Acoustics

Acoustics is the science of sound. It deals with how sound is made, how it travels through the air, and how it is heard. Sound travels as waves of air PRESSURE, and these waves behave like those on water. The way sound behaves is important to many people in everyday life.

Architects use the principles of acoustics to design buildings where unwanted sound is deadened, but music or voices can be heard clearly. Engineers use acoustics to improve the quality of recorded sound and its reproduction on hi-fi.



Above: A noise-reducing headset. Regular noise is sensed and cancelled out by electronic circuits inside the earpieces.

Sometimes, people's lives depend on being able to hear the right sounds. Pilots of noisy aircraft such as helicopters can find that engine noise drowns out their radio even when wearing headphones. New headphones introduced in 1990 overcome this problem. Microphones in them pick up the background noise and cancel it out by producing waves which are equal and opposite.

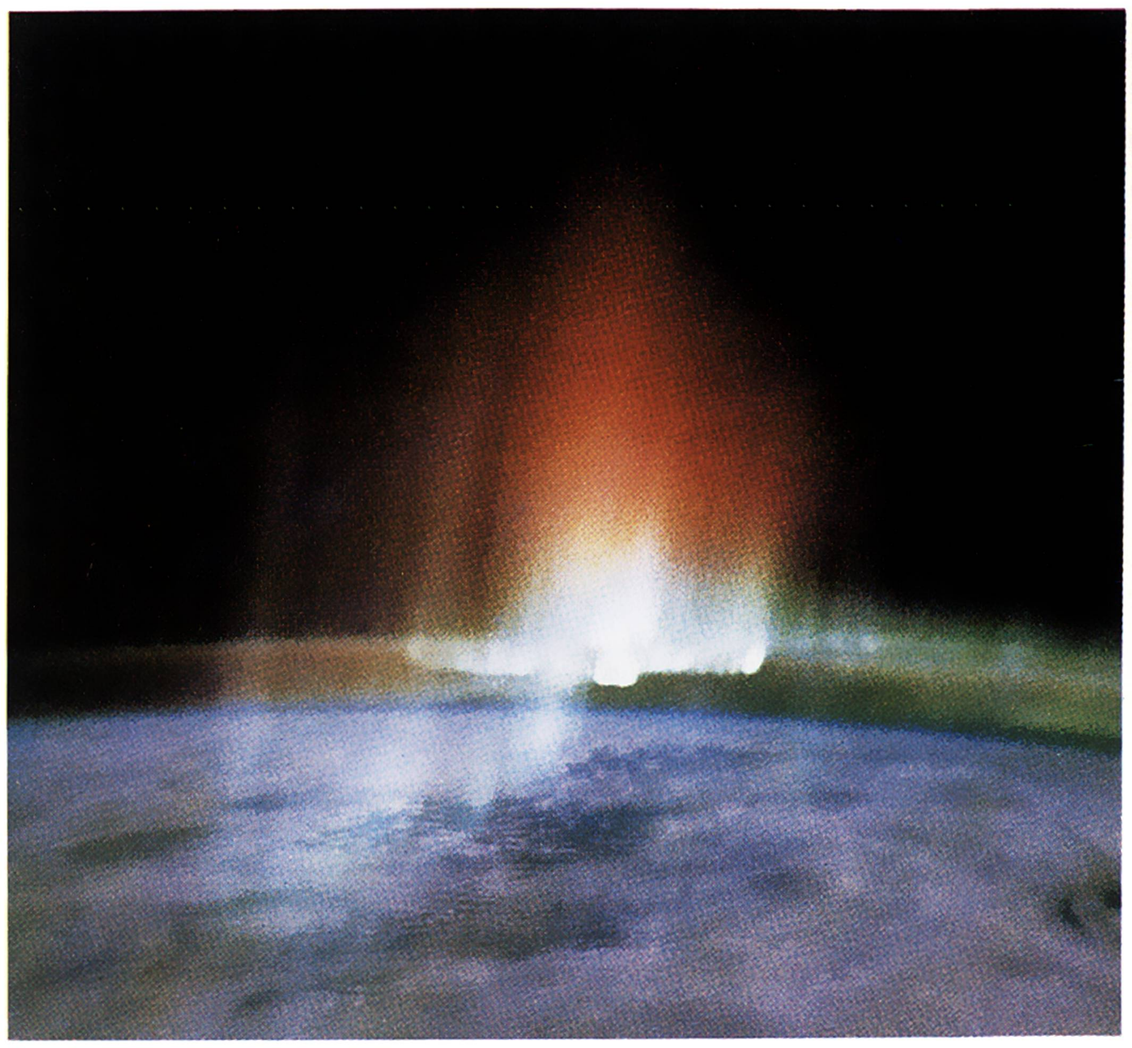
Acoustics is now being used to develop a refrigerator that does not use CFC gases. CFCs have been linked with the destruction of the ozone layer. Sound waves in safe INERT gases are used to create the cycles of compression and expansion which produce cooling. The refrigerator is 40 per cent more efficient than a normal one. This would mean a huge saving in Americans' electricity bills. A prototype has already been tested on the space shuttle.

Aeronomy

Aeronomy is the study of the earth's upper ATMOSPHERE. Even at its upper limit, around 60 miles (100 kilometers) altitude, the atmosphere can have dramatic effects. Although there is only a millionth the number of particles as at sea level, the FRICTION on low orbiting SATELLITES can slow them down. The upper atmosphere expands when the sun is active. This means that they may fall back to earth ahead of schedule.

The sun bombards the upper atmosphere with both sunlight and high-speed particles known as the SOLAR WIND. These particles cause the northern and southern lights or AURORAE. Occasionally, great storms of particles arrive and seriously affect long-distance radio communications. Scientists are searching for ways to predict these disruptions.

Volcanic dust can also affect the upper atmosphere.



Above: An aurora photographed from space shuttle Discovery. The study of aurorae was one of the tasks of its mission in April-May 1991.

The eruptions of the Philippine volcanoes Mt. Pinatubo and Mt. Mayon in 1991 and 1993 could have a major effect. Aeronomists have seen a great increase in numbers of noctilucent clouds in recent years. These are whitish clouds, at a height of 51 miles (82 kilometers), visible only in summer, glowing even at midnight in far northern or southern skies. They may be caused by increasing volcanic dust and pollution, and may show that the atmosphere is changing.

