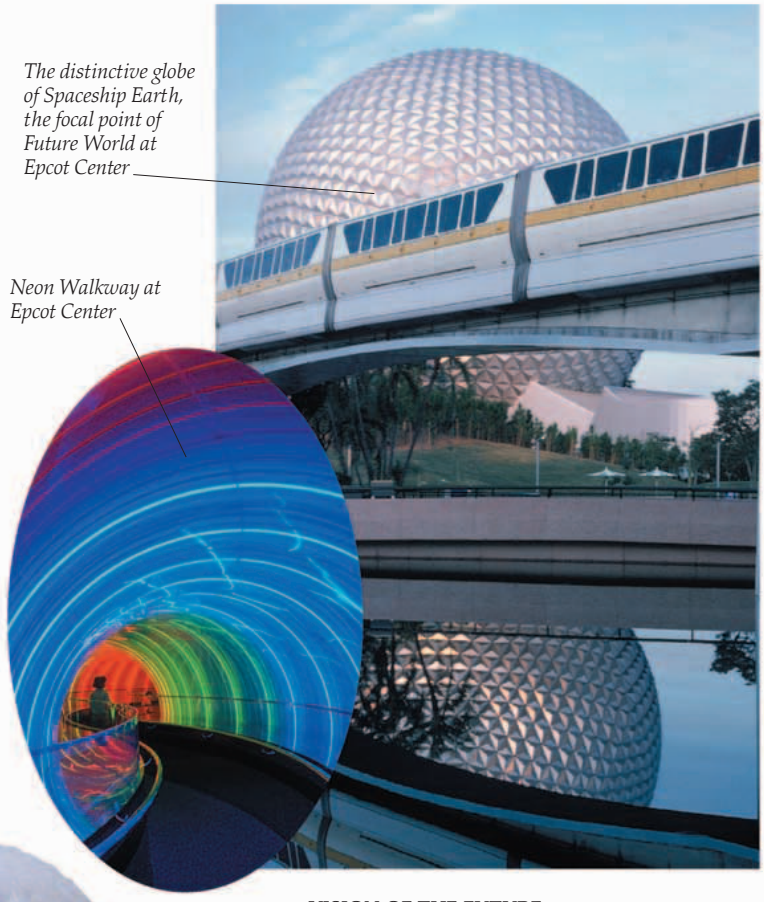
Futuroscope, France

The Digitopolis gallery

DIGITAL TECHNOLOGY
At the Digitopolis gallery in the Science Museum in London, visitors can explore an extraordinary landscape to find out about digital technology and how it might develop in the future. Interactive exhibits are set alongside more traditional objects and displays so that visitors can understand modern technology and weigh the positive and negative aspects of its impact on everyday life.

The distinctive globe of Spaceship Earth, the focal point of Future World at Epcot Center

Neon Walkway at Epcot Center



Eden Project, Cornwall, England

VISION OF THE FUTURE
Epcot Center is at Disney World in Orlando, Florida. Epcot stands for Experimental Prototype Community of Tomorrow, and it was originally Walt Disney's personal vision of a town of the future. In fact, it is a theme park, half of which is called Future World. In nine pavilions, visitors can travel on a time machine through the history of communication, see the latest gadgets, and visit the house of the future. They can also board a gondola and travel through an entertaining view of the future as imagined by famous writers of science fiction.

CONSERVING RESOURCES FOR THE FUTURE
At the Eden Project in Cornwall, England, you can visit the largest greenhouse in the world. It is made up of vast domes in a former quarry. Each dome houses a different habitat, such as a tropical rain forest. In addition to being a tourist attraction, the Eden Project is doing research into the best ways to conserve natural resources for the future.

IMAX movie about oceans

LARGER THAN LIFE
Movies at IMAX theaters are shown on giant screens, making visitors feel as if they are actually part of the action. Different movies explore topics such as futuristic cyberworlds or difficult-to-reach areas of our own planet, such as high mountaintops. Many movies are shown in 3-D to increase the impression of virtual reality.

