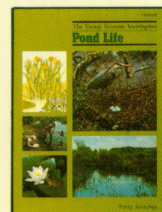
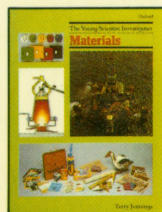
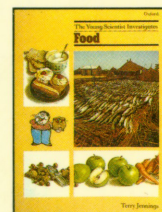
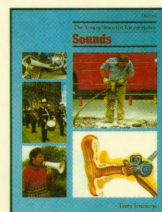
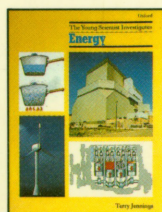
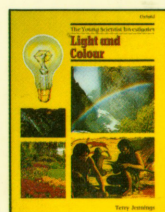
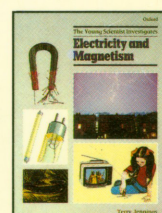
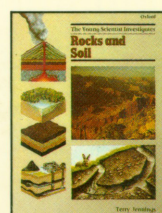
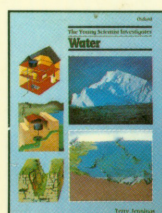
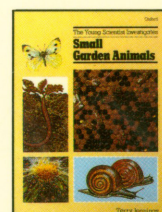
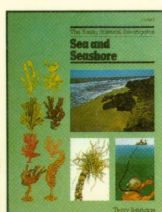
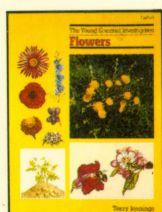
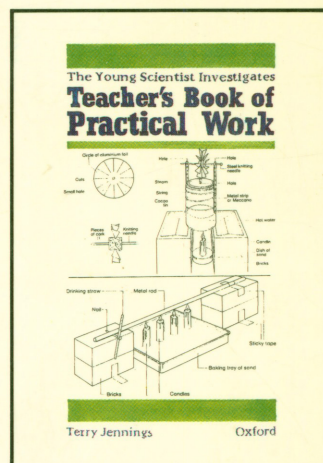
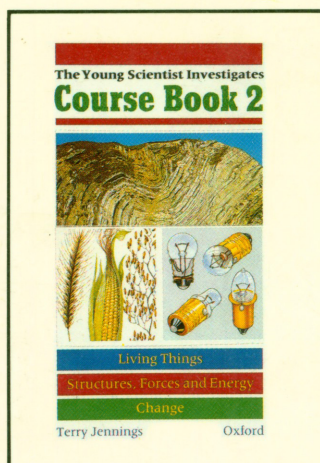
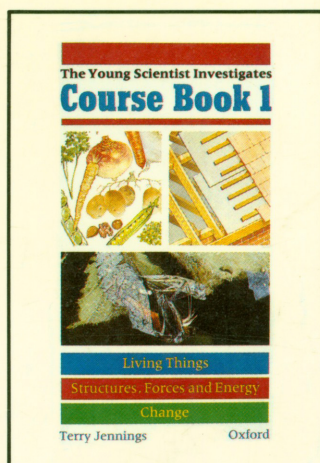


The Young Scientist Investigates

Teacher's Manual



Terry Jennings

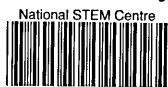
Oxford

The Young Scientist Investigates
Teacher's Manual

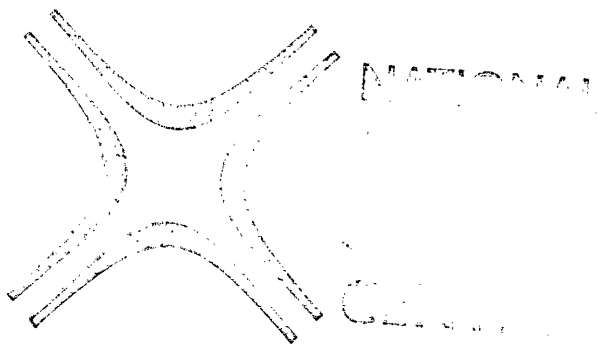
1 120961 00



Oxford University Press 1986



N28229



Oxford University Press, Walton Street, Oxford OX2 6DP

Oxford New York Toronto

Delhi Bombay Calcutta Madras Karachi

Peking Taipei Singapore Hong Kong Tokyo

Nairobi Dar es Salaam Cape Town

Melbourne Auckland

and associated companies in
Beirut Berlin Ibadan Nicosia

Oxford is a trade mark of Oxford University Press

© Terry Jennings 1986

ISBN 0 19 918185 3

All right reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior permission of Oxford University Press

This book is sold subject to the condition that it shall not, by way of trade or otherwise, be lent, re-sold, hired out or otherwise circulated without the publisher's prior consent in any form of binding or cover other than that in which it is published and without a similar condition including this condition being imposed on the subsequent purchaser

Photoset by Tradespools Ltd.

Printed in Great Britain by The Alden Press, Oxford

Contents

Introduction 4

The rationale of the Young Scientist Investigates 4
What is science? 5
The Young Scientist Investigates series of Topic Books 6
Using the Course Books 7
Recording scientific experiences 8
Seeking help or going further 8

Course Book 1

What do scientists do? 11

Theme: Living Things

Unit 1: We are all different 12
Unit 2: Fruit and vegetables 14
Unit 3: Living things depend upon each other 22
Unit 4: Pond life 29

Theme: Structures, forces and energy

Unit 5: Houses and other buildings 36
Unit 6: Materials 43
Unit 7: Skeletons, muscles and movement 50
Unit 8: Pushing, pulling, sliding and rolling 57

Theme: Change

Unit 9: Sun, moon, stars and planets 66
Unit 10: The seasons 72
Unit 11: Science in the kitchen 80
Unit 12: Life cycles 88

Course Book 2

Theme: Living things

Unit 1: Senses and sense organs 98
Unit 2: Grasses and lawns 104
Unit 3: Wildlife in the city 111
Unit 4: Reproduction in birds and mammals 118

Theme: Structures, forces and energy

Unit 5: Materials 126
Unit 6: Bridges, dams and tunnels 133
Unit 7: Energy and movement 139
Unit 8: Electricity and our increasing need for energy 146

Theme: Change

Unit 9: Weather 154
Unit 10: Rocks and the weather 162
Unit 11: Death and decay 168
Unit 12: The changing countryside 174

Introduction

The *Young Scientist* series of books is designed to help non-specialist teachers who want to use science as part of their teaching in Primary Schools, or as a foundation for the science course in Middle Schools.

The course is very flexible. The two course books can be used on their own, with the aid of this *Teacher's Guide*. Alternatively the course books can be used as the core of a course which can be expanded and extended using some or all of the 20 *Young Scientist Investigates* topic books described on pages 6–7.

It is hoped that the pupils following the course will learn some of the facts and concepts concerning the environment, develop some simple science-based skills and experimental techniques, and acquire, and be able to communicate with, a little of the language of science. This will lead on to the ability to analyse simple data, see patterns and relationships, draw critical conclusions, and think and act creatively after asking questions, testing out ideas and reading for information.

The books are intended to be work-books which it is hoped the pupils will find interesting and enjoyable. The experiments use, wherever possible, simple inexpensive everyday materials and equipment. It is envisaged that the two course books will be used as a constant reminder of the task in hand, while saving the teacher the need for lengthy instructions. In addition, the books expose problems and pose questions which it is believed will encourage the children's thought and imagination.

It is appreciated that it may not be possible for every member of the class to carry out experimental work at the same time. All science is not, of course, practical enquiry, and in order to enable the teacher to cope more satisfactorily with a large class, most of the work in the course books can be done by children either sitting at their own desks or with the minimum of disruption to the rest of the class. The *Young Scientist Investigates* topic books, this *Teacher's Manual* and the *Teacher's Book of Practical Work* contain supplementary activities, some of which are open-ended in nature, to provide extra stimulus for the dedicated and committed scientists amongst both teachers and pupils. A special effort has also been made to provide and develop the links between science and other areas of the school curriculum including language, mathematics, social studies, art and craft, and music and drama.

The course does not demand extensive knowledge of science, but merely a willingness to introduce children to the methods, skills and styles of thinking characteristic of science. This is an exciting and rewarding task but, whether or not the teacher is a science specialist, it can

also be arduous. The pressing need of all enthusiastic teachers is time, which is always in short supply. It is sincerely hoped that the *Young Scientist* course will help to remedy this situation and generally lighten the teacher's burden, while making his or her work interesting and stimulating.

The Rationale of the Young Scientist Investigates

During the past 25 years much thought and effort has been devoted to ways of introducing science into the primary school curriculum. A notable landmark in these efforts was the publication in 1967 of the Nuffield Foundation Junior Science Project. This was followed, from 1967–74, by Science 5/13, a project sponsored by the Schools Council, the Nuffield Foundation and the Scottish Education Department, and designed to exploit the children's exploratory drives. To this latter project we owe the most extensive thought concerning objectives that children might achieve through their work in science. When these objectives had been formulated, it then became possible to collect ideas for experiences through which children might achieve them. The results were published in 26 source books for teachers. They provide a wealth of ideas but leave teachers free to select, in accordance with their children's needs.

Despite the enormous expenditure of time, effort and finance involved in these and later schemes and projects, the uptake of science in primary schools has been very limited. The HMI Report, *Primary Education in England: A Survey of HM Inspectors of Schools* summarises the situation '... the progress of science teaching in primary schools has been disappointing; the ideas and materials produced by curriculum development projects have had little impact in the majority of schools.'

The main reason for this failure of the primary science projects is generally agreed to be the lack of experience and scientific background of the teachers. Many teachers are also worried about the availability of equipment and materials and the excessive amount of preparation needed to introduce science into their classrooms.

One fact about our schools which is frequently ignored is the simple one that the majority of primary school teachers are female. Science teachers in secondary schools have long been aware of the serious imbalance between the numbers of boys and girls choosing to study science

subjects. As a result of such subject specialisation, many of our primary school teachers were cut off from science at any early age. The new science projects for the primary school are open-ended and stress the processes of scientific thought and investigation rather than the subject's factual content. These are the very aspects of science which, through no fault of their own, many primary school teachers have had little experience of.

It is the very open-endedness of the Junior Science and Science 5/13 projects which has deterred many teachers from introducing science in their primary schools. It requires considerable confidence, experience and time to sift through 26 source books for help from the Science 5/13 project when selecting suitable items for a science topic such as 'Air', 'Water' or 'Electricity and Magnetism'. In truth many primary school teachers are being asked to use skills and to apply knowledge of which they themselves have little or no basic understanding.

The major primary science projects of recent years have all stressed that the best work will come from areas based on the pupil's interests. Whilst few would disagree with this principle, the result is that the teacher cannot forecast with any degree of certainty where the children's interests will lead the topic. Teachers who are unsure about large areas of science are thus placed in a situation where their areas of greatest insecurity may well be called upon by the children without warning. This lack of confidence will inevitably be transmitted to the children.

In many ways, the *Young Scientist Investigates* course is a compromise between the old-fashioned 'body of knowledge' approach to science and the observational and investigational approaches of the Junior Science and Science 5/13 projects. The *Young Scientist Investigates* provides a basic factual content, thus meeting the stipulation of HMI discussion paper, *Science in Primary Schools*, that 'There are certain fundamental facts and ideas that pupils must meet and grasp if they are to make any significant progress.' At the same time, the *Young Scientist Investigates* provides many opportunities for experiment and investigation, at the discretion of the teacher, that can vary with the particular classroom circumstances and the interests and enthusiasm of teacher and taught. Whilst a small expenditure on science materials and equipment is desirable, most of the suggested experiments and investigations use only inexpensive everyday household items and basic classroom materials. Hopefully, as the teacher gains in experience and confidence as a result of using the course, he or she will gradually be able to increase the proportion of time devoted to encouraging observational skills and a scientific approach to problem solving. Above all the *Young Scientist Investigates* aims to provide the teacher with the scientific background to teach a few popular and important topics and to keep the amount of preparation necessary to the bare minimum.

What is Science?

The very word 'science' seems to bring out all sorts of fears and phobias in many primary school teachers – mainly those who had unhappy experiences of the subject in their own secondary education or who, because of the pressures of specialisation, were cut off from science at an early age. Equally there are those who feel the subject can be taught properly only in splendidly equipped laboratories. The

conflict felt by these teachers who regard themselves as 'non-scientists' is compounded by the fact that we live in a scientific and technological age, and most people now agree that the sciences should occupy a key position in the school curriculum at both primary and secondary level. The HMI Report, *Primary Education in England* (1978) recommended that all schools should be teaching some science and Science 5–16: *A Statement of Policy*, issued by the Department of Education and Science and the Welsh Office in 1985, went on to declare that 'all pupils should be properly introduced to science in the primary school. . . .'

Having agreed that the teaching of science in the primary school is necessary, what is this mysterious subject? The word 'science' comes from the Latin *scire*, to know. Science is the vast subject concerned with knowledge of the universe and all that is in it. Science is thus an organised body of subject matter, and in this it is no different from geography, history, religious studies or any of the other subjects in the school curriculum. Where science differs from these other subjects, is that it involves a method of discovery based on experimentation. Experiments entail the examination of a number of observations in an attempt to fit general conclusions to them.

The early stage in the development of any science is based largely on observation, and it is not unreasonable that children's introduction to science in the primary school should parallel the history of the subject, beginning with observation and then moving on to test ideas by experimentation. It is important to remember that careful observation is a practical skill common to other areas of the primary school curriculum. It can be taught in, for example, art or geography as well as science, to the benefit of all.

Nor is there anything remarkable about the process of experimentation. It comes naturally for young children to try out things to see how they work, to experiment, to manipulate, to be curious, to ask questions, and to seek answers.

There are still primary school teachers who claim that they do no science with their classes. In fact, some science goes on in every good classroom where the children are actively engaged in learning. Every time a child asks a question and the teacher says, 'Let us see if we can find out,' science can be involved. A child engaged in water play may notice that a block of wood floats. He may then test other materials to see which of them will also float. That is science. In the playground, children may compare a golf ball and a tennis ball to see which bounces the highest. That is science. When decorating the classroom at Christmas or for a party, sooner or later a child will blow up a balloon and let it go, watching the balloon's erratic course across the classroom. This simple piece of curiosity or play can be used as the basis for some simple science investigations. How can we measure how far the balloon travels? Does the balloon go furthest when it is partially or completely inflated? What happens if we fit a nozzle (made from the tube of an old ballpoint pen) in the neck of the balloon? What do we see if we paint a face on the balloon and then inflate it? Which travels the furthest, a sausage-shaped balloon or an oval one? How can we use a balloon to power a small trolley made from Lego or Meccano? We can then go on to look at the history of balloon flight, the use of balloons for meteorological purposes, other methods of flight, and so on. There are many such opportunities for science in the lively classroom. Often it is

simply a case of recognising the possibilities for investigation and experiment, and then encouraging children to find out for themselves.

In recent years, natural history or nature study, formerly one of the strong points of the primary school curriculum, has come to be regarded as lacking in academic respectability. This is unfortunate, because again there are excellent opportunities for developing the powers of observation, and encouraging simple forms of experimentation, from a study of plants and animals.