Analytical Chemistry

Scientists often need to know the amount of a certain chemical that is present in a mixture. For example, how much caffeine is there in a cup of coffee, or how much lead is there in leaded gasoline? Questions such as these are answered using analytical chemistry.

These methods all rely on separating out the substances in question from the mixtures. Then the chemicals must be identified and the quantities measured.

The methods used include chromatography, SPECTROSCOPY, and the measurement of electrically charged IONS and their fragments in mass spectroscopy. Usually, such measurements take place in LABORATORY conditions using very advanced equipment. From time to time, however, it is necessary to make the measurements under field conditions.

For example, British Petroleum recently developed a new method for oil exploration. The aim is to find a thin layer of crude oil which forms on the surface of the sea over a site where oil seeps up to the sea bed. The apparatus uses an instrument which measures light emitted from the oil after it has been illuminated by light from a LASER. The equipment is installed aboard an airplane.

Anesthetics

Modern anesthetics have taken much of the pain and fear out of surgery. Since the 1980s, halothane and other similar COMPOUNDS have been used. Unlike earlier anesthetics, they are not FLAMMABLE and do not cause cancer. The patient breathes them in as a gas. They are general anesthetics, which means that they make the patient unconscious for major surgery.

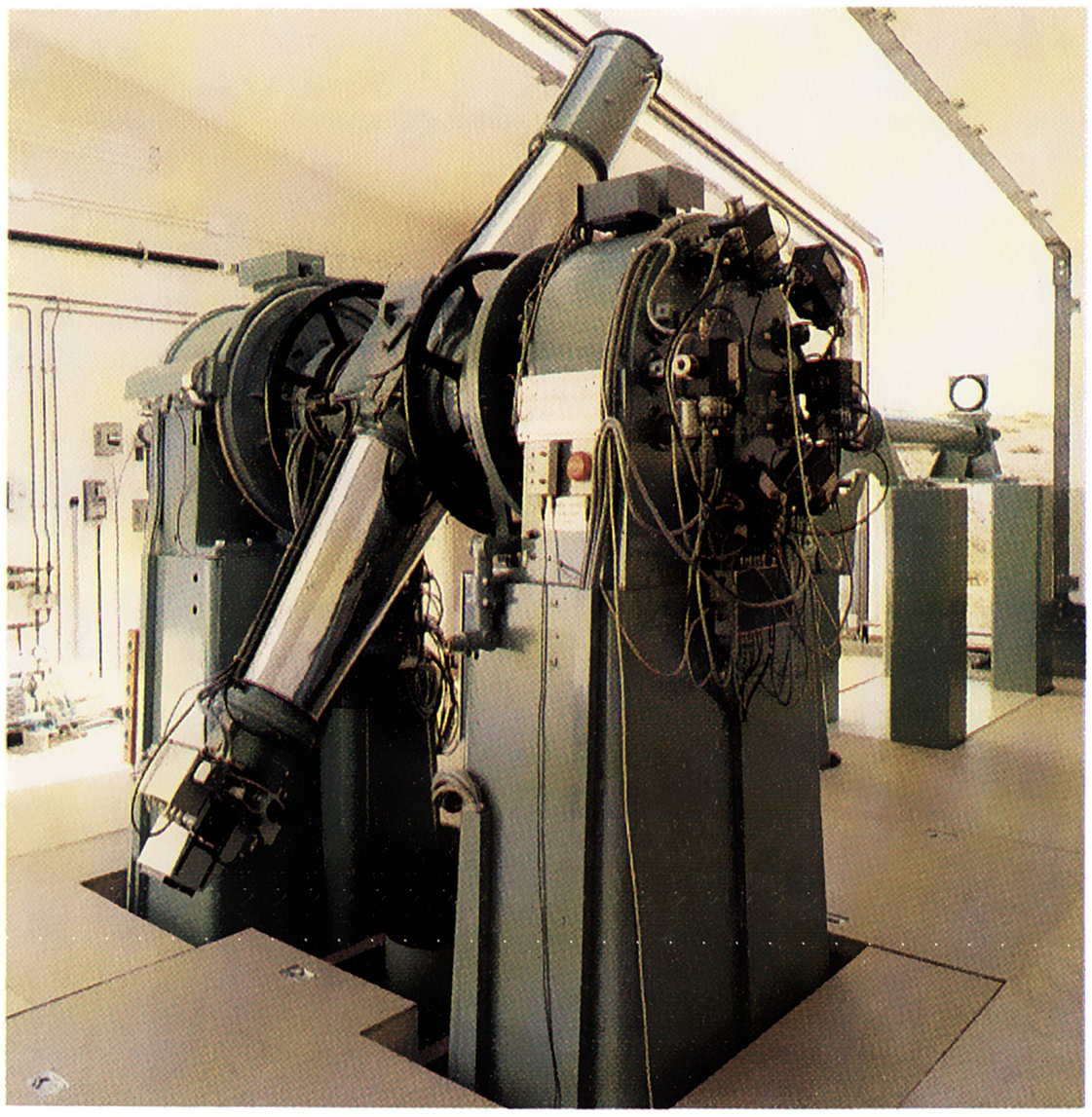
All anesthetic compounds have side effects, however. They may damage the kidneys in particular, so scientists have been looking for ways to reduce the dose. One new way is to use tiny injections into the spinal cord, rather than swamping the whole system with anesthetic. These block the transmission of pain signals to the brain. Cooling parts of the body can also reduce pain. Acupuncture is also being used. This involves inserting fine needles into particular places in the body and can be quite effective.

A technique being tried in the 1990s is to allow patients recovering from operations to control their own anesthetic supply. They can often give themselves lower doses than someone else, and do not have the worry that they might suddenly start feeling pain with no one there to help.

Astrometry

A surprising amount of information can be obtained by measuring the positions of stars and other heavenly bodies. This is the science of astrometry. Its uses range from navigation and timekeeping to finding the size of the universe.

Some astrometric observations use a special telescope called a transit instrument. This is a fixed telescope which records the positions of stars as they move through the field of view as the earth turns. Another way of measuring positions is to measure photographs taken by ordinary telescopes. This method is often used to plot the positions of newly discovered objects, such as comets or asteroids.



Above: A fully automatic transit circle at La Palma Observatory in the Canary Islands. This measures the positions of hundreds of stars in a night.