USEFUL WEB SITES

- Learn about the future of Earth's oceans, the rain forests, and the space race on the Smithsonian's science-themed site: **www.si.edu/science_and_technology**
- This kid-friendly Web site covers topics such as space, robot technology, computerized classrooms, and saving rain forests. **www.sciencefriday.com**
- The Liberty Science Centers' online learning resources cover electricity, space, engineering, and other fields of science: **www.lsc.org/online_science/online_science.html**
- Investigate Earth, space, and technology on PBS's dragonfly site. Visitors can post messages on different science subjects: **pbskids.org/dragonflytv/exploire.html**

Glossary

ANTIMATTER A form of matter that might be made of particles with the opposite electrical charge from the particles making up normal matter

ARTIFICIAL INTELLIGENCE Computers functioning like intelligent human beings, for example, learning new things for themselves and taking their own decisions

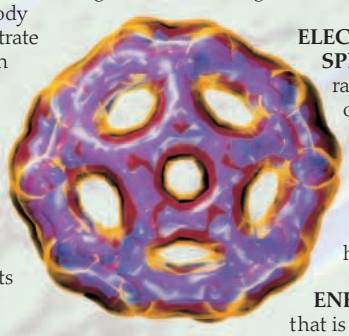
ASTEROID A rocks that circles a star; similar to a planet, but much smaller

BIODEGRADABLE A term used for waste that will naturally decompose and so generally poses little threat to the environment

BIOFEEDBACK A technique allowing people to learn to control body functions such as their heartrate by tracking their progress on a monitoring machine

BUCKYBALLS Tiny structures made up of carbon atoms that may play an important role in creating new materials

CELL One of the small units of which all living things are composed



Buckyball

CENTRIFUGAL FORCE The tendency of an object traveling in a circle, such as a stone swinging from the end of a string, to pull away from the center of the circle

CHITINOUS EXOSKELETON The hard outer shell of arthropods, animals such as beetles, crabs, scorpions, and spiders

CLONING Producing an exact replica of an individual animal or plant by some form of genetic engineering

Dolly, the first cloned sheep

CONGENITAL DISORDER An illness or other medical condition that a person is born with

CYBORG A type of robot that is partly a machine and partly a living organism

DEHYDRATED FOOD Food that has had all the water removed from it for storage

DIGITAL/DIGITIZED Information that has been changed into numbers so that it can be stored on a computer or sent through a cable as a series of electrical impulses

DIGITIZED VOICE A voice that is generated by a computer

DNA Deoxyribose-nucleic acid, the helix-shaped chemical that carries all the genetic information that is needed to make a plant or animal

Model of a DNA double helix

EEG Electroencephalo-graph, a machine used to record electrical activity inside a person's brain

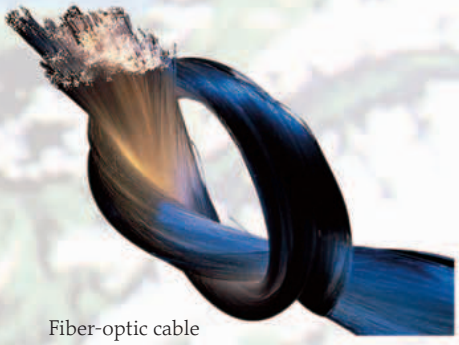
ELECTRODE A part of a system for generating an electric current. Positive electrodes are called anodes, and negative ones are cathodes

ELECTROMAGNETIC SPECTRUM The whole range of radiation, including not only the visual spectrum (the colors of the rainbow) but also infrared, ultraviolet, and X-rays

EMBRYO The earliest stage of development of an animal or a human baby in the womb

ENERGY EFFICIENT Something that is designed to use up as little energy as possible to do a task

ENZYMES Chemicals that control much of the way that cells in the body work



Fiber-optic cable

FIBER OPTICS Bundles of long, thin glass fibers used to transmit sound and images

FOAMED METAL Metal that has been filled with small holes to make it lighter

FOSSIL FUEL Fuels such as coal, natural gas, and petroleum that are made of decomposed plants from prehistoric times

FREQUENCY The number of vibrations per second of a sound wave

FUSION REACTOR A type of power station that generates electricity through a nuclear reaction

GENE A piece of DNA that passes on a specific characteristic, such as eye color, from parent to child

GENETIC ENGINEERING Techniques used to alter DNA, for example, by moving genes from one animal or plant to another

GENETICALLY MODIFIED A term for crops, animals, or foods that have been altered by some form of genetic engineering

GEOSTATIONARY ORBIT A satellite is said to be in geostationary orbit if it orbits the Earth in a fixed position above a particular spot on the Earth's surface

GIGABYTE A billion bytes, the unit of measurement for computer memory

GLOBAL POSITIONING SATELLITE A satellite that is part of a worldwide system allowing people with the right equipment to to know exactly where they are on Earth

GLOBAL WARMING A term used to describe a change in climate that makes average temperatures across the world rise

GREENHOUSE GASES Gases, such as carbon dioxide, that trap heat in the Earth's atmosphere, contributing to global warming