To sum up, in order to encourage children to think scientifically, they should be helped to bring questioning minds to their experience of things around them, to ask Who? What? Why? Where? When? How many? How much? How far? and so on. They should then be encouraged to find their own answers, as far as possible, by devising simple experiments.

The testing out of an idea – properly called a hypothesis – is the usual way in which scientists carry out an experiment. But children often carry out experiments with no particular hypothesis in mind – simply to see what happens. This form of experimentation is often frowned upon by adult scientists, but it is a useful stage in the development of scientific enquiry in young children.

To some teachers, one of the most embarrassing situations is the experiment which ‘does not work’. In fact, all experiments ‘work’, but not always in the ways we expect them to. When experiments fail to produce the expected result, it is sometimes because the hypothesis being tested needs to be thought through again, or the experiment itself may be badly designed. Deciding which is the case is a matter of experience, but also a golden opportunity for more scientific thought and experimentation.

The ultimate test of science is the *controlled* experiment, in which two situations are compared which are identical except for the one factor being tested. Having observed cress seeds growing on a number of occasions, we might decide that water is an important factor in initiating the germination of cress seeds (our hypothesis). We might then take two saucers lined with cotton wool, on which equal amounts of cress seed are sprinkled. Both saucers are placed on a warm, sunny windowsill. They are identical except that the cotton wool on one is kept moist, while the other is left dry. The saucer with the dry cotton wool on it is the control of the experiment.

Devising suitable controls for experiments is beyond the scope of most primary school children. Indeed it is a common criticism of secondary science students at both O- and A-levels, that they frequently fail to describe suitable controls for experiments in their examination answers. However, primary school children do have a well-developed sense of fairness, and this is really a necessary stage in the development of an understanding of the need for controlled experiments. If, for example, we try to see which of two materials floats the best, we may soon be rebuked by the child who points out, quite rightly, ‘That’s not fair, this piece is bigger than that one!’ We should, wherever possible, encourage children to see that their experiments are ‘fair’.

No matter how desirable it may be, it is not possible in the ordinary classroom for all learning about science, or any other subject, to be acquired by discovery. Life is too short and the world too complex for us to all rediscover the wheel and all the other remarkable human discoveries and achievements.

Often it is necessary for children to have to read or to be told facts which they cannot discover for themselves.

Children may have to be told, for example, that the world is round. In giving this information we have a duty to ensure that our explanation is expressed in terms that the child can understand. ‘Round’ to a child can be round like a ball, like a ring or hoop, or like a coin. It is equally important that the child should also be introduced to scientific vocabulary wherever this seems appropriate.

Inevitably, sooner or later, a child will ask a question to which the teacher does not know the answer. There is absolutely no reason for the teacher to feel guilty about expressing his or her ignorance, but hopefully the teacher and children together can set about finding the answer, by experiment if possible, if not with the aid of reference books. If the teacher can approach the finding out by experiment without any preconceived ideas, then the experience will be very valuable for both teacher and taught. This is definitely one situation where the clear-thinking, ‘non-scientist’ teacher has a distinct advantage.

Sometimes it will be necessary for the child to be told that the answer to a question is quite simply too difficult for him or her to understand at present. It is, for example, almost impossible to give a simple answer to the question ‘What is electricity?’ without becoming involved in a confusing ‘explanation’ that involves electrons, potential differences, and such like. Some people compare the flow of electricity through a wire with the flow of water through a pipe. However, the matter-of-fact child soon points out that a pipe is hollow whereas wires are solid. Perhaps the best analogy to the flow of electricity along a wire is the way in which heat passes along the solid metal handle of a saucepan or frying pan. We have to accept the fact that children’s knowledge about science, like human knowledge in general, will always be incomplete and to some extent inaccurate. It is to be hoped that the child’s knowledge will gradually be extended and refined as he or she grows older and is exposed to an increasingly wide variety of scientific experiences.

The Young Scientist Investigates Series of Topic Books

There are 20 books in this series, each of which explores a different field of study. Every book contains two colourfully illustrated sections of text followed by extensive work sections with questions on the text, things to do, which are mainly of a non-experimental nature, together with a selection of simple experiments. There is a glossary at the end of each book.

The topic books lend flexibility to the *Young Scientist* course. The teacher can select some or all of the topic books to extend the scope of work covered by the two course books. Alternatively, the topic books can be used to give pupils the opportunity to select their own areas of study and to be able to use one of the topic books as a starting point for further work. Hopefully the topic books will give rise to questions and problems which the pupil can investigate in a scientific way.

Briefly, the text of the 20 topic books covers the following areas of work:

BIRDS The size and variation of birds; adaptations to flight; feathers; grooming; beaks and feet and their adaptations to the bird’s way of life; birds of prey; water

birds; courtship and nest building; eggs, incubation and the care of the young; the enemies of birds; migration.

FLOWERS Plants and flowers; the parts of a plant – roots, stems, leaves and flowers – and their functions; the parts of a flower; pollination; garden flowers; buttercups; seeds, bulbs and corms; insects and flowers; daisies and dandelions; grasses; the hazel tree and wind pollination.

SEA AND SEASHORE Oceans and seas; the seashore and sea bottom; tides and waves; plankton and whales; molluscs and some other seashore animals; sandy beaches; rock pools; seaweeds; the tideline; sea birds; sand dunes and shingle beaches; divers and fuels; fishing for food; the deep sea; pollution.

SEEDS AND SEEDLINGS Flowers; pollination; the formation of fruits and seeds; seed dispersal; the parts of a seed; germination and growth; stored food in seeds; poisonous fruits; cereals and other grasses; planting seeds.

SMALL GARDEN ANIMALS Vertebrate and invertebrate animals; flies and other insects; ladybirds; butterflies and moths; gnats and mosquitoes; honey bees, wasps and ants; garden spiders, wolf spiders and house spiders; woodlice; centipedes and millipedes; slugs and snails; earthworms.

TREES The distribution of trees; the parts of a tree; deciduous and evergreen trees; leaf-fall; tree flowers, fruits and seeds; germination; seedlings and saplings; trees in winter; the death and decay of trees; the importance of trees; timber.

WATER The world distribution of water; what we use water for; clean and dirty water; water purification; ice and steam; clouds, rain, fog and snow; dew and ice; where our water comes from; the water cycle; water at work; evaporation; wet and dry; water and solutions; floating and sinking; life in dry places; living in water; the sea.

AIR Air and the atmosphere; air and our bodies; oxygen; how other living things breathe; plants and the air; wind; compressed air; air pressure; fire; moving through the air; flying animals; birds; balloons; aeroplanes; keeping warm; dirty air and pollution.

ROCKS AND SOIL The Earth; rocks; minerals; volcanoes; glaciers and earthquakes; how rocks are broken down; how new rocks are formed; fossils; fuels from the Earth; soil; the formation of soil; different kinds of soil; sandy soils and clay soils; loam; earthworms and soil fertility; plant foods; taking care of the soil.

ELECTRICITY AND MAGNETISM Early magnets; uses of magnets; compasses; attracting and repelling; making magnets; electricity; power stations; wires and cables; electricity in the home; electric lights; electricity and safety; batteries; electrical circuits; static electricity; electric fishes.

LIGHT AND COLOUR Light; rays of light; light and materials; shadows; mirrors and reflections; lenses; electric lights; other kinds of light; eyes; colour vision; flowers; cave paintings; dyes; rainbows; coloured lights; coloured paints; camouflage colouring.

HEAT Fire; bonfires; putting out fires; fuels; getting warm; melting substances; expansion and contraction; temperature; animals and temperature; sunshine; expanding air; water vapour; conductors and insulators of heat; air as an insulator.

ENERGY Moving things have energy; energy and our bodies; doing work; energy from the sun; coal, oil and gas;

heat; electricity; methods of making electricity; engines; friction; different kinds of energy; energy can be stored; saving energy.

SOUNDS Types of sounds; sounds that give us information; how sound is made; low sounds and high sounds; sound waves; sound travels through solids and liquids; animal voices; human sounds; how we hear; animals' ears; musical instruments; echoes; using echoes; storing and sending sounds; noise pollution.

FOOD Why we need food; food chains; energy; energy-giving foods; body-building foods; proteins; mineral salts; vitamins; water; digestion; fibre; keeping food fresh; enjoying food; fun foods; food and famine.

STRUCTURES Different structures; invertebrate animals; bones and skeletons; trees; foundations; walls; waterproofing; roofs; bridges; arch bridges; cantilever and suspension bridges; roads; making a road; tall buildings; cranes; dams.

EVERYDAY CHEMICALS Chemicals everywhere; chemicals and heat; chemicals from coal and oil; chemicals from the air; carbon dioxide; acids and alkalis; salt; using salt; sugar; chalk; dyes and colourings; soaps and detergents; killing germs; farm and garden chemicals; pollution.

MATERIALS Natural and man-made materials; wood; paper; rubber; fibres; coal; oil; iron and steel; copper, aluminium and gold; sand, gravel and clay; cement and concrete; glass; plastics; recycling materials.

POND LIFE How ponds were formed; changing ponds; pond plants; small water animals; fish; some common water birds; ducks and swans; ponds in summer and winter; frogs and toads; newts; dragonflies and damselflies; water beetles and water bugs; caddisflies and water spiders; water snails; ponds in danger.

THE HUMAN BODY What we are made of (cells); the skin; bones and skeletons; muscles and movement; teeth; digestion; air to breathe; the heart and blood circulation; blood; excretion; speaking and hearing; eyes and seeing; other senses and sense organs; nerves and the brain; having babies; growing up.

Using the Course Books

The demands which the *Young Scientist Investigates* make upon the teacher depend entirely on how far he or she wishes to progress with that particular class or group of children. The two course books are intended to provide core material on the three themes of *Living Things*, *Structures*, *Forces and Energy*, and *Change*. In this they meet the suggestion of the HMI's paper: *Science in Primary Schools*, that the science children meet in the primary school should include the study of

- (a) living things and their interaction with the environment;
- (b) materials and their characteristics;
- (c) energy and materials;
- (d) forces and their effects.

The themes chosen are based firmly on the children's own experience and cover areas affecting their everyday lives. The units in the two course books contain a high proportion of direct teaching, so that they can be used as they stand or as part of a more extensive programme, with the help of some or all of the 20 *Young Scientist*

Investigates topic books. If they can be pre-recorded, selected programmes of the excellent schools radio and television science broadcasts would be valuable additional resources.

The Units can be taught in almost any order. If there are two or more teachers with classes of children of the same age, they could each choose two different Units. The teachers could acquire the materials for their particular Unit and then, after the work is completed, they could exchange materials and ideas, and discuss any problems that arise.

Do not be afraid if you find that the children are engrossed in a topic which they have discovered for themselves. Let the children follow their own devices, with help and guidance from you, for that is where the best science will result. All the way through the course, the children should be encouraged to realise that science is a *doing* subject, rather than one where they spend all their time passively reading or listening. If you invite the children to experiment with some batteries, lampholders and pieces of wire, for example, you will probably find that they are at a complete loss where to begin or what to do. But soon, after a little prompting from the teacher or the course books, the children will start to have original ideas. Again trying things out with real materials is fundamentally more important than reading, writing notes, making drawings or other basically worthwhile activities.

It will be necessary to divide the class into groups of a size you consider appropriate for each practical activity. The groups should be as small as possible but should have enough pupils to adequately handle the materials and to keep a record of the results. For most activities, two or three children is probably the optimum number for a group. Many of the activities can be done individually. Certainly the groups should never be so large that some children are merely spectators. It is suggested that while part of the class is engaged in practical activities, which require the teacher's attention, the remainder of the class will be busy with the 'desk-bound' written or other activities in the course books.

Comprehensive details are given throughout this *Teacher's Guide* on how to deal with each of the Themes and Units. Most of the sections on the remaining pages are self-explanatory. *Science background* is aimed at giving the non-scientist teacher confidence. It contains all of the scientific knowledge needed to teach that particular Unit. *Extending the learning* contains activities, experiments, demonstrations and suggestions for discussion which can be used to add depth to each lesson or to reinforce it. The more important or longer experiments are written in a form in which they can be used directly by the children if they are copied on to the blackboard or photocopied and made into work-cards. How many of these additional activities and experiments are used is entirely at the discretion of the teacher, and obviously will depend upon the time and facilities available, and the teacher's and children's interests. Important links and relationships exist between science and other areas of the curriculum, and *Interdisciplinary activities* contains suggestions for integrating science work with these other subjects.

Recording Scientific Experiences

As well as increasing the sum of human knowledge by formulating hypotheses, carrying out experiments and

producing generalisations about their results, another attribute of scientists is the ability to communicate their discoveries to others and to invite discussion, comment and criticism.

In this way science can also make a significant contribution to the language development of children. However, many children, having carried out some exciting and stimulating investigation, sum up their feelings by asking the teacher, 'Oh no, Miss, do we really have to write about it?'

While it is important to encourage children to record and communicate their discoveries, it is equally important for them to gain experience in recording their findings in a variety of ways. Nor should the importance of oral work as a means of presenting scientific discoveries be underestimated.

Ideally the children should have at their disposal a wide range of attractive materials, including large sheets of coloured sugar paper, thin card, drawing paper, tissue paper, black paper, squared paper, and gummed paper shapes of assorted colours. As the HMI discussion paper, *Science in Primary Schools* points out, 'Not only will these stimulate their (the children's) desire to communicate and increase their pleasure in doing so, but it enables them to learn about the properties of different materials and gradually, with the teacher's help, to choose the best means of communicating whatever they have to say.' As a result of this help from the teacher, and with the help of the course books, the children will eventually learn when it is most appropriate to use a drawing, a graph, a model, or a class display to record their results, and when to write down their ideas and explanations.

When a written account is prepared, there is certainly no place for the stereotyped secondary school headings such as Experiment, Method, Results and Conclusion. If it is thought desirable that children should have headings to guide them in their thinking and written work, then *What I wanted to find out* (or simply *The problem*), *What I thought would happen*, *What I did*, *What did happen*, and *What I learned* are sufficient.

Whatever method of recording is used, the children should be made aware of the dangers of drawing conclusions from a single test or experiment. Ideally the experiment should be repeated several times to see that the results obtained are typical. In addition the children should be encouraged to compare their results with those of their classmates. As they increase in confidence, the children will learn to be critical of their own observations and ideas and those of other people. The discussion of differences in discoveries and findings can itself lead to ideas for further investigation and experimentation.

Seeking help or going further

Apart from the local authorities' science advisory staff, there are a number of other sources of help or inspiration for the primary teacher, whether a trained science specialist or a reluctant or conscripted scientist.

The School Natural Science Society, 10 Plantation Road, Faversham, Kent, 'aims to bring together, for mutual help and advice, those interested in all branches of Natural Science . . .' Its journal, *Teaching Science*, which is published three times a year, contains many items of direct interest to primary school teachers. The Society also runs an advisory service.