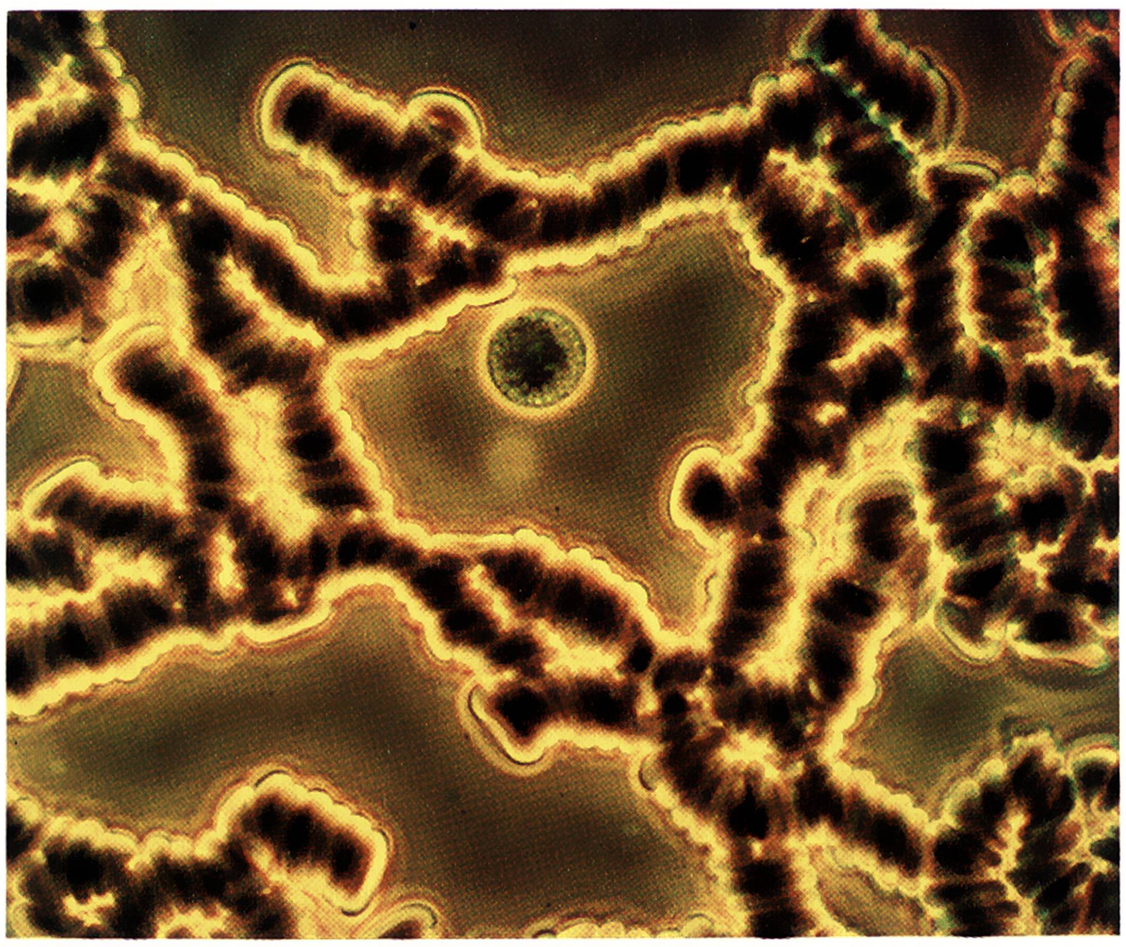
An important use of astrometry is to find the distance of stars by parallax. As the earth moves around the sun, the position of some nearby stars changes very slightly. This is because the direction from which we view them is changing. The nearer stars will vary in position the most.

In 1989 a SATELLITE named Hipparcos was put into orbit to measure star positions. By 1995, it will have measured 100,000 stars far more accurately than is possible from the ground.

Cytology

Cytology is the study of the CELLS that make up all living things. The subject has advanced with every improvement in microscopes. By the turn of the 20th century, for example, cytologists had discovered CHROMOSOMES inside the nucleus. These are the chemical PROGRAMS that control the way a living thing inherits the features of its parents.

Living cells can be studied by "phase contrast microscopy." which uses a special way of illuminating the subject. Very often, special dyes are used which are taken up by certain structures within the cell. These dyes may be fluorescent, so they show up under an ULTRAVIOLET light. Another way of "tagging" certain cells is to use RADIOACTIVE chemicals. These can show how PROTEINS or ANTIBODIES INTERACT with one another.



Above: These human red blood cells are viewed using a phase contrast microscope. The circular cell in the middle is a granulocyte – a type of white blood cell.

Other methods being used include electron microscopes, LASERS, and high speed CENTRIFUGES. These spin a sample very rapidly so that some parts of the cell are torn away and separated from the rest. One important role of cytology is to classify cells to find out a person's blood group or identify antibodies.

Research cytologists are now trying to unravel the deepest secret of all – why cells die. At the end of their lifespan, healthy cells suddenly seem to self-destruct.

If scientists can find out why, they might discover clues to other problems such as the causes of AIDS, cancer, and even death itself.

Dendrochronology

An archaeologist wishing to discover how old a site is may well turn to dendrochronology. This is the science of finding the dates of wooden objects from the ANNUAL growth rings visible in timber.

As trees grow, their trunks and branches increase in DIAMETER by putting on a new layer around their circumference each year. Because the climate varies from year to year these rings differ in width. The rings from just a few years will always have roughly the same pattern. These year patterns are rather like supermarket bar codes – a sequence of thick and thin lines that identifies a particular set of years.