HEAD-UP DISPLAY A system in some modern aircraft that projects data onto the windshield so the pilot can read it without having to look down at the control panel

HERBICIDES Chemicals that are sprayed on crops to kill harmful weeds

HOLOGRAPHIC PROJECTOR A device used to project a three-dimensional image

HOT BADGE A wearable device that broadcasts information about its owner's interests and personality and that tells the owner if someone similar is nearby

Hot badges

IMPLANT Something permanently inserted into a human body, such as a pacemaker

INFORMATION SUPERHIGHWAY A term for the links between computers that allow people to access and distribute information worldwide

INFRARED SIGNALS Signals sent using infrared radiation, which is not visible

INTEGRATED CIRCUIT A complete set of electronic components in a single tiny unit, typically on a silicon chip

INTERNATIONAL SPACE STATION A large satellite that is in orbit around the Earth. The station weighs almost 400,000 pounds (181,000 kg), and the interior is about the size of a three-bedroom house

LASER RANGE FINDER A device used to make guns more accurate by bouncing a laser beam off the target to measure precisely how far away it is

MAGLEV A type of train that is raised above its track by a powerful magnetic field (magnetically levitated) so that it glides along at high speed without friction

Maglev train

MODEM A device that transforms digital information from a computer into a form that can be sent through a telephone line

MONORAIL TRANSPORT SYSTEM Trains that travel on one rail instead of two

MRI Magnetic resonance imaging, a technique for building a 3-D picture of the internal structure of the body

ORGAN TRANSPLANT A surgical operation to transfer a vital body organ, such as a heart or liver, from one person or animal to another

PALMTOP A personal computer small enough to be held in the palm of your hand

PESTICIDES Chemicals that are sprayed on crops to kill insects or other pests

PREFABRICATED A term used for parts of a house that are made in a factory and then taken to a construction site to be put together

PROSTHETICS A term used for attaching artificial limbs or other artificial parts to the body in place of natural ones

PROTEINS Chemical compounds that are an essential component of all living things, whether animals or plants

Prosthetic arm

QUADROPHONIC SOUND A sound system using four speakers instead of the two used in stereo systems

RADAR A method for finding and tracking a distant object, such as an aircraft or a ship at sea, by bouncing radio pulses off it

RECYCLING Reprocessing a manufactured product, such as paper, to retrieve the materials it is made of so that they can be reused

REM SLEEP Rapid eye movement. It is during periods of sleep characterized by REM that dreams occur

RENEWABLE ENERGY Any source of energy that can, in principle, be used forever without being used up. Waves, the wind, and the Sun are all examples of renewable energy sources

SATELLITE IMAGING A technique for creating close-up images of the Earth's surface using information gathered by sensors on a satellite orbiting the Earth

Satellite image

SENSE ORGAN A part of the body that is specially adapted to perceive the outside world, such as an eye or an ear

SENSOR A piece of equipment that enables a machine to react to conditions around it, such as a change in heat or light levels

SILICON CHIP A tiny piece of silicon that contains a set of electronic components capable of carrying out computer processing

SIMULATOR A machine that gives the user an illusion of a real experience

SMART CARD A card containing a silicon chip that carries all of an individual's personal details in electronic form

SMART WEAPONS Bombs or missiles equipped with guidance systems that make them exceptionally accurate

SOLAR POWER Energy from the Sun that can be used for heating or for providing electricity

F-117 Stealth Fighter

SONAR A device for locating objects under water by the sound waves bouncing off them

STEALTH TECHNOLOGY Term for the use of materials and design that make an aircraft invisible to radar

TILTROTER An aircraft that takes off like a helicopter but flies like a traditional fixed-wing airplane

TRANSISTOR An electronic switch in computer circuitry. There may be millions of transistors on one silicon chip

Ultrasound image of a baby in the womb

ULTRASOUND A technique for obtaining internal pictures of the body, such as of a fetus in the womb, using ultrasonic waves

ULTRAVIOLET RADIATION Invisible rays that are part of the electromagnetic spectrum

VIDEOPHONE A type of telephone that would let you see the person calling you

VIRTUAL REALITY An environment created by a computer that gives the user an illusion of being a part of a real scene