The Association for Science Education, College Lane, Hatfield, Herts, AL10 9AA, aims to further all aspects of science education. Its two major publications, *Education in Science* and *The School Science Review*, contain articles of interest to primary school teachers. In addition, there is a separate newsletter, *Primary Science*.

The monthly magazine, *Junior Education*, and its additional 'Special Numbers', contain articles on practical science teaching ideas and methods for teachers concerned with children aged 7 to 13 years.

The British Association for the Advancement of Science, Fortress House, 23 Savile Row, London W1X 1AB, has established a scheme of 'Awards for Young Investigators' to encourage scientific and technological interest among children aged 8 to 12, concentrating especially on work carried out to complement the normal curriculum.

The Science and Technology Regional Organisation (SATRO), has 24 centres throughout the country. They are all anxious to give practical help, including the loan of materials and equipment, to aid the development of any scientific or technological work in any school. Ask your

L.E.A. for the address of the nearest SATRO resource centre.

British Broadcasting Corporation produces a range of radio and television science programmes supported by teachers' notes, booklets, pupils' pamphlets and filmstrips.

Full details are given in the current *BBC Radio and Television Annual Programme for Schools and Colleges* sent to schools in March, and the termly timetable. All BBC school broadcasts are sponsored by the School Broadcasting Council for the United Kingdom, The Langham, Portland Place, London W1A 1AA.

Independent Broadcasting Authority (IBA) also produces science programmes – most accompanied by teachers' notes and/or pupil material. These are described in detail in the *Annual Programme Booklet for Schools and Colleges*. Some series are shown only in certain regions. Requests for information on these programmes should be sent to the Education Officer at the appropriate regional ITV company. General educational enquiries: Education Officer (Information), Independent Broadcasting Authority, 70 Brompton Road, London SW3 1EY.

Course Book 1

What do scientists do? (pages 2–3)

Aims

- a To show that science is concerned with everything around us.
- b To demonstrate the importance of careful observation.
- c To encourage the taking of measurements wherever possible.

Science background

This introductory section is largely self-explanatory. However, it is worth bearing in mind that science is divided into many branches and that most professional scientists are specialists. The main branches of science are astronomy, biology, chemistry, geology and physics. *Astronomy* is the study of the various bodies in space, including the sun, moon, stars, planets and comets. *Biology* is the study of living things. *Chemistry* is the study of the nature of all the substances which surround us in the world. Chemists also produce new substances from existing ones. *Geology* deals with the structure of the Earth, as well as the rocks, minerals and fossils it is made of. *Physics* is the study of the behaviour of solids, liquids and gases, as well as such forces and forms of energy as heat, light, sound, electricity, magnetism, mechanics and gravity.

Books for the children

Wide Range Science Stories (Books 1, 2, 3 and 4) by Michael Holt and Alan Ward (Oliver and Boyd)

Books for the teacher

Science 5/13: *Using the environment: 1 Early explorations* (Macdonald Educational)

Materials and organisation

One promising place to begin this short topic, would be to discuss with the children the famous scientists they know of, or to discuss the benefits which science has brought to mankind. Alternatively, a story describing the work of a famous scientist could be read to them.

Throughout the course, it would help the children to understand the importance of scientific discoveries in our everyday lives, if you keep a *Science Bulletin Board* on which are displayed newspaper cuttings and magazine articles describing the work of scientists and important new scientific discoveries. These should be changed and updated regularly. In addition, you could keep a *Science Table* in the classroom on which materials can be displayed relating to the themes and topics dealt with in the Course Books.

Extending the learning

Other ways to encourage the children to extend their senses and powers of observation include:

- 1 Playing 'I spy' games in the classroom or on walks with the teacher.
- 2 Letting the children take it in turns to identify some common objects and materials while they are blindfolded.

Theme: Living Things

Unit 1: We are all different

Science 5/13: *Like and Unlike* (Macdonald Educational)

Aims of the Unit

- a To begin the study of living things by encouraging the children to take an interest in themselves and the people around them.
- b To help the children to appreciate that, although we are all built on the same basic plan, we are all different.
- c Once the idea of variation has been established, it will enable the children to later understand modern theories of evolution and also, during adolescence, to accept that individual differences in rates of growth and development are quite normal.

Science background

Individuals within a species are all slightly different from each other. It is these variations which form the basis of the theories of evolution, put forward in 1858 by Charles Darwin and Alfred Russell Wallace, which are generally accepted today. More important from the point of view of primary school children, is the fact that although there are over 4,200 million people on the Earth and, although we all have the same basic features, no two people are exactly alike. However, in spite of the fact that we are all different, we do share characteristics with our parents and ancestors, including the colour of the hair and skin, the shape of the nose, and sometimes unfortunate characteristics such as the bleeding disease, haemophilia. An understanding by children of the great range of variation shown by all individuals, will help them to cope with the rapid growth and mood swings of adolescence. Treated tactfully and sensitively, this topic should also help to promote racial tolerance and understanding, as well as tolerance of those who have physical or mental handicaps or who are otherwise disadvantaged.

Books for the children

The Young Scientist Investigates: *The Human Body* by Terry Jennings (OUP)

Books for the teacher

Science 5/13: *Ourselves* (Macdonald Educational)
Science 5/13: *Early Experiences* (Macdonald Educational)

Materials and organisation

Children are always interested in themselves and in comparing themselves, favourably or unfavourably, with other people. A large number of suggestions are made in the text of ways in which children can find out more about themselves and other people.

There is no one place to begin this topic. However, since the whole theme is concerned with living things, a good starting point would be an examination of what it means to be living. The teacher, for example, might make a display on the Science Table of materials, pictures and, ideally, a few living plants and animals. It would also be useful to include a teddy bear or some other toy animal. The children could then classify these objects as being living or non-living. They should begin to realise that animals (including humans) and plants are living objects. Non-living matter is not now alive, although in the case of a feather or a piece of coal, it may have been alive once. Hopefully the children will come to realise that most living things use food, water and air, respond to light, changes of temperature, sounds and smells, and grow and produce other living things of the same kind. Non-living things do not respond to the above stimuli in the way that living things do, nor do non-living things reproduce themselves.

Materials and equipment:-

tape measures or rulers and string
large sheets of squared paper
drawing paper
boxes containing beads, peas or marbles
ink pads or black shoe polish
washing-up liquid
30 cm rulers
Sellotape
strips of paper (about 3 cm wide)
small nails or paper clips
mirrors

We are all different (pages 4–5)

Lesson objectives

- a To enable the children to learn more about themselves.
- b To enable the children to gain an understanding of biological variation.

Setting the scene

There is no fixed starting point. As with most teaching, the best work usually comes from spontaneous interest and questions posed by the children. Possible starting points are:

- 1 Discussing with the children the problems that might arise if everyone in the class, or indeed in the world, looked, thought and behaved in exactly the same way.
- 2 Asking the children to discuss their likes and dislikes.
- 3 Discussing the arrival of a new baby. An excellent opener would be if a teacher or one of the parents could bring a young baby to school, when weights and measurements of it could be made for comparison with the children in the class.
- 4 Measurements in mathematics, leading on to measuring the body.
- 5 How many boys and girls are there in the class?
- 6 Each child draws a simple outline diagram of himself or herself and writes in the names of as many of the parts of the body as they know.

New words

Humans (human beings) – the name given to the species or kind of animal to which all the people on Earth belong.

Variation – the differences between people or animals and plants belonging to the same species.

Class management

It is suggested that the materials for the various activities are distributed around the classroom. The children can then work in pairs or other small groups and circulate from activity to activity, until they have completed them all.

Safety precautions

During the discussions of this work, a particularly sensitive approach is needed when considering, for example, whether tall children have tall parents or whether blue-eyed children have blue-eyed parents. It is essential that children who are adopted, fostered, 'in care', or members of one-parent families should not be made to feel unfortunate, abnormal, unusual or in any way odd.

It is also wise to ensure that all children taking part in the more energetic activities are physically fit.

Answers to questions in the text

- 1 Height in adults does not seem to be appreciably influenced by environmental factors. However, factors such as diet and health do seem to affect the height of children, in whom growth occurs in spurts. At puberty, for instance, there is a spurt in height, and the later this occurs the greater the final height of the individual. In spite of these complications, in general tall parents have tall children and short parents have short children.
- 3 The method described in the text for measuring the amount of skin is inaccurate because it treats the body as a two-dimensional object, and measures only the front and back. It makes no allowance for the varying thickness of the body.

Another way to estimate the amount of skin would be to measure the area of reasonably tight-fitting

clothing, once this had been removed from the body.

Another method of comparing the sizes of peoples' hands is to compare the gloves they wear, assuming these are a good fit.

In general, the person with the biggest hand can pick up the most beads, peas or marbles.

- 6 The two ears shown in the picture demonstrate the two main variations in the form of the outer ear. In some people the outer ear has a distinct lobe at its base where it joins the head. In others, no lobe is present.
- 8 The ability to roll the tongue is another inherited characteristic. Children either can roll their tongues or they cannot. No amount of practice will produce a tongue-roller from someone who was born without this characteristic.

Now try these

- 1 It is possible to say most words while holding the tongue, although the results are not very clear.
- 2 In many people, left and right feet differ slightly in length, which is why, when buying new shoes, it is important to try on both shoes of a pair.
- 3 The many things we can do which other animals cannot include talking, walking on the hind limbs all the time, writing, driving a car, riding a bicycle, telling the time, using a computer and other tools and machines, measuring accurately, doing complicated sums, counting to high numbers, and so on.

Extending the learning

- 1 A survey of eye colour.
- 2 A survey of the number and size of freckles on the face.
- 3 Study the imprints made by teeth. Get the children to bite into apples, fudge or soya flour marzipan. Compare the patterns produced.
- 4 Measure lung capacity (see page 30 of *The Young Scientist Investigates: The Human Body*. Note the SAFETY PRECAUTIONS given for this experiment).
- 5 Animal footprints, tracks and trails.
- 6 How strong is a finger? Pull with each finger in turn on the hook of a spring balance, or press down with each finger in turn on a set of bathroom scales.
- 7 Catching a tennis ball.
- 8 A skipping contest.
- 9 Heading a football.
- 10 Aiming a small ball at skittles (washing-up liquid bottles?).
- 11 Estimating and then measuring lengths and distances.
- 12 A test of memory. Try the class with telephone numbers or unfamiliar sequences of letters.
- 13 Chest measurements, and chest expansion when breathing in.
- 14 A survey of the different kinds of houses and homes in which the children live, displayed as a block graph or histogram.

Some more ways in which we are different (pages 6–7)

Lesson objectives

- a To enable the children to learn more about themselves.
- b To develop further the children's understanding of biological variation.

Setting the scene

There is no fixed starting point. One possibility would be to read the children a newspaper cutting describing the successful detection by the police of a criminal who was identified by his fingerprints. Possibly a visit to the local police station could be arranged, or perhaps a policeman could come to the school and talk about his work.

New words

Unique – having no like or equal.

Class management

It will probably be most convenient to again arrange the materials around the classroom so that the children can move from one activity to another, until they have completed them all.

Safety precautions

In view of the emotive reaction of a few parents to the possibility of their children's fingerprints falling into the 'wrong' hands, it is sensible to allow the children to have all of their own fingerprints they take, and to let them destroy any themselves which they do not wish to keep.

Answers to questions in the text

- 1 No two fingers have exactly the same prints and no two people have been discovered with identical fingerprints. Even identical twins have slightly different fingerprints.
- 4 a The children will differ in the number of teeth they have. Young children have 20 first or 'milk' teeth, but from the age of about six, these are gradually replaced by a second or permanent set of teeth. Eventually there are 32 of these, 16 in each jaw.

Now try these

- 1 In many people the left and right eyes are not equally effective when reading at a distance.
- 5 It is difficult to count how many times a minute a person breathes since the rate is frequently altered merely by the person thinking about what is normally an unconscious action. It is best to take several readings, discard the highest and the lowest, and find the average of the others.
It would also be instructive to measure the rate of breathing before and after a run around the playground or a bout of running on the spot, so that the children can see the dramatic increase in the rate of breathing after strenuous exercise.

Interdisciplinary activities

Art and craft

Figure drawing.

Use the delicate texture of thumb-prints on white paper to form the basis for pictures of birds, comic characters etc.

English

Poems entitled 'Me'.

Our language – see Oxford Junior English Book 5: *Our Language* by Oliver Gregory (OUP).

The story of Douglas Bader.

The Borrowers by Mary Norton.

Goodnight Mister Tom by Michelle Majorian.

Kids Like Us (4 books) by Beverly Allinson and Barbara O'Kelly.

Geography

People of different races and languages.

Health and hygiene

Care of the hair and skin.

History

Fashion through the ages.

Mathematics

Use hand spans, shoe lengths, or other parts of the body to measure objects in the classroom, and then introduce the notion of the need for *standard* measurements.

Make a book called 'The Mathematics of Me' (ages, weights, heights, size of family, sizes of clothes etc).

Make block graphs or histograms of the numbers of children whose first names begin with the different letters of the alphabet.

Children measure themselves, and then draw their outline on squared paper to scale.

Graphs of birthdays – When were most people born?

Music, drama and PE

Individual performances at athletics, games etc.

Religious education and social studies

What do we do on Sundays?

Friendship, family and community.

Unit 2: Fruit and vegetables

Aims of the Unit

- a To examine the differences between fruits and vegetables.
- b To introduce some simple ideas concerning the production of different varieties of cultivated fruits and vegetables by selective breeding, starting with wild plants.
- c To examine the ways in which new plants can be obtained either from seeds or by vegetative methods.

Science background

Plants have always been a major part of people's diet. As we saw in Unit 1, no two humans are exactly alike. Such variation also exists in other living things, including plants, which reproduce sexually. However, many plants can also reproduce by vegetative means, such as bulbs, corms, tubers and runners, when the offspring are identical to the parent plant. The offspring are also identical to the parent plant when people take cuttings.

Our earliest ancestors collected seeds from wild plants for food. Some of these that were accidentally dropped to the ground probably germinated, and grew into mature plants around the nomadic camps. By 6000 BC, in Palestine people had become settled and grew crops, rather than searching for suitable plants in the wild. As long ago as 4500 BC, people not only grew crops from seed, but there is evidence that they selected and used seeds only from the strongest, most productive plants.

This process of selection by using only the best plants, is still the most widespread method of producing new kinds of plants from old. Today, plants are selected not only for yield, but also for such features as speed of ripening, disease resistance, and the ability to withstand bad weather, atmospheric pollution and poor soils.

Selection to produce the required new plant is usually a very long process, and can require the equivalent of up to 20 years of growing seasons. Occasionally, however, a quite different individual appears spontaneously in a crop. This is called a 'sport' or mutation, and if it bears characteristics useful to people, it can be propagated. Nowadays it is possible to induce mutations by the use of chemicals, X-rays and other forms of radiation. In some instances once a desired mutant or variation has been found, it is possible to grow new individuals from single cells of the new plant contained in test-tubes, so increasing rapidly the production of an economically large stock of the new plant.