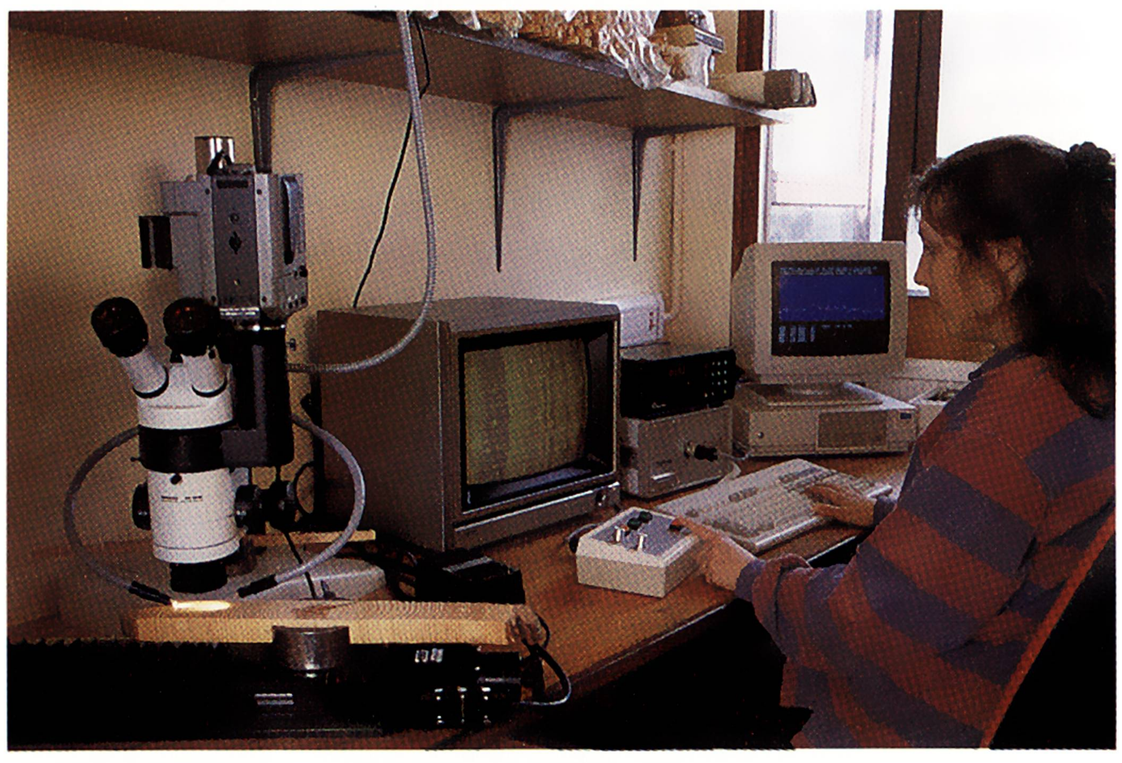
The problem has been to link separate sets of sequences. Although most trees live for only a few hundred years at most, some live for over 4000 years. The bristlecone pine of California is one of these. Such trees give a long sequence of rings against which others can be matched.

Modern science has made this method very precise. Logs have been preserved in such places as Irish peat bogs and Swiss lakes, where whole towns were built on stilts in prehistoric times. The sequences from these different sites have now been linked.

Computers can now assist the scientists by storing the data and comparing it with known sequences. It is sometimes possible to discover the date to within a year when a piece of wood thousands of years old was felled.

Recently dendrochronologists have become interested in the reasons for the change in width of the rings. Long periods of small growth may be linked to periods when volcanic dust darkened the sky for years on end.

Below: Computers now count tree rings. The sample is viewed by a video camera and the operator marks the ring positions by pressing a button.



Dermatology

Dermatology is the branch of medicine that deals with diseases of the skin. The most common of these is dermatitis. This has several causes. It can be brought on by contact with chemicals or even some cosmetics, plants, or animals. A problem with a patient's internal organs can also produce it. The skin of sufferers may be reddened, blistered, dried, cracked, or scaly.

Some skin diseases, such as shingles and herpes, are caused by viruses. Bacteria cause boils. Anthrax is caught from infected animals. Molds and fungi cause problems such as ringworm and athlete's foot. Some diseases are inherited, such as psoriasis, which affects about three percent of people. They have flaky, scaly patches of skin.

Many adolescents suffer from the pimples caused by acne. Sadly for them, its cause is often difficult to pin down. It could be caused by HORMONES, bacteria, or even emotional stress. In fact, there are over 50 different types of acne. The treatment varies from applying balm to letting more sunlight get at the skin.

A major worry in the 1990s is too much exposure to sunlight. ULTRAVIOLET light causes skin melanomas, a type of cancer. People are being urged to use more skin protection, particularly in sunny climates.

Exobiology

Most scientists believe that there is life elsewhere in the universe. The scientific investigation of the possibilities of this is exobiology. None of the other planets in the solar system shows any signs of harboring life, however.

Astronomers believe that there are very large numbers of planets orbiting other stars. Biologists believe that life will arise SPONTANEOUSLY wherever the right conditions occur. Using good estimates for the number of suitable planets, there should be thousands, if not millions, of other planets in our own GALAXY where life has arisen.

The vast distances between stars mean, however, that even the nearest of such life-bearing planets is probably too remote for us to investigate directly. Using the Hubble Space Telescope, however, astronomers hope to be able to find stars that definitely have planets.

The best chances of detecting life beyond earth lie with SETI, the search for extraterrestrial intelligence. This aims to detect any radio signals sent out by other civilizations. Earth already sends out powerful signals in the form of our radio, TV, and RADAR TRANSMISSIONS. Although these are not beamed at other planets, they would indicate to others that there is life here.

A major SETI program began in 1992. It uses large radio telescopes to survey large numbers of stars in detail. While the chances of it finding new life are small, it may still produce interesting astronomical discoveries.

Below: NASA announced a major search for life on other worlds in October 1992. This radio telescope in Puerto Rico will search for radio signals from aliens.



Fluid Mechanics

Fluid mechanics, the science of liquids and gases, covers many different areas. The movement of fish through water and the flight of birds are two examples. The flow of air through a jet engine, or blood through the heart and the eruption of a volcano are others.

There are two main branches of the subject, HYDROSTATICS and fluid dynamics. Hydrostatics is the study of FLUIDS at rest. This is of practical use in such areas as hydraulics, which uses fluids to transmit pressure. In 1992, for example, engineers reported that they had found a new way to extract more oil from a well. They force down the well a special fluid which combines a jelly-like material with rocky particles. It causes the rock at the bottom to crack, releasing more oil. In this way, up to seven times as much oil can be pumped from a single well.

Fluid dynamics examines how fluids flow. Many industrial processes, such as in the chemical and oil industries, depend on flows of materials. Scientists are now studying the way flows suddenly become turbulent using the mathematics of chaos theory. This shows how simple mathematical rules can sometimes produce complex and chaotic results.

Geochronology

Geochronology is the study of the history of the earth itself. The information is built up by examining FOSSILS and the composition of rocks.