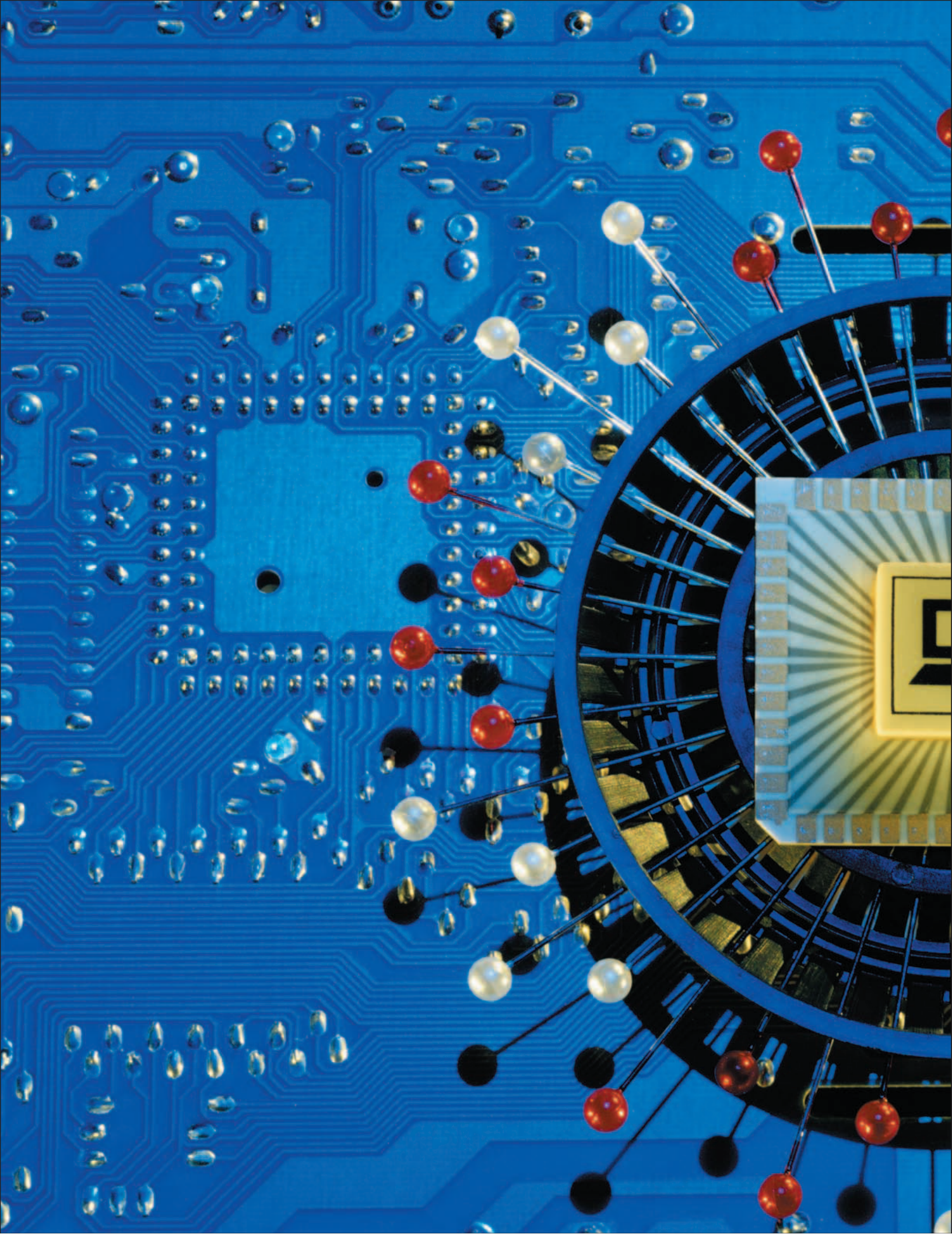
VOICE RECOGNITION Term for the ability of a computer to identify an individual voice before responding to commands