One of the reasons for conservation is to preserve as wide a variety of wild plants as possible, so that in the future it may be possible to use some of their characteristics in new cultivated plants.

The flowering plants which reproduce sexually, bear seeds. These consist of a food store surrounding a miniature or embryo plant. In order for a seed to start to grow, or germinate, air (or oxygen), water and warm conditions are necessary. A few seeds need light if they are to germinate, and all seedlings must have light if they are to grow into healthy plants.

A fruit is the part of a plant which encloses the seeds. When we eat a fruit, we should remember that its original function was, and still is, to assist in dispersing the seeds.

Vegetables are the parts of the plants we eat, other than fruits. When we eat most vegetables, we are eating the plant organ containing food which the plant had stored for its own use. Often, as in the case of potatoes, carrots, turnips and onions, this stored food is needed to enable the plant to reproduce, or to begin growing again when warmer conditions return after the winter period of dormancy.

Books for the children

The Young Scientist Investigates series: *Flowers; Trees; Seeds and Seedlings; Food* by Terry Jennings (OUP)
Science Workshop by Irene Finch (Longman)
 Science in a Topic: *Food* by Doug Kincaid and Peter S. Coles (Hulton)
 Oxford Junior English Book 2: *Food and Farms* by Oliver Gregory (OUP)
 Finds: *Leaves* by Barbara Trinder (Evans)

Books for the teacher

Teaching Primary Science: *Seeds and Seedlings* by Dorothy Diamond (Macdonald Educational)

The Oxford Book of Food Plants (OUP)

Materials and organisation

Children are always interested in food and they will welcome information on where the fruits and vegetables which form an important part of our daily food come from.

The catalogues of seed merchants and other garden suppliers are usually very colourful, and will provide a convenient source of materials for work cards, and wall charts and other displays.

Supplies of seeds are obtainable almost everywhere during the winter and spring. However, Thompson and Morgan, London Road, Ipswich, Suffolk IP2 0BA, have a particularly comprehensive selection.

Materials and equipment:-

- seed catalogues
- scarlet runner bean seeds
- a selection of vegetable leaves
- Sellotape
- cartridge paper or card for mounting leaves
- hand lenses or low-power microscopes
- food colouring or red ink
- sticks of celery
- broad bean seeds
- pea seeds
- large clear glass jars
- blotting paper
- plant pots, yoghurt pots or similar
- soil or compost
- cress seeds
- saucers
- towelling, flannel or cotton wool
- matchboxes
- bird seed or hamster food
- potato tubers
- onions
- apples, tomatoes or other fruits
- alfalfa, mung beans or fenugreek seeds
- muslin or J-cloths

Vegetables (pages 8–9)

Lesson objectives

- a To enable the children to have some appreciation of the wild origins of our common vegetables.
- b To illustrate the wide range of plant parts we eat as vegetables.

Setting the scene

A good starting point is to carry out a survey amongst the children of their favourite vegetables. Alternatively they could carry out some potato printing, or the teacher could arrange a display of vegetables on the Science Table. Whichever starting point is adopted, it could lead to the question: Where do vegetables come from?

New words

Veins – the bundles of tiny tubes which form a network throughout a leaf. Veins carry food and water to and from leaves (cf. the veins in the bodies of animals which carry blood).

Class management

For the practical activities, arrange the appropriate materials in groups so that some of the children can examine seed catalogues, some can draw and colour pictures of scarlet runner bean seeds, while the remainder are studying and drawing or mounting leaves of various kinds.

Safety precautions

The children should wash their hands thoroughly after handling the seeds or leaves, and before touching food.

Answers to questions in the text

Scarlet runner beans (page 8)

It is not normally possible to find two scarlet runner beans seeds which are exactly alike.

Vegetable leaves (page 9)

The vegetable leaves shown in the picture are leek, potato, cabbage, parsnip and lettuce.

If a large number of kinds of leaves are examined, the children will notice that they are of two kinds: most leaves are broad, and have a network of veins which branch out from a larger vein which runs from the leaf stalk up the centre of the leaf. However, the leaves of leeks, onions and other bulbous plants, and of all the grasses and cereals, are strap-shaped and have a system of parallel veins.

The importance of the veins in transporting water and food materials should be emphasised. The children may also notice that all the leaves are green or greenish. This is due to the green pigment chlorophyll, which is important in the manufacture of plant foods.

Now try these

- 1 Most vegetables are available all the year round because of improved techniques of preservation, including freezing and canning. In addition the use of heated greenhouses has extended the growing season for certain vegetables, while faster, improved means of transport, have enabled vegetables to be imported in winter from other, warmer, countries.
- 2 Once early man learned how to collect seeds and to cultivate wild plants, he no longer had to go in search of wild vegetables to eat.
- 3 As well as fresh young stinging nettle, dandelion and lime tree leaves, in the Middle Ages salads often contained wild water cress, hairy bittercress, common winter cress, Jack-by-the-hedge, wood sorrel, salad burnet, brooklime, hawthorn leaves, beech tree leaves, greater prickly lettuce, common scurvy-grass, wintergreen, yarrow and many more wild plants.
- 4 Not all food colourings work equally well for this experiment. One of the most effective substances is red ink, which is not always easy to obtain nowadays. When the experiment does work, the children will notice that the network of veins inside the stick of celery is stained by the colouring. If a section is cut across the celery and viewed with a hand lens or a low-power microscope, the arrangement and detailed structure of the veins will be seen.
- 5 A cabbage leaf has a waxy layer which waterproofs it, so that water does not soak in. If a thin piece of the skin

from the underside of the leaf is examined with a powerful hand lens or the low-power of a microscope, hundreds of tiny pores will be seen. These pores, known as stomata, permit the entry of carbon dioxide gas into the leaf when the plant makes its food in sunlight, and allow oxygen and water vapour to leave the plant.

Expected results of activities and experiments

See *Now try these* (above)

Extending the learning

- 1 Other methods of preserving or collecting leaves, such as making plaster of Paris casts, preserving leaves in wax, and making leaf prints with boot polish or paint, are detailed in *The Young Scientist Investigates: Trees* by Terry Jennings (OUP).
- 2 A survey of the vegetables on sale in local greengrocers' shops, or a visit to a fruit and vegetable warehouse or market would be very instructive.
- 3 If it has not already been done as an introduction to this topic, a collection of fresh and preserved vegetables (or the packets and cans which contained the latter), could be displayed on the Science Table.
- 4 Compare the surface areas of different kinds of leaves. Draw around the outline of the leaves on squared paper and then use the technique employed to measure the area of the skin, described on page 4 of Course Book 1.
- 5 Crush up different vegetable leaves in water, and see how effective the resulting juices are as dyes.

Growing vegetables (pages 10–11)

Lesson objectives

- a To demonstrate that a seed is a resting stage in the life cycle of a plant, and that it contains an embryo surrounded by a supply of stored food.
- b To infer the conditions needed for the germination of seeds.

Setting the scene

Show the children a packet of large seeds, such as scarlet runner beans or broad beans. Alternatively, arrange a display of seeds of different sizes, shapes and colours on the Science Table, and begin by letting the children suggest ways of grouping the seeds into sets. These activities can lead on to the questions: What is inside a seed? How can we get a seed to grow into a new plant?

New words

Germinate – when a seed starts to grow and produce a new plant it is said to germinate.

Embryo plant – the miniature plant within a seed.

Class management

If large seeds are soaked in water overnight, and then cut in half to examine their internal structure, one seed and a hand lens will be needed by each child. Usually it is

possible to split open large, soaked seeds such as broad beans with the finger nails to avoid using knives.

To obtain the most benefit from growing seeds, this activity should be done with the children working individually or in pairs. If there is a shortage of seeds, it is suggested that each jam-jar contains only one seed. Paper towels can be used instead of blotting paper.

Safety precautions

If knives are used to cut open soaked seeds, the children should be instructed to cut *downwards* on to a board.

Answers to questions in the text

Growing vegetables (page 10)

The children will notice that when the seeds have been soaked in water, they change from being hard and dry, to being moist, tender and easily damaged. The volume and weight of the seeds also increases, due to the uptake of water.

Now try these

- 1 A few of the foods we eat which are made from seeds are cereals, such as porridge oats, corn flakes, shredded wheat, puffed wheat, rice crispies and muesli. In addition there is Ryvita, rice, wheat flour, cornflour, semolina, custard, macaroni, spaghetti, noodles, lasagne, bread, pastries, cakes, pies, puddings, blancmanges, lentils, peanut butter, desiccated coconut, coffee, cocoa, chocolate, mustard, pepper and caraway seeds.
- 2 As the dried peas absorb water, they swell up. Eventually they will push out the sides of the box or even burst it. This experiment could also be tried in a small plastic screw-topped bottle filled with water or a small tin fitted with a lid.
- 3 Usually, if you sow half a seed, nothing happens. If, however, the seed is quite a large one, such as a broad bean or a runner bean, and the half planted contains the embryo, it may grow and produce a normal plant.
- 4 The seedlings of vegetables are thinned out to give those that remain enough space to grow to their full extent. In addition a process of selection takes place, because the largest, strongest plants are left, and the smallest, weakest plants are thrown away.
- 5 It is not possible to predict what seedlings will grow from bird seed. Normally most of the plants which grow are grasses and their relatives. Sometimes the packet will give an indication of what seeds are present. In the case of hamster food, the main constituents will probably be cereals, such as wheat, oats and barley, together with peanuts and sunflower seeds. All of these may grow.

Expected results of activities and experiments

Growing vegetable seeds (page 10)

It is not possible to predict the rate at which the various seeds will grow. This depends upon the temperature. However, the children will notice that the first part of the seedling to emerge is always the root, with the shoot following later. Whichever way up a seed is planted, the root will always grow downwards and the shoot will always grow upwards.

An examination of each seedling with a hand lens, will reveal tiny root hairs growing from its root, just behind the tip. These root hairs are important in the uptake of water and mineral salts by the growing seedling.

Extending the learning

- 1 The following experiment is a good opportunity to demonstrate to the children what is meant by a *fair* test, one which tests only one thing at a time. The experiment consists of a series of fair tests.
An experiment to find out what things a cress seed must have to grow.
What you need: Some cress seeds; cotton wool; some egg-cups or small paste jars; a jam-jar.
What you do: Fill each egg-cup or paste jar with cotton wool. Take two of the egg-cups. Wet the cotton wool in one of them.
Sprinkle cress seeds on the cotton wool in both egg-cups. Stand them on a warm, sunny windowsill. Keep the cotton wool in the first egg-cup watered.
Look at the egg-cups every day. Say what happens to the cress seeds. What have you learned?
Now take two more egg-cups. Put cress seeds in both. Water both. Put one egg-cup in a warm cupboard, and the other in a refrigerator. Look at them every day. What happens?
Now take two more egg-cups. Put cress seeds in both. Water both. Put one egg-cup in a dark cupboard and the other on a sunny windowsill. Look at them every day. What happens? What do you see? What happens if, after a week, you put the egg-cup from the dark cupboard on to a sunny windowsill?
Take two more egg-cups. Put one at the bottom of a jar of water. Water the other egg-cup in the usual way, and put them side by side on a sunny windowsill. What happens? What differences do you see? Why?
What have you learned about cress seeds? Why do cress seeds not grow in the packet?
Try this experiment with other kinds of seeds. Make sure your tests are fair.
Discuss with the children what is being tested in each pair of egg-cups.
Expected results: The first two egg-cups show that cress seeds need water if they are to germinate. The seeds on dry cotton wool do not grow.
The second part of the experiment indicates that cress seeds need warm conditions if they are to germinate. Those kept in the refrigerator do not grow.
The seeds kept on a sunny windowsill and in a dark cupboard will probably all germinate. However, the seedlings kept in the dark will be yellow, straggly and unhealthy.
In the fourth part of the experiment, the seeds kept at the bottom of the jar of water receive light and water but little or no air. [It is best if water is used which has been boiled to drive off dissolved air and then cooled]. These seeds do not grow.
From this experiment we learn that cress seeds need air, water and warmth if they are to germinate. If the seedlings are to grow healthily, light is also needed.
This experiment is also easy to perform with peas, radishes, grass seeds or any of the Chinese sprouting seeds. Clean egg-shells could be used instead of egg-cups or paste jars.
- 2 Another interesting and amusing way of growing cress

seeds is to sow the seeds on moist cotton wool contained in a clean egg-shell. If a face is drawn or painted on the egg-shell, when the cress seeds germinate, the seedlings will resemble 'hair' growing from the egg-man's head.

Alternatively, cress seeds can be sown on wet cotton wool, flannel or paper towelling in the shape of a child's initials.

Further experiments and activities on seeds and germination are given in *The Young Scientist Investigates: Seeds and Seedlings* by Terry Jennings (OUP).

New vegetables from old (pages 12–13)

Lesson objective

To identify ways in which new plants can be produced without the aid of seeds.

Setting the scene

To introduce this topic, you might want to bring some potato tubers into the classroom. Ask the children how new potatoes are grown. Are there seeds inside a potato tuber?

New words

Tuber – the end of an underground stem on a potato plant which is swollen with food. The tuber is the part of the potato plant we eat.

Cutting – a piece broken or cut from a plant which will grow roots and become a new plant.

Class management

If enough potato tubers and onions are available, the children could work in pairs to examine both vegetables in turn. Alternatively, the teacher could demonstrate the internal structure of potato tubers and onions to the whole class.

Safety precautions

If the children cut up potato tubers or onion bulbs to examine the internal structure, they should be warned to cut *downwards* on to a board. It will also be necessary to warn those children not familiar with these vegetables, that onions can irritate the eyes when they are cut.

Answers to questions in the text

Plant a potato (page 12)

The buds on a potato are called 'eyes', because they are shaped rather like human eyes.

Know your onions (page 12)

We eat onions raw in salads, and also boiled or fried, and pickled in vinegar.

Now try these

- 2 The children will recall that the 'eyes' of the potato are buds, and that eventually a shoot will grow from each of these buds. It would be instructive to stand a potato in a dark cupboard, as well as the one on the sunny

window sill, and notice the different ways in which the two potatoes grow. The shoots on the potato on the sunny window sill will be short and eventually grow to be dark green in colour, whereas the shoots on the potato kept in the dark will be long and pale. In late spring or early summer, some of the sprouted potatoes could be planted out in the garden.

- 3 Potatoes originated in the bleak uplands of the Andes Mountains in South America. Sir Walter Raleigh is generally credited with having introduced the potato to Europe, although it was probably the Spanish who did it first. However, Raleigh may have introduced the potato into the British Isles, by taking it to Ireland, where he lived for a time during 1588 and 1589.
- 4 In the early 19th century, very many of the poor people in Ireland lived almost entirely on potatoes, for they were a cheap, nourishing and easily-grown crop. In 1845 a blight or fungus disease of potatoes appeared and spread through the country. In 1846 about three-quarters of the potato crop was ruined by blight, but the devastation was even worse between 1847 and 1850. More than a million people starved to death and hundreds of thousands emigrated to the United States. Before the famine, the population of Ireland was 8.5 million. By 1851, the year after the famine ended, it had dropped to 5.1 million.