People realized in the 19th century that rocks bearing fossils must have been laid down at the bottom of ancient seas. The layers nearer the surface are the most recent, while those deeper down are older. Different rock layers contain different fossils. The upper layers have complex animals such as dinosaurs, while the deepest have very simple creatures. These link the fossils in a rock to its age.

The actual age comes from techniques such as radiometric dating. Some rocks contain radioactive ELEMENTS which are slowly decaying into lead. The rate at which they do this can be discovered from work in a LABORATORY. So by measuring the amount of the element and the amount of lead in a rock, scientists can tell how old it is.

In the 1990s, however, scientists are finding problems with the ages given in this way. When the same techniques are applied to the atmosphere, for example, it appears to be younger than the fossils of some air-breathing creatures.

Below: This apparatus is used to find what elements are in rock samples. Called ISOLAB, it is an advanced mass spectrometer at Cambridge University, U.K.



Geodesy

The science of the shape and size of the earth is known as geodesy. This knowledge is vital when constructing roads, bridges, and dams. Geodesy is also important to mapmakers.



Above: A surveyor uses a Global Positioning System receiver to find his exact position. The unit runs on camcorder batteries and is fully portable.

The surface of the earth is measured by triangulation. This uses the principle that, in a triangle, if two angles and the length of one side are known, the length of the other two sides can be calculated.

Until recently the points of the triangle had to be visible from one another so that surveying instruments could be used. Now, however, geodesy uses the SATELLITE and the high-speed computer. The position of each point is measured using the Global Positioning System. This is a network of satellites that transmit exact details of their positions.

Special portable receivers pick up these signals and give their position RELATIVE to the satellites. The accuracy of this system is measured in a few millionths of the distances involved. So the relative positions of two points, say, a mile apart can be found to within a few millionths of a mile – 1/10 inch.

Geodesy also involves the study of the orbit of the earth, the movement of the poles, and variations in gravity across the surface of the earth. Its principles are also used in the study of the surface of other planets.

Geomorphology

Geomorphology is the study of natural landforms such as hills, valleys, rivers, and soils. Technology has helped geomorphologists in recent years. New LABORATORY equipment now lets them examine in detail the chemical processes of weathering. This is what happens when rocks break down and soils are formed.

There are also new ways of finding the age of rocks. These are very important when studying how the landforms developed. Most of the landscape features we see arose within what is called the Quaternary period. This occupied the last 1.8 million years.

DIGITAL data loggers are recording machines which can be connected up to monitoring equipment which is left in place. This includes stream flow monitors or automatic weather stations, for example. The data loggers mean that data can be collected all the time without someone being there to write it down. Geomorphologists may study rocks at the sub-microscopic scale, using scanning electron microscopes, or on a large scale, using SATELLITE photographs. These show how the landscape is changing over time.

A branch of geomorphology is concerned with hazards caused by landforms. Disasters are often caused by people not being aware of the risks. A volcano may not have erupted within living memory, for example, so farmers feel safe to work on its slopes and even build villages. Geomorphologists can now measure the swelling of the slopes as PRESSURE builds up. They can advise on the dangers, and therefore perhaps avoid costly rescue operations, such as those which took place on Mout Etna in Italy in 1992.

Glaciology

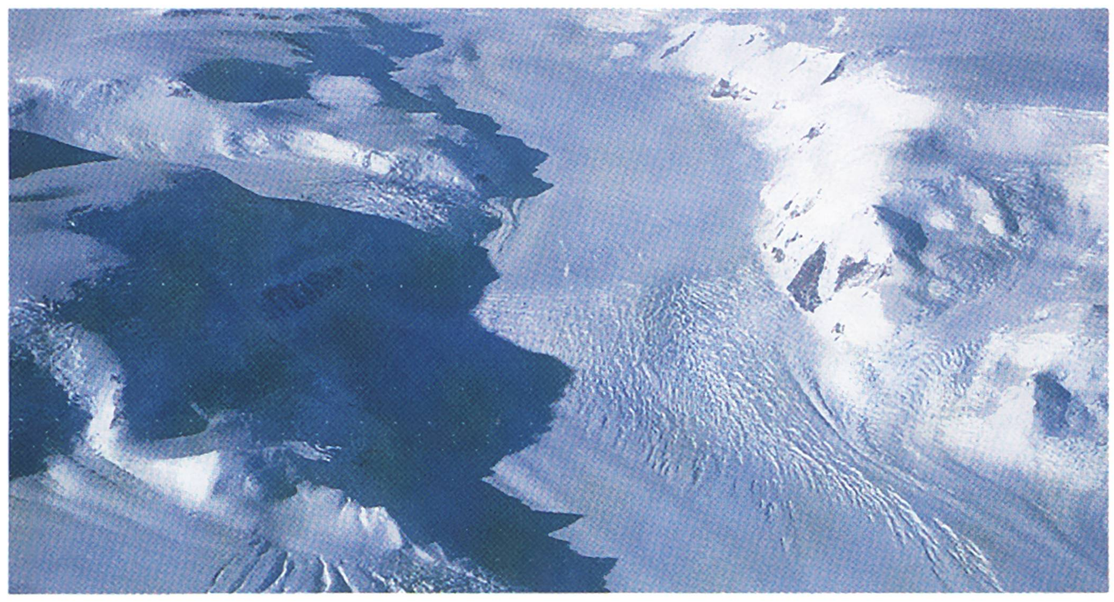
Glaciology is the study of glaciers. These are like rivers of ice that form in polar regions and high up in mountains. Snow which gathers at their heads is crushed under its own weight and turns into ice, just as squeezing a snowball produces a lump of ice.

Glaciology can reveal a great deal about the way the earth's climate has changed in the past. This may help predictions of the way it will change in the future. For example, glaciologists studying cores of ice drilled down into the Greenland ice cap have seen a sudden warming at the end of the last ice age, 11,500 years ago. The temperature is estimated from the PROPORTIONS of ISOTOPES of oxygen in the ice. In 1992, the scientists reported that they had found a warming of 13 degrees F (7 degrees C) over just 50 years.

Another team working in Antarctica, however, found that the ice sheet there expanded between 4000 and 7000 years ago, when the rest of the world was getting warmer.

Glaciologists can also monitor the world's current state. In 1991, French researchers announced that the amount of lead in snow has been reduced by seven times over 22 years. The use of lead-free gasoline is thought to be responsible.

Below: The Liv Glacier in Antarctica's Queen Maud Range of mountains. Large chunks of ice break off the glacier where it meets the sea, forming icebergs.