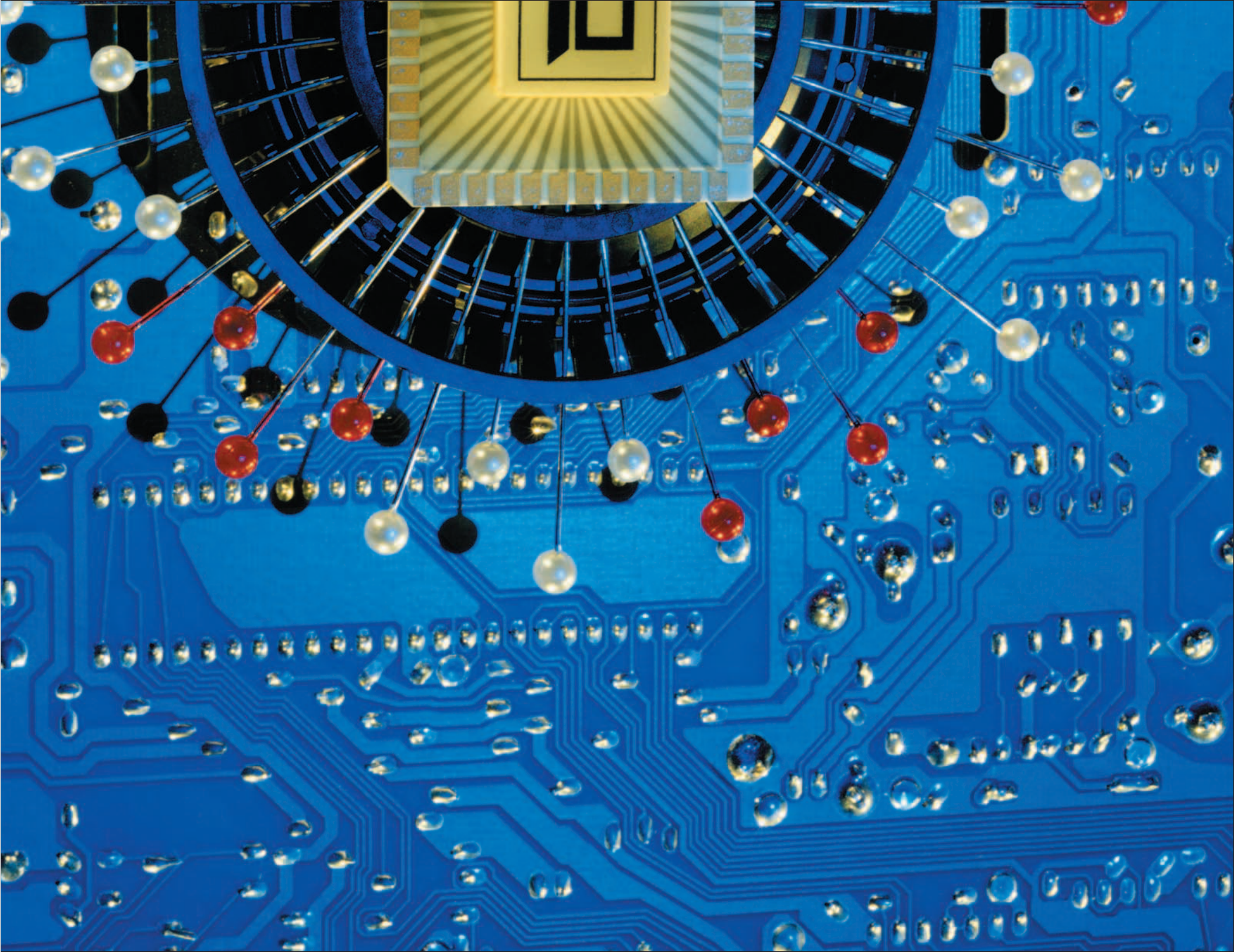
WORLD WIDE WEB The network of connections between computers all around the world

Videophone

WRAPAROUND SCREEN A type of curved television or movie screen that lets the viewer see the action all around them

X-RAYS A type of radiation used to see inside something, such as the human body





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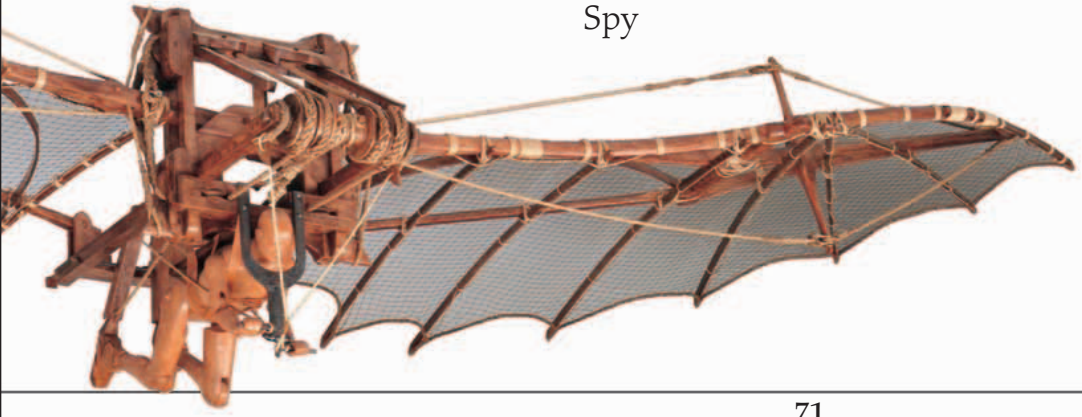

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