Expected results of activities and experiments

Growing your vegetable tops (page 13)

Although it is usually thought of as a fruit rather than a vegetable, the top of a pineapple can also be grown like this. Plant the top in a pot containing a mixture of soil and sand, and keep this damp. Leave the pot in a warm place, and if the pineapple top produces roots, transfer it to a new pot containing potting compost.

Cuttings (page 13)

Cuttings can be taken and stood in jars or glasses of water as shown in the illustration, when many of them will root. Particularly good ones to try for this are busy-lizzie, privet, willow and mint.

Another method is to take pieces 7 to 15 cm long from the tips of plant shoots. Cut the end of each shoot cleanly, and remove the lower leaves. Push the cuttings into pots containing a mixture of half sand and half peat or soil. Keep this compost moist and cover the pots and cuttings with polythene bags. Rooting of cuttings is accelerated if, before planting, the cut ends are dipped in one of the hormone rooting powders obtainable from garden centres.

Ask the children what might be the advantages of growing plants from cuttings rather than from seeds. (It is faster, and the new plants produced from cuttings are exactly like their parents. New plants from seeds are often different from their parents.)

Extending the learning

- 1 The growth of a potato tuber can be demonstrated to the children: Fill a large flower pot to within 2 or 3 cm of the top with damp sandy soil or potting compost. Take a small potato or cut a large one into several pieces. Make sure that each piece has a bud. Plant the small potato or one of the pieces in the flower pot just below the surface. Stand the pot where it will receive the light. Do not let the soil dry out.

Ask the children to record what happens. If the potato plant gets too big for its pot, move it to a larger container. Let the children draw or describe any flowers or fruit the potato plant may have on it. After the potato plant has finished flowering, pull it up and see whether it has produced any small new potatoes. Note: The fruits of the potato plant are POISONOUS.

The children could try to find out what is the smallest piece of potato tuber that can be made to grow into a new potato plant.

Do potato peelings grow? (If they are fairly thick and contain a bud or 'eye' they will usually grow.)

In the late spring and summer potato tubers, or pieces of them, can be planted in the school garden.

- 2 Investigate with the children how strawberry plants spread. (As well as spreading by seeds, they produce stems that radiate out above ground from the parent plant. From the ends of these stems, called runners, new strawberry plants grow. It is easy to demonstrate this with a strawberry plant kept in a flower pot on the windowsill.)
- 3 In the autumn and winter, grow daffodils, tulips and other bulbs indoors in pots or bowls of compost. Let the children see how new bulbs are eventually formed on the sides of the original ones.
- 4 If you have access to the country, take the children to see how a bramble or blackberry plant spreads. (Roots and then shoots form on the ends of stems that arch outwards from the parent plant.)

Fruits (pages 14–15)

Lesson objectives

- a To verify that a fruit is a part of a plant which encloses the seeds.
- b To show that not all fruits are brightly coloured and succulent.
- c To explain that, like vegetables, our cultivated fruits have been produced by a process of selective breeding from wild plants.

Setting the scene

How you introduce this topic will probably depend on the time of the year. You might, for example, display on the Science Table a collection of unlabelled fruits which are not brightly coloured and juicy. Ask the children what these objects are. They could cut each of the fruits open, when they will discover that all contain seeds (or pips). Alternatively, you could display a mixture of cultivated fruits and wild fruits of various kinds, and ask the children to think of as many ways as they can for grouping the fruits into sets. (Size, colour, country of origin, wild and cultivated, eaten by humans, not eaten by humans, and so on.)

It is important the children eventually understand that the function of a fruit is to assist in the dispersal of the seeds of the plant on which it grows.

New words

Fruit – the part of a plant which grows from the flower and encloses the seeds. The fruit assists in the dispersal of the seeds. A fruit may contain one seed or many.

Class management

Most of the work on these two pages can be carried out by the children working at their own desks.

Safety precautions

Warn the children that, when cutting up the various fruits provided, they should always cut *downwards* on to a board.

When arranging a display of wild fruits on the Science Table, it is important to choose only those which are *not* poisonous.

Answers to questions in the text

Fruits (page 14)

The fruits shown in the picture are: marrow, tomato, strawberry, pumpkin, cucumber, pepper, apple, plum, banana, peach and pear.

Apples (page 14)

Point out to the children that all our cultivated apple trees have been grown and improved over hundreds of years, but their ancestors were wild apple trees like the crab apple tree shown in the picture on page 14.

There are more than 160 common varieties of apple tree. The most important dessert apples are Cox's Orange Pippin, Golden Delicious, Worcester Pearmain and Egremont Russet. The most important cooking apples are Bramley's Seedling, Grenadier and Lord Derby.

The main apple-growing areas in Britain for cooking and dessert apples are Kent, Worcestershire and Cambridgeshire. Here the rainfall is low and sunshine levels fairly high. Cider apples are grown mainly in the West Country. Many of our apples are now imported, notably from France (the Golden Delicious variety in particular), but also from Australia (the popular Granny Smith's), as well as from Canada and the United States.

Some other fruits (page 15)

The fruits shown in the picture are acorns, from an oak tree, sycamore fruits, hazel nuts, and 'conkers' from a horse chestnut tree.

Acorns and hazel nuts are usually dispersed by birds or mammals. A jay, squirrel or wood mouse, for example, may take one of these fruits and bury it for later consumption during the winter. If the fruit is not retrieved, the seed within it may grow.

Sycamore fruits are dispersed by the wind, their wings enabling them to float away from the parent tree in the manner of the rotor blades of a helicopter.

Horse chestnut fruits are blown from the tree by the wind. On hitting the ground the ripe fruit may burst open, shooting the conkers out. These may then be dispersed by mice and voles or even children.

Now try these

- 2 Some examples of poisonous fruits include deadly nightshade, black nightshade, woody nightshade, white bryony, black bryony, wild arum or cuckoo pint, guelder rose, holly, mistletoe, spindle berry and privet. Almost all poisonous fruits are eaten by birds, wild mammals, or both, with no apparent ill-effects.
- 3 Some of the different arrangements of seeds inside fruits are:

one seed

sloe
elderberry
hawthorn
plum
greengage
blackberry
raspberry
cherry
damson
date

stone around the seed

sloe
plum
greengage
cherry
damson
hawthorn
date

many seeds

apple
strawberry
rose hip
pear
gooseberry
orange
lemon
grapefruit

no stone around the seed

elderberry
apple
strawberry
blackberry
raspberry
rose hip
pear
gooseberry
orange
lemon
grapefruit

Technically a blackberry or raspberry 'fruit' is a cluster of tiny fruits, each containing a single seed.

- 4 Most fruits can in fact be dried, although not all the results are equally edible. Some of the more readily available dried fruits include:

Raisins – prepared from black grapes with seeds, in wine-growing countries such as the United States, Greece, Turkey, Spain, South Africa and Australia.

Sultanas – prepared from small seedless, yellow grapes, mostly in Turkey.

Currants – prepared from small black grapes, mainly in Greece.

Prunes – prepared by drying plums. The name comes from the French word *prune*, which means plum.

Figs – dried mainly in Turkey, Greece, Italy and Algeria.

Dates – dried mainly in Tunisia, Morocco and Israel.

Apricots – dried mainly in California, Israel and Tunisia.

Originally the only way to dry fruit was to spread it whole or cut in half on trays or rushes exposed to the sun. This method is still used in the countries around the Mediterranean, California and parts of South Africa and Australia. More and more, though, fruit is dried in special driers in which hot air is circulated by machinery. This method is quicker, more reliable and dries the fruit evenly.

- 5 Not all apple trees are the same shape because many are pruned to limit their growth. This encourages the tree to put its strength into the growth of fruits rather than in an abundance of leaves, twigs and branches. Some trees are allowed to grow to the normal ('standard') size and shape with a straight trunk, others are kept pruned short as bushes so that the fruit can be picked without the aid of a ladder: some trees are pruned into a fan-shape so that they will grow up a wall or fence and take up the minimum amount of space in a small garden, others are pruned to enable them to be trained along wires stretched between posts.

Expected results of activities and experiments

Plants from pips and stones (page 15)

Some fruit pips and stones are very slow to germinate, so great patience is called for with this activity. One reason for this slow germination is because the 'stone' takes weeks or even months to decay sufficiently for the root of the germinating seed to be able to penetrate. Gently cracking the stone first with a small hammer or nutcrackers, enables the root to emerge much quicker, as long as the embryo has not been damaged.

Tomatoes (page 15)

When growing tomato seeds, a higher success rate is achieved if seeds from over-ripe fruits are used. It is often possible to obtain over-ripe tomatoes free of charge from market stallholders or greengrocers.

Extending the learning

- 1 A more detailed description of the method of planting fruit pips and stones is:

Soak the seeds in cold water overnight.

Fill some small pots (yoghurt pots will do if drainage holes have been pierced in the bottom) with soil or compost. Water the soil or compost.

Make a hole with your finger or a blunt piece of wood and plant the seed. Put one seed in each pot. As a rough guide, plant the seed as deep as it is thick, so that a peach stone should go much deeper than an apple pip.

Cover each pot with a plastic bag. Use a rubber band to hold the bag in place.

Put the pots in a warm place. Keep them covered until the pips or stones start to grow. Then move them to a sunny windowsill.

Some other seeds worth trying are lemon or grapefruit pips, melon pips, unsalted and uncooked peanuts straight from their shells, and the seeds from inside pine cones which have been dried near a radiator or on a sunny windowsill.

- 2 It is also possible to grow acorns and conkers on the tops of bottles of water. Collect the fruits in the autumn, plant some right away and keep others until the spring to plant. Soak an acorn or a conker for 24 hours in water, and then simply rest it on the top of a narrow-necked bottle of water, so that the water just touches the bottom of the seed. When the young tree is growing well, transfer it to a pot of moist soil or compost.

Further experiments and activities with tree fruits and seeds are given in *The Young Scientist Investigates: Trees, and Seeds and Seedlings*, both by Terry Jennings (OUP).

Checking (pages 16–17)

Thinking

- 1 The children should realise by now that 'seed potatoes' is not an accurate term. The potatoes bought for planting, or for eating, are swollen underground stems, or tubers. Potato plants do bear flowers, and fruits which contain seeds, but these seeds are rarely sown.
- 2 The first part of a seedling to grow is always the root.
- 3 The depth at which seeds are planted does matter, although seeds planted upside down or sideways will

still grow. In general, seeds grow best if they are lightly covered with soil or compost. Seeds planted deeply may grow, but they use up most or all of their stored food in struggling to reach the surface.

- 4 Strictly speaking the banana grows on a plant, not a tree. New banana plants are grown from side shoots or suckers removed from the parent plant. Seedless orange trees are grown from cuttings or, more often, from small pieces of the parent plant grafted on to the root of a wild orange or lemon tree.
- 5 Inside the packet, seeds normally have a little air (although some modern packets are hermetically sealed), but in the absence of water they will not grow.
- 6 Rhubarb is a vegetable.
- 7 The seeds of a tomato plant, like those of many other brightly-coloured juicy fruits, can pass through the body of an animal unharmed, while the fleshy part of the fruit is digested. The tomato seeds which frequently grow at the sewage works, have passed through the bodies of the people who ate them, and then travelled in the faeces to the sewage works.
- 8 Most seeds are sown in the spring and summer, because the soil and air are warm then, and the days are long and sunny.
- 9 Plants need roots to anchor them in the soil and to take up water and mineral salts from the soil. Some plants, including parsnips, carrots, turnips and swedes, store food in their roots.
- 10 Those fruits which are brightly coloured and juicy are attractive to many mammals and birds. These eat the fleshy part of the fruit and either spit out the hard dry seeds or stones, or swallow them so that they pass out of their bodies in their faeces. In this way, the seeds are dispersed from the parent plant.

Doing

- 2 Moulds or fungi, relatives of mushrooms or toadstools, grow on the surface of the apple. Eventually they cause the apple to decay away.
- 3
 - i a cucumber, b apple, c runner bean and d tomato, are all fruits. Cabbages (e) are vegetables.
 - ii If a seed is to grow into a small healthy seedling it must have a air, c water and d light. As we can see with mustard or cress seeds, soil is not absolutely necessary until the seedling grows large enough to need support.
 - iii The correct order of the stages of a seed's germination is c.
- 4
 - a Most of the vegetables we eat are grown from *seeds*.
 - b Although potato plants have fruits and seeds, we grow most of them from *tubers*.
 - c When a seed starts to grow, it is said to *germinate*.
 - d A tuber is an underground *stem* which is swollen with stored food.
 - e For a seed to start to grow it needs air, warmth and *water*.
 - f A seedling grown in the dark is often *yellow* in colour.
 - g If a part of a plant contains seeds, it is a *fruit*.
 - h The *embryo* is the tiny plant inside a seed.

- i The *root* is the first part of a seedling to grow.
- j A *scar* shows where a seed was joined to the fruit or pod in which it grew.

Going further – some other suggestions

1 Make a study of a fruit tree

Some of the activities the children could carry out include:

Draw a fruit tree (such as an apple, pear or plum tree) in the winter when there are no leaves on it. Draw the tree again in summer when it has leaves. Press one of the leaves and stick it in a book, or use it as part of a display on the Science Table.

Measure or estimate the height of the tree.

Measure the girth or circumference of the trunk of the tree, using a tape measure or a piece of string and a ruler.

Measure the spread of the branches in each direction from the trunk.

Make a bark rubbing of the fruit tree.

Draw a winter twig of the tree.

In April, collect some of the fruit tree twigs and stand them in a jar of water on a sunny windowsill. How many leaves are there in each bud? How were the leaves protected while they were inside the bud? (by bud scales).

Draw the flowers and fruit of the tree.

Try to grow some of the seeds.

What mammals, birds and insects visit the fruit tree?

2 Investigate which tree fruits and seeds birds like best. (See page 30 of The Young Scientist Investigates: *Trees*.)

3 Investigate fruit and seed travellers. (See page 29 of The Young Scientist Investigates: *Seeds and Seedlings*.)

4 Investigate the effect of light on cress seeds. (See page 30 of The Young Scientist Investigates: *Seeds and Seedlings*.)

Interdisciplinary activities

Art and craft

Dyeing, using fruits, roots and leaves.

Making necklaces and bracelets with pips and seeds.

Potato printing

Collages with seeds and dried fruits.

'Still life' compositions.

Corn dollies.

Make model birds and mammals from acorns, conkers and other fruits and seeds.

Making patterns with pictures of sections of fruits and vegetables.

English

Robinson Crusoe by Daniel Defoe.

Oxford Junior English Book 2: *Food and Farms* by Oliver Gregory (OUP).

Geography

The world our larder – where our food comes from.

Mediterranean and tropical fruit farming.

Climate and food production.

Wholesale fruit and vegetable markets.

Nomadic and food-gathering tribes of the world.

Coffee and cocoa farming.

The apple growing regions of Britain and France.