Hydraulics

Hydraulics is the practical use of the study of moving fluids. The power of flowing water has been exploited by humankind ever since the invention of the water wheel to grind flour. The same principle of turning running water into power is used to generate hydroelectric power.

Hydraulics engineers are concerned with movements of water on a larger scale as well. The flow of water from a dam, or under a bridge, is their concern. Their work can be of major importance in controlling floods. In 1991, 150,000 people died in floods in Bangladesh, for example. To prevent these, engineers are studying the flow of the river Brahmaputra. The problem is that raising embankments to protect cities against river floods may make the floods caused by cyclones worse elsewhere.

Such studies include measuring the flow of water in the many channels at the river's outlet. Models can then be made using computers to study the effects of making changes in different places. In China, it has been found that making a river flow along one channel instead of several causes it to drop more silt. This in turn means that embankments have to be even higher.

Hydrology

Hydrology is the study of water in the environment. At the heart of this is the water cycle. Under the heat of the sun, water EVAPORATES from the oceans. This forms into clouds which are carried on the wind. These clouds return the water to the surface as rain, snow, sleet, and hail. This is our water supply.

A major concern of the hydrologist is the way this water runs off the land, and how it is lost through evaporation. Many of the world's problems happen in this area, either through floods or drought. The way water is lost from the land where it has fallen concerns farmers who irrigate their land.

It is not just the Third World that suffers. Water shortage has become a major problem in the U.S., particularly the southwest. Farmers have found their crops shriveling as the cities of Tucson, Phoenix, and Los Angeles drain their water supplies.

The Central Arizona Project is now diverting water from the Colorado River to the farm lands. Farmers are installing storage tanks to catch rainwater. A huge new desalination plant is being built in Santa Barbara, California, to provide fresh water from salt water. In the long term, hydrologists are using satellite studies and computer modeling to help manage the world's scarce water supplies.

Jet Technology

Jet engine designers are constantly trying to improve the engines which power airplanes. The main concerns are to increase the thrust or power, reduce the fuel consumption, and limit the noise produced.

In the 1990s, the emphasis is on reducing the pollution from jet engines. When you see an airplane traveling high in the sky, you usually notice a "con trail," short for "condensation trail." This is made of water vapor which CONDENSES on the smoke particles and unburned fuel left by the engine exhaust. Some experts believe that this material, plus the invisible carbon monoxide and oxides of nitrogen, are disturbing the balance of the atmosphere. The nitrogen oxides in particular can destroy the ozone layer which protects us from the sun's harmful ultraviolet rays.

Fuel consumption continues to be a concern. There seems little room for improvement, however. Engines now extract almost all the energy available from the fuel they burn. Instead, designers plan to use the energy more efficiently. One way to do this is to build ultra-high-bypass turbofan engines.

In a turbofan engine, only part of the air which enters the engine is mixed with fuel and burned. The rest passes though the fan, which provides most of the engine's thrust. In ultra-high-bypass engines three times as much air passes through the fan as in a normal turbofan engine. The fuel consumption is cut by a fifth for the same thrust.

Kinetics

When light shines on the retina of your eye, it is ABSORBED by special light-sensitive CELLS. Then a series of chemical changes takes place. Eventually, an IMPULSE travels down the optic nerve to your brain, and you are aware of the object. All this takes place so quickly that we are not aware of any delay. But how long does the process actually take? The science of chemical REACTIONS such as this is called kinetics.

In the case of the reactions in the eye, the first step is a rapid chemical reaction. The molecule that absorbs the light changes its shape. American scientists recently discovered the kinetics of this reaction. They found that in certain types of cell, the reaction is complete



Above: The eye's iris opens in dull light and closes when it is bright. Most changes in the eye's sensitivity, however, are caused by chemical reactions.

within 200 millionths of a billionth of a second.

One important area of study concerns the reactions in the earth's ozone layer. Chemists all around the world are studying what happens when ozone molecules meet a variety of chemicals containing chlorine. In this way, they hope to learn about the most important reactions that can result in the destruction of the ozone layer.

Limnology

The branch of hydrology that is concerned with lakes, ponds, and other surface water is called limnology. It includes the chemistry of the minerals and nutrients dissolved in the water.

Environmentalists are concerned about the condition of many lakes around the world. The lakes of Canada are being studied for the effects of acid rain which have poisoned much of the water there. But the polluted lakes of the former Soviet republics are possibly in the most serious danger.

Lake Baikal in southern Siberia is in great peril. At 5370 feet (1637 meters), it is the deepest lake in the world. It contains more fresh water than all the Great Lakes put together. In 1991, a three-seater submersible visited the bottom of the lake collecting sediment samples. Pebbles and crystals also showed the lake to be the world's oldest, at possibly 30 million years.

But there are more than 100 factories around Baikal's shores which dump their waste directly into its pure water. Much of its wildlife is unique, yet it is beginning to disappear. Scientists warn that unless many plants are closed, the wildlife could be ruined.

Metallurgy

We use metals all the time, but only pure gold, copper, and silver occur in nature. Early humans found iron in meteorites. So where do the metals we use come from? Most metals occur as chemical combinations in minerals called ORES. It is the job of metallurgy to extract the metals from the ores.

To extract the metals, the ore is first crushed into tiny pieces. Then it is smelted – that is, it is heated until it is freed from its chemical bonds and the liquid metal runs free. Some metals can be extracted by electrical means, or by dissolving the ore in an ACID or SALT SOLUTION.

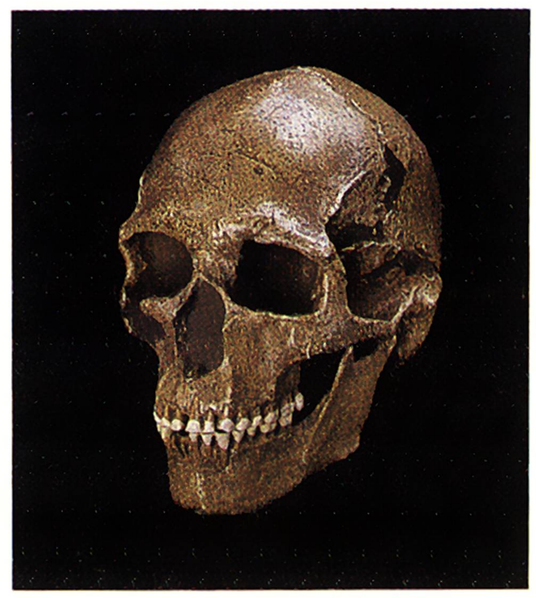
There is only a limited supply of metal and many of the purest sources of ore have already been used up. All that is left in many places is extremely poor ore, sometimes in spoil heaps left over from the old workings. There is metal in the rock, but only in small quantities. The task is to find a way of extracting the metal without making it so expensive that no one could afford to use it.