Grapes and wine production in Britain and Europe.

Health and hygiene

- Recipes and menus which include fruits and vegetables.
- The hygienic preparation of fruits and vegetables.
- Vitamin C and mineral salts in the diet.
- The importance of fibre in the diet.

History

- Nomads and hunters.
- The Spice Voyages.
- The discovery of 'new' foods – coffee, cocoa, tea etc.
- Sir Walter Raleigh and potatoes.
- The Irish potato famine.

Mathematics

- Measures and measuring.
- Temperatures and timing in the growth of seeds.
- Recording growth.
- Weighing very light objects such as seeds (weigh perhaps twenty and then find the average weight of one).
- Graphs of favourite fruits and vegetables.
- A comparison of the surface areas and perimeters of different leaves.

Music, drama and PE

Use seeds to make musical instruments (see the Young Scientist Investigates: *Seeds and Seedlings*, and *Sounds*).

Religious education and social studies

- Hunger in the world today.
- The Parable of the Sower.
- Food in the Bible lands.
- Christmas berries – holly, ivy and mistletoe.

Unit 3: Living things depend upon each other

Aims of the Unit

- To demonstrate that all living things depend on one another and affect each other's lives.
- To show that most living things become food for others.

Science background

All living things are interdependent. The basic reason for this is that the only living things which are able to make their own food are green plants. These use the energy of sunlight to combine carbon dioxide gas from the air with water to make food products such as sugar and starch, in the process known as photosynthesis. These substances, which are rich in energy, travel from the leaves and are used to help in the growth of other parts of the plant. Oxygen, which all living things need to breathe, is produced as a waste product of photosynthesis.

Animals, and plants which do not have the green substance chlorophyll, including mushrooms, toadstools and other fungi, are not able to make their own food. For this reason they are often called consumers, whereas green plants are known as producers. The consumers have to rely on living green plants, or their dead and decaying remains, for their food and energy. This is the scientific basis for the biblical saying that 'all flesh is grass.'

All living things are linked together because every living thing depends upon another for food. The animals which feed directly on green plants are called *herbivores*. The

herbivores, in turn, are food for predators, or *carnivores*, which may themselves be eaten by other, larger carnivores. These food links between organisms are known as food chains. Some common food chains are:

Grass→Sheep→Human
Alga→Shrimp→Herring→Cod→Human
Grass→Vole→Weasel
Lettuce→Snail→Thrush→Hawk
Carrot→Rabbit→Fox

In reality, the food chain is an over-simplification. This is because, for example, if we consider the two food chains above beginning with grass, it will be obvious that there are many other organisms which eat grass besides sheep and voles. In fact, in a grassy field, or some other plant community, there are many interlocking food chains. The complicated relationship so produced is known as a food web. However, for children of this age group, it is sufficient that they should understand food chains.

As we move along a food chain, the animals generally become larger and fewer in number, as less and less energy from the plant producers is available to them. And with living things dependent upon each other for food, energy and oxygen, it is perhaps not surprising that relatively small changes in the numbers of individuals of one species, can produce a whole chain-reaction of effects throughout a living community.

Books for the children

Conservation Today by Terry Jennings (Kaye and Ward)
Nature in Close-Up: Food Chains by Jan Ethelberg (A. and C. Black)
Science in a Topic: Food by Doug Kincaid and Peter S. Coles (Hulton)
The Young Scientist Investigates: Food by Terry Jennings (OUP)
The Young Scientist Investigates: Flowers by Terry Jennings (OUP)

Books for the teacher

Science 5/13: Using the Environment: 3 Tackling Problems (Macdonald Educational)

Materials and organisation

The teaching of this topic would be greatly enhanced by a visit to a farm, zoo, wildlife park or natural history museum. Such a visit could very well provide an introduction to the topic or be used to reinforce the learning when the topic is completed.

Materials and equipment:-

- pictures of plants, herbivores and carnivores
- large sheets of card
- large jars or plastic food containers
- muslin or old tights
- rubber bands
- small bottles
- cotton wool
- rose shoots bearing aphids (greenfly)
- ladybirds

You and grass (pages 18–19)

Lesson objectives

To show how living things depend upon each other, and affect each other.

Setting the scene

One approach is to write the words 'depend' and 'dependent' on the blackboard, and to ask the class what these words mean. The children could then be asked to give examples of people at home or in school they depend upon. This could lead on to a consideration of the people (or pets) that depend upon the children.

New words

Depend – to rely upon.

Class management

All of the work on these two pages can be done by the children sitting at their desks.

Safety precautions

None

Answers to questions in the text

You and grass (page 18)

The picture shows a falcon, a deer, a lion, a cow, a rabbit and a cat. Of these animals, the falcon, lion and cat are carnivores. However, the deer, cow and rabbit are herbivores and might eat grass.

The products in the picture which come, directly or indirectly, from cows are milk, butter, yoghurt, beef, cream and leather. Eggs, bread, potato chips and rubber have nothing to do with cows.

The coloured photograph shows a neglected field in which buttercups and daisies are flowering profusely. These plants have a bitter taste and cows will not eat them, which account for their abundance in the field

Our daily food (page 19)

The foods in the picture are:

Spaghetti – produced from wheat flour (a plant)

Beefburger and roll – the beef comes from cows and the roll is made from wheat flour (animal and plant)

Fish fingers – processed pieces of fish in breadcrumbs (animal and plant)

Potato crisps – processed potato slices (a plant)

Tea – from the dried leaves of the tea plant. If milk is added, that comes from a cow (an animal), while if sugar is added that comes from sugar cane or sugar beet plants.

Now try these

- 2 a Cow – an animal which produces meat, milk and leather.
- b Wheat – a plant which produces grains from which breakfast cereals, flour and food for farm animals are made. Its straw can be used for animal bedding, thatching, making cardboard and as a fuel.

- c Chicken – an animal which produces meat and eggs.
 - d Mushroom – a kind of plant called a fungus, used as a food.
 - e Apple tree – a plant which provides fruit we can eat.
 - f Shrimp – an invertebrate animal which, together with its close relative the prawn, is eaten by humans.
 - g Pine tree – a plant whose trunk provides us with timber, fuel, and wood pulp from which paper and artificial silk (rayon) can be made.
 - h Cat – an animal kept as a domestic pet.
 - i Dog – an animal kept as a domestic pet but which is also used for police and guard work, tracking, finding drugs, explosives and missing people, driving sheep and cattle, leading the blind, helping the deaf, hunting etc.
 - j Honey bee – an invertebrate animal from which we obtain honey and beeswax.
- 3 Common sayings and expressions which mention bread and dough include:
- 'I haven't got enough dough to be able to afford that!'
- 'He earns a lot of bread.'
- 'She knows which side her bread is buttered.'
- 'Use your loaf!'
- 'Oh crumbs!'
- 'I'm the breadwinner.'
- 'You want jam on it!'
- 'He would take the bread out of your mouth if he could.'
- 'You want your bread buttered on both sides!'
- 'They are living on the breadline.'

- 4 During most of the Stone Age, people had to follow herds of wild animals and birds to hunt for meat. They also gathered fruits and seeds for food, and collected oysters, mussels and fishes. During the New Stone Age people learned how to grow crops and tame and use animals. They started to live together in settlements of several families, although they still needed to hunt for some of their meat and fish.

The main foods for most ordinary Roman people were bread and porridge made from wheat flour. Vegetables, olives, herbs and other flavourings were added to the porridge to improve its taste. Wheat pancake biscuits, with dates, honey or olives were another favourite food, and so were fruit, eggs and cheese. Very little meat was eaten. By contrast, wealthy Romans ate a much more varied diet which included considerable quantities of meat, such as roast venison, boiled ostrich, ham, flamingo and even dormice. Fruits of all kinds, pastries and cakes were eaten in large quantities, and much wine was drunk.

The word 'Viking' is often used to describe those people who sailed, raided and traded in ships from Sweden, Denmark and Norway. Life was hard in those countries and few crops could be grown in the poor soil. The people lived largely on seal meat, shellfish, birds' eggs, fish, and cakes and bread made from oatmeal.

The poorer people in Shakespeare's time had very little choice of food. They probably ate porridge, black bread, butter and cheese or eggs and ham washed down with ale. Again little meat was eaten, although vegetables such as parsnips, turnips and cabbage formed quite a large part of the diet. The nobility ate white bread and large quantities of meat and poultry

including beef, veal, mutton, rabbit, chicken, cygnets, quail and gulls, together with fish such as soles, conger eels, flounders, ling and bream.

- 5 If a disease destroyed all the grasses in this country, there would be no food for sheep, cattle, poultry and other domestic animals and, none of the human foods made from cereals and flour. Soil erosion would occur on most hills, mountains and sloping land. There would be widespread famine, and it is doubtful whether civilisation as we know it could continue.

Extending the learning

- 1 Discuss with the children how bees in a hive depend upon each other, and how they depend upon their human owner. (The queen bee lays eggs. A male or drone bee mates with the queen, so that the queen can begin her egg-laying life. The worker bees gather pollen and nectar, build the honeycomb, care for and feed the young or larvae, protect the hive and keep it clean. The bee-keeper keeps the hive in good repair, sites it in a position where the bees can find flowers, and feeds the bees in winter when pollen and nectar are scarce. In return, he takes supplies of honey from the bees.)
The children could then be asked what would happen if any of the individuals or groups of individuals – queen bee, drone bee, worker bees or bee-keeper, stopped doing their work.
- 2 Collect pictures of as many different foods as possible. Encourage the children to make sets of the pictures. They might, for example, divide the pictures up into those which come from plants and those which come from animals. Other sets could be foods grown or produced in this country and those which come from other countries, or fresh foods, packaged foods, frozen foods, dried foods and canned foods.
- 3 Many other activities and experiments concerned with human food are given in *The Young Scientist Investigates: Food* by Terry Jennings (OUP).

Food and feeding (pages 20–21)

Lesson objectives

- a To demonstrate that most living things become food for others.
- b To establish that what happens to one organism may affect many other organisms.
- c To show that all living things depend upon the oxygen plants produce in sunlight.

Setting the scene

In the previous lesson, we have already established that all of our food comes directly or indirectly from plants. Before reading the next section, the children could be asked to list their favourite foods, and then to decide which plants these foods came from originally.

New words

Chlorophyll – the green substance which gives plants their colouring, and with which they trap sunlight and use it to help to make their food.

Mineral salts – the chemical substances which plants obtain from the soil and use as food.

Carbon dioxide – one of the gases of the air. Green plants use carbon dioxide to help make their food. Fizzy drinks also contain carbon dioxide.

Oxygen – the gas in the air which all plants and animals need. Oxygen goes into our blood from our lungs when we breathe in, and is used to help make our food give us energy. It is also needed when something burns.

Herbivores – animals which feed mainly on plant material.

Carnivores – flesh-eating animals, or predators.

Class management

All of the work on this topic can be done by the children sitting at their desks.

Safety precautions

None.

Answers to questions in the text

Food and feeding

The leaves in the picture (page 20) all come from trees, although they are reduced in size. They are: ash, oak, horse chestnut, copper beech (centre), sycamore, elm and holly. The children will notice that all the leaves are green except that of copper beech. However, even copper beech leaves contain the green pigment chlorophyll, although this is mixed with a darker, reddish-brown pigment.

Of the animals shown in the picture (page 21), the elephant, horse, giraffe and snail are herbivores, whereas the wolf, tiger, spider and otter are carnivores. A fully-grown elephant is unlikely to be eaten by other animals (except possibly by humans) because of its large size. It is unlikely that any animal would also eat a fully-grown wolf or tiger. All of the other animals might be eaten by large carnivores, including the giraffe and horse, both of which are sometimes eaten by lions in Africa.

What does light do to grass? (page 21)

The grass under the brick in the picture has turned yellow. This is because the green pigment, chlorophyll, is formed only in sunlight. If the brick was not put back on the grass, after a few days the grass would turn green again as new chlorophyll was formed.

Now try these

- 1 Plants and animals have the following major differences, and so a scientist could see which of these features were possessed by his new living thing:

	<i>Plants</i>	<i>Animals</i>
Movement	Plants move by growing.	Most animals can move from place to place using legs, wings or fins, or by wriggling.
Sensitivity	Plants do not have sense organs although many respond to light, water and gravity.	Many animals have sense organs such as eyes and ears to find out about their surroundings.

Feeding	Plants make their own food using the energy of sunlight, carbon dioxide gas and water.	Animals get their food by eating living or once-living things.
Growth	Most plants grow continuously throughout their lives.	Animals grow until they reach a certain adult size.

- The difference in weight between that of newly-sown wheat seeds and the large amounts of new wheat seeds and straw present at harvest time, comes from the food material the wheat plants have made for themselves using sunlight energy, carbon dioxide gas and water, and mineral salts from the soil.
- Rabbits live in underground burrow systems, called warrens, in hedgebanks, woods, heaths, grassland and other open country. The main enemies of rabbits are people, foxes, badgers, weasels, stoats, buzzards and the disease called myxomatosis. Rabbits have some protection from their enemies in their camouflage coloration, ability to run fast, excellent sense organs and the protection of their burrows.
- The largest and heaviest animal in the world is the blue whale, which feeds almost entirely on small shrimp-like animals called krill.

The largest living land carnivore is the Kodiak bear of North America. The largest British land carnivore is the badger.

The largest living land animal is the African elephant, a herbivore, while the largest British wild herbivore is the red deer.

Carnivores are sometimes smaller than the herbivores they feed on, since they have to be able to both run fast and to conceal themselves in order to catch their prey. In addition some carnivores, such as lions, wolves and hunting dogs, hunt in groups to catch and kill larger prey.

- Some common breeds of cattle are:
Beef cattle: Aberdeen Angus, Sussex, Beef Shorthorn, Charolais, Galloway, Hereford, Lincoln Red, Highland and Devon.
Dairy cattle: Ayrshire, Dairy Shorthorn, Friesian, Guernsey, Jersey and Kerry.
Dual purpose cattle (kept for both milk and beef): Belted Galloway, Dexter, South Devon, Simmental, Red Poll and Welsh Black.

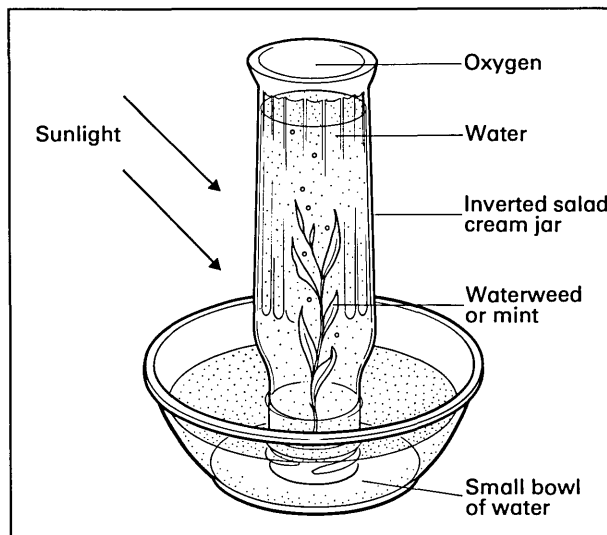
In winter cattle are fed on straw, hay, turnips, mangolds, kale and cabbage. Grass and other greenstuffs are fed to them in the preserved form called silage. They may also be given barley, oats and special food mixtures from oil seeds which, after the oil has been extracted, are still rich in protein, or crushed cereals, fish meal, soya meal and other dried foods.

- Carnivores have pointed teeth for gripping, killing and tearing up their prey. Herbivores have sharp front teeth for cutting off the plants they feed on, and flat-topped or ridged back teeth for grinding up the plant material. Herbivores do not have the fangs or dog-teeth called canines.

Extending the learning

- The oxygen given off by green plants in sunlight can be

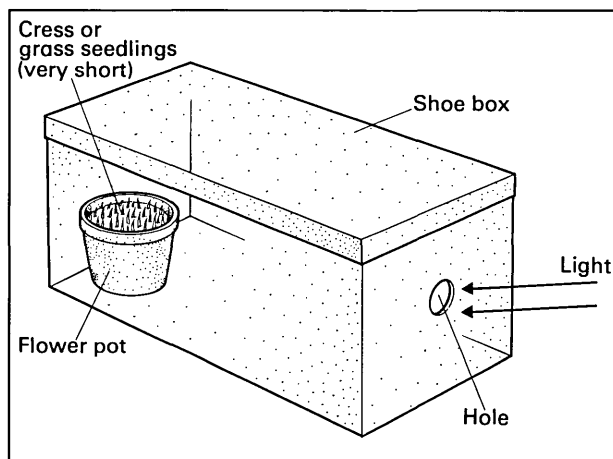
demonstrated if a piece of waterweed or a sprig of garden mint is put in a clean salad cream jar completely filled with water. The salad cream jar is then inverted in a bowl of water, and the whole apparatus is stood on a sunny windowsill or near to a desk lamp. Bubbles of oxygen will be seen coming from the plant, and these collect at the top (really the bottom) of the salad cream jar.



2 How do plants behave towards light?

What you need: A small flower pot; some soil or compost; some cress or grass seeds; a shoe box; scissors.

What you do: Put some moist soil or compost in the pot. Sprinkle cress or grass seeds on top of the soil or compost.



As soon as the seeds start to grow, put the pot at one end of the box. Make a small hole, the size of a 2p coin, in the middle of the other end of the box. Put on the lid.

Stand the box so that the hole faces a window. Water the seedlings if the soil begins to dry out, but do not move the pot or box. Always put the lid back on the box.

What happens to the seedlings? Why is this?
 (Expected results: All green plants need light if they are to make their food, and if the light is coming from one direction, they will grow towards it. This is what happens in this experiment, where the seedlings bend towards the light as they grow.)

How much food does a herbivore eat?

Slugs and snails are herbivores which are easy to keep and feed. In this experiment we are going to find out how much food a slug or snail eats.

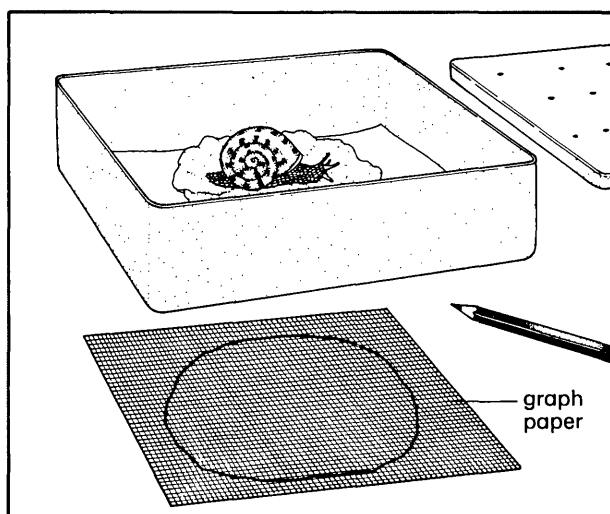
What you need: A lettuce or cabbage leaf; a pair of scissors; a large slug or snail; a pencil and squared paper; some paper towels or blotting paper; a cardboard or plastic box with holes in the lid; a large jar with holes in the lid.

What you do: Put a slug or snail in a jar with moist blotting paper or paper towels for 24 hours. Do not give it any food.

Use scissors to cut a square of lettuce or cabbage leaf. Carefully draw round the piece of leaf on the squared paper.

Line the box with moist paper towels or blotting paper. Lay the piece of cabbage or lettuce leaf in the box.

Put the slug or snail in the box. Leave the box, with the lid on, in a warm (but not hot) place for 24 hours.



Look at the leaf again. Compare the new leaf shape outline with the old one. Mark how much the slug or snail has eaten. Count the number of squares it has eaten.

If the slug or snail kept eating, how long would it take to eat the whole leaf?

Try this experiment with slugs and snails and other leaves. When you have finished the experiment, return the animals to where you found them.

(It is not possible to predict the exact results of this experiment. It depends upon the species of slug or snail used, since they have individual food preferences – another subject for investigation! Besides lettuce and cabbage leaves, good ones to try are dandelion, celery, stinging nettle and deadnettle leaves. Most species of slug and snail are also fond of carrot root cut into thin discs.)

- 3 Further activities and experiments are described in The Young Scientist Investigates: *Food*.

The hunters (pages 22–23)

Lesson objectives

- To examine the adaptations to their way of life of some carnivores.
- To develop the concept of a food chain.

Setting the scene

One approach is to discuss with the children what equipment and special abilities they would need if they were stranded on a desert island and had to hunt for their food. Their answers might include: weapons of some kind, such as a spear or bow and arrow, the ability to move quietly, camouflage or some other form of concealment, and well-developed sight, hearing and other senses. The class could then read on to find out how some carnivores are adapted to catching and killing their prey.

New words

Food chain – a series of animals and plants linked together by their food and what eats them. Food chains always start with plants.

Class management

All of the work on this topic can be carried out by the children while sitting at their desks.

Safety precautions

None.

Answers to questions in the text

The hunters (page 22)

Some other British carnivores the children might choose to draw and write about include the badger, stoat, weasel, otter, polecat, mink, wild cat, grey seal, common seal, killer whale, golden eagle, owls, osprey and kestrel.

Food chains (pages 22, 23)

Some food chains which end with a peregrine falcon, a fox and a pike include:

wheat→pigeon→peregrine falcon
wheat→chicken→fox
grass→vole→fox
cabbage→rabbit→fox
pond weed→water snail→perch→pike
pond weed→mayfly larva→trout→pike

As you go along most food chains, the size of the animals increases. Exceptions are where a lithe, fast-moving carnivore preys on slower-moving animals, such as when a weasel preys on a rabbit, or where several carnivores join together to kill a larger herbivore, as when wolves prey on caribou or lions prey on wildebeest and giraffe.

A few food chains which begin with grass are:

grass→slug→thrush→hawk
grass→sheep→human
grass→cow→human
grass→rabbit→fox

Three food chains which begin with a lettuce plant are:

lettuce→human
lettuce→slug→blackbird→cat
lettuce→snail→hedgehog→fox

Now try these

- Carnivores need keen eyesight and a good sense of smell to be able to detect their prey from a distance.
- Badgers feed on young rabbits, mice, rats, voles, moles,

hedgehogs, frogs, toads, slugs, snails, earthworms, wasp grubs, beetles and other large insects. They will also eat fruits of all kinds once these have fallen to the ground. As far as their food is concerned, on balance badgers are probably beneficial. They do, however, occasionally trample growing crops and they have also been accused of spreading the disease tuberculosis (of which they are often carriers) to cattle.

- 3 Strictly speaking, a 'carnivore' is a flesh-eating mammal, although usually the term is applied to any animal which preys on other animals. Well-known carnivores include lions, tigers, hyenas, cheetahs, bears, foxes, jaguars, stoats, weasels, wolves, otters, and wild and domesticated cats and dogs. Carnivores that live in the sea include seals, sea-lions and walruses.
- 4 A parasite is a plant or animal which lives on another plant or animal from which it gets its nourishment. Many parasitic plants are fungi, and so are related to mushrooms and toadstools. The rusts, mildews and blights are fungal parasites that live on ordinary green plants. Ringworm, a disease of the skin in humans and other mammals, is caused by a parasitic fungus. Mistletoe is partially parasitic on the trees on which it grows – it makes some of its own food. Among the single-celled parasites are the bacteria ('germs') which cause disease.

Some parasitic animals live on the outside of their animal hosts, including fleas, lice and ticks, all of which feed by sucking blood. The tapeworm, roundworm and threadworm are parasitic animals which live inside humans and other animals.

Extending the learning

- 1 The peregrine falcon, like many other predatory birds and mammals, has seriously declined in numbers over recent years. The children could investigate why so many of our carnivores are in danger of extinction. The main reasons are: disturbance and loss of habitat; the direct or indirect effects of pesticides and other farm chemicals; killing by gamekeepers, sheep farmers, and others; and the theft of birds of prey for use in falconry.

2 Keeping spiders

Spiders are carnivores. They feed on flies and other small insects. They will also eat each other, and so should be housed individually.

Almost any large container can be used to house a spider – aquaria, sweet jars, plastic food containers, and large tins or shoe boxes fitted with glass, polythene or cling-film tops. There should be plenty of small holes to allow air into the container.

Put a thin layer of soil or sand in the bottom of the container, together with a shallow dish or tin lid of water. Several branching twigs will provide a foundation for the webs, while a scroll of paper or a partly opened matchbox will serve as a shelter for the spider. Feed the spider on live flies.

Encourage the children to answer these questions about their spiders:

Does the spider make a web? Which part of the web does it make first? Is the web sticky? Is it sticky all over? Ask the children to draw a picture of the web.

Does the spider go towards a fly as soon as it touches the web? How does the spider bite? Can the children see its jaws eating? Does the spider eat all of an insect?

If not which parts does it leave?

After a few weeks let the spiders go where they were caught.

Checking (pages 24–25)

Thinking

- 1 There are too many human food chains to be able to list them here, but we can summarise them thus:

Plant material → herbivore → human
(provides us with meat, milk, eggs or fish)

Plant material → human
(fruit, vegetables or cereals)

There are few examples of food chains where we eat carnivores. One is:

Algae → small water → trout → human animals

- 2 The urine and dung of animals help to provide plant foods. By eating some kinds of plants, herbivores provide space for other plants to grow. In addition, animals help to disperse the seeds of plants.
- 3 Some chemicals used as weed killers or pesticides accumulate in plant tissues. If the plants are eaten by herbivores, the chemicals accumulate in a greater concentration there (since one herbivore eats many plants). If the affected herbivores are eaten by carnivores, they too will accumulate the poison in large, and possibly fatal, concentrations. In this way some or all of the food chain will be affected. The chemical pesticides found in the bodies of birds and mammals in the Antarctic (where these chemicals have never been used) probably arrived there by passing along food chains. There is also the obvious danger to humans of eating plants or animals contaminated by chemical pesticides.
- 4 If all the carnivores in an area were killed, the herbivores would increase in number. They would probably destroy all the plant foods in the area, and eventually starve. This happened in northern Arizona at the beginning of this century, when hunters killed all the wolves and cougars that preyed on the deer. The numbers of deer increased dramatically, and they ate all the plant life, causing widespread soil erosion. Eventually most of the deer starved to death.
- 5
 - a Plants provide us with our fruit and vegetables, and all the foods derived from cereals such as wheat, oats, barley, maize and rice.
 - b We obtain cotton clothes from the fruit of the cotton plant, linen from the flax plant and artificial silk or rayon from wood pulp. Natural silk comes from silk worms, which feed on the leaves of the mulberry tree. Wool is obtained from sheep, which feed on grass and other plants. Leather is made from the hides of cattle and other animals that feed on plants.
 - c Wood is an important fuel. Charcoal, which is also sometimes used as a fuel, is made from wood. Coal and peat are the fossilised remains of plants. Oil and

natural gas are the fossilised remains of minute sea plants and animals.

- d Chemicals and medicines obtained from plants generally have only scientific names. Some of the better-known ones include morphine, the pain-killer, from poppies; digitalin a heart drug from foxgloves; quinine, used in the treatment of malaria, from the bark of the cinchona tree; while some iodine is prepared from brown seaweeds. And of course, both coal and oil contain many chemicals which came originally from plants.
 - e Much furniture is still made from wood.
 - f Wood is also used in the construction of houses and homes. Some roofs are thatched using straw or reeds. Plants are used to decorate the interiors and exteriors of homes.
- 6 Many animals depend upon plants for shelter, nest sites and nesting material. This is particularly true of birds and mammals and of insects such as bees and wasps. Many insects also use plants to camouflage themselves.
 - 7 Trees are often planted by the sides of streets in towns a) to look attractive, and b) to help to purify the air by removing carbon dioxide and replacing it with vital oxygen.
 - 8 Larger omnivores include pigs, brown and black bears, badgers and baboons. Many herbivores, including wood mice and bank voles, eat small amounts of animal material, and many carnivores including cats, dogs and foxes, eat some plant material.

Doing

- 2 There are many ways of completing the table correctly. One way is:

Lion	Eagle	Shark	Fox	Spider	Otter
Antelope	Rabbit	Herring	Vole	Housefly	Trout
Grass	Lettuce	Shrimp	Grass	Sugar	Water
		Algae		(from	snail
				sugar cane	Water
				or sugar	plants
				beet	
				plants)	

- 3
 - 1 A cabbage (c) can make its own food, the chicken and pike cannot.
 - 2 A cow (b) cannot make its own food, grass and wheat can.
 - 3 The example which does not show the correct order for a food chain is:
b chicken→wheat→cow
 - 4 Deer (a), rabbit (c) and sheep (e) are herbivores.
 - 5 A wolf (c), otter (d) and lion (e) are carnivores.
- 4
 - a Animals and plants living near each other usually *depend* on each other.
 - b Green plants use the sun's *energy* to help make their food.
 - c The green substance in plants is called *chlorophyll*.
 - d All animals depend on plants directly or indirectly for their *food*.
 - e An animal which eats plants is called a *herbivore*.

- f A *carnivore* is an animal which eats other animals.
- g Most food chains begin with *green plants*.
- h Green plants help to replace the *oxygen* in the air.

Going further

Studying a food chain

All aphids have sharp mouth-parts that are used to pierce the outer layers of the plant, and the juices are then sucked up.

A ladybird seizes an aphid in its jaws to catch it and eat it. Usually the juices are sucked from the aphid's body, and its skin is left.

Ladybird larvae also feed on aphids, and a fully-grown larva may eat 50 aphids in a day.