Some metals are now being extracted from poor ores with the help of bacteria. MICROORGANISMS have been discovered that live by oxidizing the sulfur that binds copper, zinc, lead, and uranium. As they do this, they release the metal. This is a cheaper process than smelting and causes less pollution. Normal smelting releases large amounts of sulfur, which is one of the main causes of acid rain.

Morphology

Morphology is a part of biology which studies the size and shape of living ORGANISMS. If you look at skeletons of creatures, you may see that the bones of the human arm have similarities with those in a bird's wing or the front leg of a frog, for example. There are differences as well, and these give them all their own purposes and abilities.

By studying the similarities and differences, biologists can learn more about the way the structures in ORGANISMS work. Originally, morphology was used as a way of sorting animals and plants into SPECIES or families. Later, it was helpful in developing the theory of EVOLUTION. Today, it is useful in learning more about the way the size and shape of a part of a living organism affects it.



Right: This human skull dates from 30,000 BC. It is very similar to that of a modern human. The teeth reveal much about the person's diet and lifestyle.

Why do the leaves of different plants and trees vary so much? Morphology shows how the size and shape of a leaf depends on the conditions in which the plant grows. In the same way, the speed and movement of an animal depend on its weight and muscles. By understanding how modern plants and animals have developed, morphologists can work out how their long-extinct ancestors lived. They can tell which dinosaurs could run and how much food they would have needed, for example.

Morphologists are at the center of the debate about how humans evolved. Experts still disagree about which early humanlike creatures we evolved from. Here, the teeth are very important. They can reveal what our distant ancestors ate, what sounds they could make, and how closely they are related to ourselves.

Paleobotany

Paleobotany tries to build up a picture of the plant life of the distant past. This is possible by studying the FOSSILS of ancient vegetation.

Some rocks, such as shales, coals, and sandstones contain the fossils of prehistoric leaves and stems. Other parts of plants, such as fruits, seeds, pollen, and wood have also been preserved. For example, some rocks formed when mud settled at the bottom of lakes and swamps. Plant remains became trapped under layers of this mud. Over time, the mud became compressed and heated and turned into stone. The fossils of the plants remain inside. Another way for plant fossils to be preserved is under layers of volcanic ash.

Below: Fossil of a fern, *Neuropteris*. This was common 300 million years ago. At that time, most creatures lived in the sea and only a few AMPHIBIANS could survive on land.



Coal seams are a rich source of plant fossils. Coal is formed from vegetation that gathered in ancient swamps. Shales are found above coal seams.

By comparing plant fossils found in different parts of the world, scientists have worked out how the continents on earth once fitted together. These continents have drifted apart over millions of years.

A big change took place some time before, about 65 million years ago. By then, flowering plants had become widespread. Some people see the extinction of the dinosaurs at this time as more than coincidence. They suggest that as brightly colored flowers contain poisons, the plant-eating dinosaurs which ate them would have died. The meat-eating dinosaurs would have had no prey to feed on.

Paleomagnetism

The MAGNETIC FIELD of the earth has not always been the same. Its strength has varied over the years. In the distant past the magnetic POLES have wandered and even reversed. A compass needle would have pointed in a quite different direction from today. Paleomagnetism is the study of these changes.

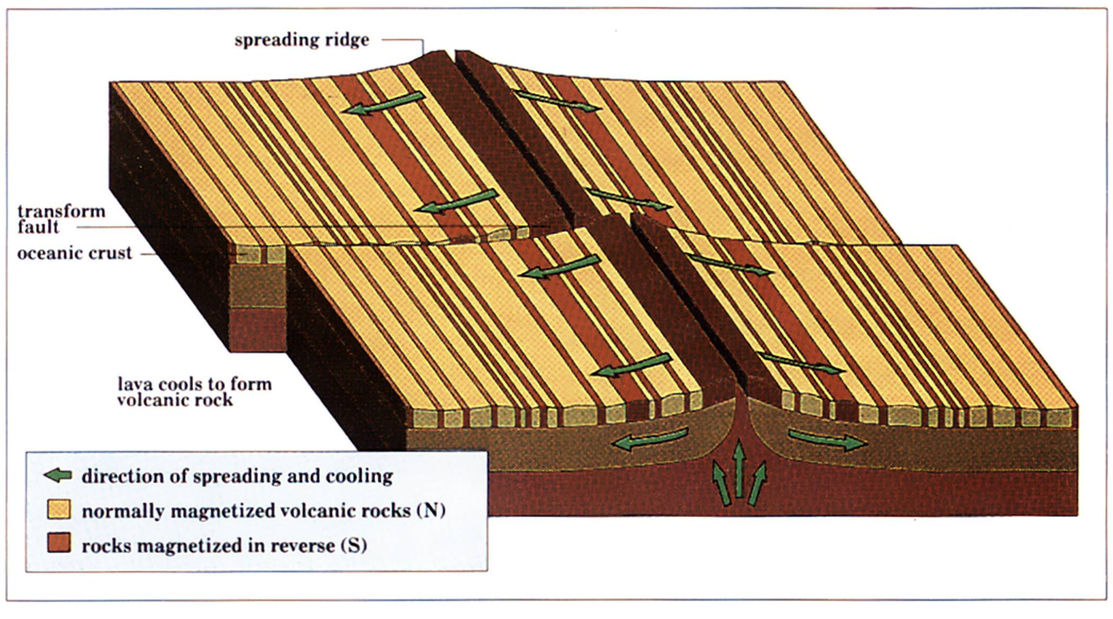
There are two main types of rock: igneous and sedimentary. Igneous rock is formed when molten rock cools and turns into a solid. As this happens, tiny magnetic particles in the rock line themselves up with the earth's magnetic field, just like tiny compass needles.

Sedimentary rocks form as particles of material fall to the bottom of lakes and seas. As they settle, magnetic particles also line up with the magnetic field.

These particles are fixed in position in the rocks. By measuring the magnetic field of rock samples, scientists can work out the direction of the magnetic poles at the time the rocks were formed. The field reverses every 100,000 to 100 million years. It takes less than 2000 years to switch.

Rocks on the Atlantic Ocean floor show clear magnetic stripes when measured in this way. They act like a tape recording of the changing field, since the rocks are being produced continuously in the middle of the ocean. The Atlantic is widening. This is one of the best pieces of evidence that the continents sit on huge "plates" that have drifted over millions of years.

Below: Paleomagnetic studies of seabed rocks show magnetic field stripes. This is because the earth's magnetic field reverses from time to time.



Paleontology

Paleontology is the study of FOSSILS. The earth was formed 4.5 billion years ago, and the oldest fossil is about 3 billion years old. It was a BACTERIUM. It seems to have taken another billion years for the first ALGAE to form. Their fossils have been found in Canada. The earliest fossil animal is just 600 million years old. The first vertebrate, or animal with a backbone as we have, was a rather simple fish. Its fossil dates from 350 million years ago. REPTILES evolved soon after that.

Although there were small MAMMALS alive when the dinosaurs became extinct about 65 million years ago, it seems that humans have only existed for the last few million years. Most experts believe that human beings evolved in Africa and then spread slowly into Europe and Asia.

Fossils also indicate how the earth's climate and appearance has changed during all this time. Fossils typical of tropical coral reefs occur in northern England, for example. Between ice ages, the whole globe was warmer than it is now. This study of ancient climates through fossils is called paleoclimatology. It may help us to understand more about the results of global warming.

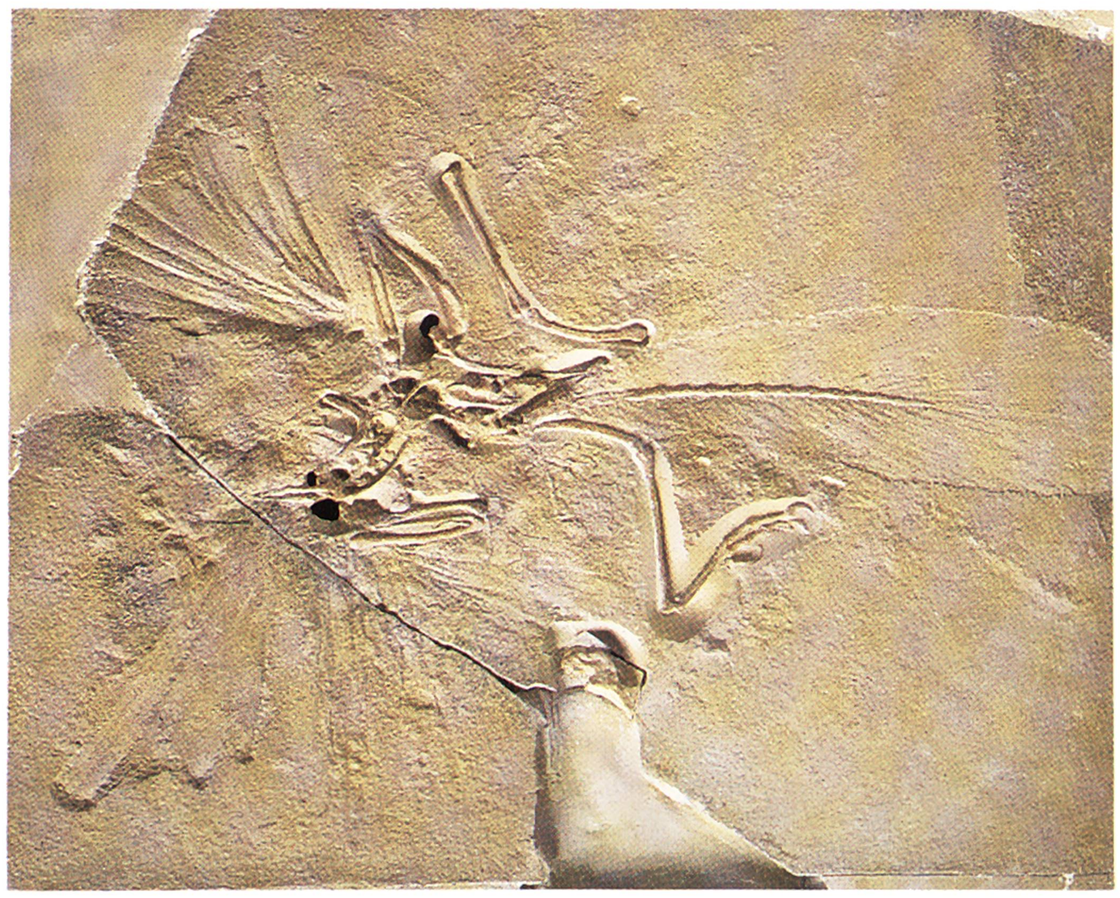
Below: The fossil of a trilobite found in Coal County, Oklahoma. These distant ancestors of the woodlouse lived about 500 million years ago.



Paleozoology

Paleozoology is the study of prehistoric plants and animals through their FOSSILS. Since the first studies in the early 1800s, paleozoologists have found out a great deal about such creatures as dinosaurs. They can even find out how they behaved.

One of the most famous fossils is that of a "feathered REPTILE" called *Archaeopteryx*. It made an almost perfect link between reptiles and birds. When the first of these fossils was discovered in the 1880s, it helped confirm the theories of EVOLUTION put forward by Charles Darwin and others. Recently, however, one top scientist has suggested that the fossil is simply a clever fake. Few experts believe this.



Above: *Archaeopteryx*, the early birdlike fossil. There are clear patterns of feathers in the rock, but one scientist has claimed that these have been faked.

As well as the fossil patterns in rocks, scientists are now examining fossilized blood CELLS from fish that lived 100 million years ago. They are also searching the remains of ancient bones for DNA. If some is found, it can be amplified and studied by the techniques of genetic fingerprinting. Experts rule out the chance of reconstructing a dinosaur from its DNA, however.

One of the great mysteries of paleozoology is the reason the dinosaurs became EXTINCT about 65 million years ago. There are over 40 different theories to account for this. The current favorite is that a huge asteroid hit the earth. The dust cloud thrown up altered the climate so much that large reptiles could no longer remain alive – but the tiny MAMMALS of the time survived.