The food chain demonstrated by this experiment is:

Rose bush→aphid→ladybird

Going further – some other suggestions

- 1 Another convenient method for investigating food chains is to set up an aquarium in the classroom containing plant life, herbivores and carnivores. A study of this would also act as an introduction to the next Unit.
- 2 Cut out pictures of plants, insects, birds, mammals and other animals. Mount them in a collage to show a food chain.
- 3 The food chain experiment described on page 25 can be repeated with the larvae of ladybirds and hoverflies, and the larvae and adults of lacewings. All these creatures can be found on aphid-infested rose bushes during the summer months. The notion of the biological control of pests and diseases (using the natural enemies of pests and diseases to control them) could be introduced and compared and contrasted with the chemical methods of control, based on pesticides, which are commonly used nowadays.

Interdisciplinary activities

Art and craft

Dyeing using fruits, roots and leaves.

English

Food in the time of Chaucer and Shakespeare.

Robinson Crusoe by Daniel Defoe.

Comic and curious foods by Edward Lear, Hilaire Belloc et al.

Oxford Junior English: 2 *Food and Farms* by Oliver Gregory (OUP).

Geography

The Common Market.

Climate and food production.

Supermarkets and shops.

Poultry and dairy farming.

Health and hygiene

The hygienic preparation and handling of food.

A balanced diet.

Animal products as sources of protein foods.

History

Nomads and hunters.

The manor and three-field system of farming.

New ways of farming – the agrarian revolution.

The potato famine in Ireland.

Wartime rationing of food.

Mathematics

- Shopping around for food; value for money.
- Shops, shopping and surveys.
- The speed and acceleration of some carnivores.

Music, drama and PE

The traditional song 'On Ilkley Moor 'Baht 'At' as an example of a food chain.

Hunting songs.

Religious education and social studies

- Hunger in the world today.
- Harvest thanksgiving.
- 'Our Daily Bread'.
- Five loaves and two fishes.
- Parable of the sower.
- Feast of the Passover.
- Foods of Muslims, Hindus and Buddhists.
- Vegetarianism, hunting for sport, factory farming and animals for research.

not static, it is changing all the time. The animal life is similarly adapted to living in the different zones of a pond.

Books for the children

- The Young Scientist Investigates: *Pond Life* by Terry Jennings (OUP)
- Pond Animals* by Irene Finch (Longmans)
- Nature Trail Book: *Ponds and Streams* by Su Swallow (Usborne)

Books for the teacher

- The Family Water Naturalist* by Heather Angel and Pat Wolseley (Michael Joseph)
- Science 5/13: *Minibeasts* (Macdonald Educational)
- Science 5/13: *Using the Environment: 3 Tackling Problems Part 2* (Macdonald Educational)
- Science 5/13: *Using the Environment: 4 Ways and Means* (Macdonald Educational)

Unit 4: Pond life

Aims of the Unit

- To show that a pond is an example of a community of living things.
- To show that a pond community is made up of animals and plants that are adapted to life in and near fresh water.

Science background

The plants and animals that live together in a certain place make up a *community*. The plants and animals in a community are dependent upon each other and on their environment.

In a pond community, the example of a community chosen for this Unit, many small invertebrate animals live on the plants which grow in and around the pond. These herbivores in turn are food for the carnivores. At the same time, the green plants in and around the pond produce oxygen, some of which enters the air, while some remains dissolved in the water. Animals, as well as plants, use this oxygen when they breathe.

Whatever community they live in, most living things have the same basic needs: food, water, oxygen and protection. Plants and animals are adapted to meet these needs. The plants and animals living in a pond have no shortage of water; in fact they are adapted to life in an abundance of this substance. The plants growing in and around a pond, for instance, are not indiscriminately placed, but are arranged in distinct zones. This zoning reflects the plants' degree of adaptation to an aquatic life.

The first plants to colonise a new pond are the totally submerged water plants. As the pond silts up, then plants such as water lilies which have floating leaves can grow. Eventually more silting makes way for tall emergent plants such as reeds, bulrushes and yellow flag irises. As these die, they raise the level of the mud still further. After many years of silting and plant growth, a swamp is left where there was once open water. In time this could become scrub and woodland, as the site of the former pond dries out. Thus a pond community, like all communities, is

Materials and organisation

A pond and its occupants are a continuous source of interest to children. If there is not a pond, lake or some other stretch of still water to which the children can make regular visits, it may be possible to construct a small pool in the school grounds. Details of one such pool are given in the Science 5/13 publication *Using the Environment: 4 Ways and Means*.

If you are going to include visits to a pond, lake or ditch in the work for this topic, it is essential to make a preliminary visit, without the children, to check for possible problems of safety and to get to know some of the species to be found there.

It is not essential that plants and animals be identified, but it makes it much easier to talk about them and to find out more about them from books. In addition, children enjoy learning new names. If a species is found which it is not possible to identify, or which has only a scientific (Latin) name, the children will enjoy inventing names of their own for the organism.

Materials and equipment:-

- jam-jars
- small sewing needles
- tissue paper
- hand lenses
- drinking glasses
- coins
- nets
- pie dishes
- white plastic trays
- aquaria, washing-up bowls or large sandwich boxes
- thermometers
- access to a refrigerator
- pond plants and animals

The pond community (pages 26–27)

Lesson objectives

- To demonstrate that a community is a group of organisms that live together and interact with each other and with their surroundings.
- To describe the adaptations of pond plants to their life in water.

Setting the scene

There are many possible starting points, including:

- 1 A preliminary visit to a pond, lake or ditch.
- 2 A film or television programme showing pond life.
- 3 A well-stocked aquarium set up in the classroom.
- 4 Compile on the blackboard, with the children's help, a list of all the animals and plants they know of which live in or around ponds. When a substantial list has been produced, you could point out that a pond must be a busy place to have so many different plants and animals living in it.

New words

Community – a group of plants and animals that live together in one place.

Class management

If a visit is made to a pond, lake or ditch, careful briefing, and adequate supervision, with one adult to every 10 or 12 children, will be necessary. It is suggested that if more than one visit can be made, the first should be spent examining the environs of the pond or lake, preparing a sketch-map of it, and if there are water birds present, studying these.

If paddling is to be allowed, it is advisable to take at least one towel for the benefit of the child who inevitably falls over. A first-aid kit is also necessary.

Safety precautions

It will be necessary to warn the children to take care while standing on the edges of the pond, lake or ditch, and to beware of broken glass if they are allowed into the water.

Answers to questions in the text

The pond community (page 26)

The picture shows:

- a drake mallard alighting
- a coot on its nest
- a moorhen
- a swallow drinking
- a water vole feeding
- two water shrews
- a frog and a newt

The plants in the picture include water crowfoot, reeds, water milfoil, yellow water lily, duckweed, Canadian pondweed and common reedmace.

Water plants (pages 26, 27)

The leaves of floating plants are rounded and relatively large, and they have extra long leaf stalks, so that the leaves remain floating whether the water level rises or falls.

Now try these

- 1 Basically a garden weed is a land plant growing where it is not wanted. A pond weed is a plant adapted to growing in or under water. Garden weeds are able to produce large numbers of seeds, or to spread rapidly by other means. Most pond weeds spread much more slowly. Pond weeds are eaten by large numbers of water animals. Garden weeds are eaten by few animals, which

partly accounts for their success as colonists.

- 3 Many kinds of water plants can grow in a pond because the water is still and there is often deep mud at the bottom in which some of the plants can root themselves. A fast-flowing stream generally has a bottom of shingle, pebbles or rock in which few plants can root themselves. If any seeds of water plants do succeed in germinating in a fast-flowing stream, the seedlings are usually soon swept away by the current.
- 4 The stale water from a vase in which cut flowers have been kept will often turn green in sunlight because of algae, and can also be used for this activity.
- 5 The water lily produces large seeds which have a spongy coating around them. When the seeds are ripe, they break off the parent plant and float away. They may settle somewhere suitable and there grow and produce new plants.

Extending the learning

- 1 Break off small shoots of water plants, submerge them in jars of pond water, and see if they grow roots. (cf. the growing of cuttings of land plants described on page 13 of Course Book 1)
- 2 The production of oxygen by green plants in sunlight can be demonstrated using the apparatus described on page 25 of this book. If the day is not sunny, put a desk lamp close to the apparatus.
- 3 A number of other experiments and activities concerned with water plants are detailed in *The Young Scientist Investigates: Pond Life* by Terry Jennings (OUP).

Pond animals (pages 28–29)

Lesson objectives

- a To describe some of the common animals that live in or near a pond, and to examine their feeding habits.
- b To describe the adaptations of some pond animals to a life in water.

Setting the scene

One introduction, before the children read this section in Course Book 1, is to discuss with them how the water in a pond protects the animals from being eaten. They may realise how the water acts as a barrier between water animals and the carnivores on land. In addition, the muddy water and dense growth of plants hide the animals and provide privacy and quiet where they can breed.

New words

Camouflaged – an animal whose colour makes it hard to see because it matches its surroundings is said to be camouflaged. Soldiers, army lorries, tanks and guns, and some military aircraft, are also often camouflaged.

Class management

It is suggested that the children take it in turns to carry out the activities concerned with the surface 'skin' of water, while the class as a whole works its way through the text.

Safety precautions

Care is needed in removing the sewing needle from the jar or glass of water at the end of the activity. The simplest method is to pour the water and needle into a gravy strainer held over the sink.

Answers to questions in the text

Pond animals (page 28)

It is worth reminding the children that the general pattern of a food chain is:

Plant→herbivore→carnivore 1→carnivore 2 . . . and so on

A few of the many food chains that can occur between the organisms described in the text are:

Alga→gnat larva→water boatman→stickleback

Alga→water flea→stickleback

Pond weed→water snail→mallard

Pond weed→water flea→tadpole→dragonfly larva

Rotting plants→lesser water boatman→great diving beetle

Caddisfly larvae (page 29)

Two reasons why caddisfly larvae build homes of tiny stones and pieces of leaf or stick around themselves, are to camouflage them against the bottom of the pond, and also to make it more difficult for other animals to eat them.

How do water animals get oxygen? (page 29)

Animals which breathe the air dissolved in the water

Sticklebacks and other fish

Young tadpoles

Leeches

Swan mussel

Water flea

Freshwater shrimp

Water louse

Dragonfly larva

Damselfly larva

Animals which breathe the air above the water

Water vole

Otter

Mallard

Great diving beetle

Water spider

Great pond snail

Moorhen

Mayfly

Dragonfly

Damselfly

Water boatman

Water scorpion

Now try these

2 *Carnivores*

water boatman

great diving beetle

great diving

beetle larva

water scorpion

dragonfly larva

damselfly larva

stickleback

water spider

tadpoles (later stages)

Herbivores

water flea

lesser water boatman

water snail

gnat larva

tadpoles (early stages)

water vole

caddisfly larva

3 It is most effective if the glass of water is viewed from the side as coins are gently dropped into it. With care it is possible to get the surface 'skin' of the water to rise up above the top of the glass.

4 Adult caddisflies look rather like brownish moths. Like moths they cannot eat, but only sip the nectar of flowers. The largest species of caddisfly has a wing span of 6.5 cm. It can be found in summer near still or slow-running water. Caddisfly eggs are usually laid in or near

water and, as we have seen, the larvae of most species build tubes from sand grains, tiny shells or pieces of plant around themselves. Most caddisfly larvae feed only on plant material, although the larvae of the largest species will sometimes attack small water animals.

5 Although sticklebacks are quite conspicuous when viewed from the side in an aquarium, like many other fishes their backs are a dark blue-black or green colour and, when viewed from the surface it is difficult to see them against the bottom of the pond, ditch or river.

A frog is capable of changing the ground colour of its skin slowly to match its surroundings, although the basic pattern of blotches and patches remains the same.

The water slater is a dark, metallic grey colour and this, and the flattened body of the animal, make it very hard to see amongst the plant litter and mud at the bottom of the pond.

Expected results of activities and experiments

The surface skin of water (page 29)

A reasonable level of manual dexterity is necessary to carry out this activity. It is also essential that the glass or jar used is completely clean with no trace of soap or detergent present.

Once the needle is floating on the surface 'skin' of the water, if a tiny drop of washing-up liquid or a speck of soap is added to the water, the needle will sink. This is because soap and detergent break the surface 'skin' of the water.

Extending the learning

1 The air dissolved in water, which is breathed by fish and many other aquatic animals, can be demonstrated by filling a clean jam-jar with cold water and standing it near a radiator or on a sunny windowsill. As the temperature of the water rises, tiny bubbles of air will be seen rising to the surface.

2 Encourage the children to carefully watch a fish in an aquarium. How many times a minute does the fish open and close its mouth and gill covers as it breathes? If they tap on the glass gently, does the fish breathe faster or slower?

3 Investigate how often water boatmen have to come to the surface of a pond to breathe.

Fill a jam-jar two-thirds full with pond water. Put a small piece of water plant in the jar, together with one water boatman. Time carefully over a period of, say, 30 minutes and see how often the water boatman comes to the surface to breathe. What is the longest time the water boatman stays under water? (Results will vary with the temperature of the water. Investigate the rate of breathing with water at different temperatures, eg 5°C above or below the first trial.)

Try this experiment with a pond snail. How often does the snail come to the surface to breathe?

4 Examine carefully the undersides of the leaves of water lilies and other water plants during the spring and summer, to find water snails' eggs. The egg masses are enclosed in strips or blobs of jelly. Collect a leaf which has eggs on it. Put the leaf in a white dish together with some pond water. Study the eggs with a hand lens. How many eggs are there in one mass? How many of them

hatch out? What do the baby snails look like? (Miniature versions of their parents.) How quickly do they grow? (This will depend upon the temperature of the water and the food supply.)

- 5 Compare the animals found in fast-flowing streams with those found in a ditch.
- 6 Many other ideas for activities and experiments are given in *The Young Scientist Investigates: Pond Life* by Terry Jennings (OUP).

Studying a pond (pages 30–31)

Lesson objectives

- a To describe the techniques necessary for studying a pond and its inhabitants;
- b To show that while a pond protects its occupants, it is very vulnerable to pollution and other human disturbance.

Setting the scene

Assuming that a visit to a pond, lake or ditch will be made to coincide with this section, it is essential before the visit to let the children read the story on page 30, and then to prepare the collecting equipment and discuss with the children how to use it.

Depending on the age of the children and the time available, it might be advisable to draw and duplicate an outline of the pond before the children visit it, so that they can fill in the details at the site.

New words

The word 'pollution' can be introduced when the section *No escape* on page 31 is discussed.

Pollution – the dirtying or poisoning of air, water or the soil, or the making of so much noise that it annoys other people.

Class management

Collect identification books and other materials that will be needed to follow up the visit, well beforehand.

Immediately the children arrive back from the visit to the pond, lake or ditch, transfer the specimens to tanks or containers that have been prepared and filled in advance with rain water or pond water.

Safety precautions

Again care will be necessary to ensure the children do not go out of their depth in the water, do not sink in the mud, or have an accident with broken glass. They should wash their hands thoroughly with soap and water when the work is finished, and before handling food.

Answers to questions in the text

Keeping pond animals (page 31)

The containers shown in the picture would not make good homes for pond animals, because they do not have an adequate area of water exposed to the air. A goldfish bowl might be suitable if it was only half-filled with pond water,

but there would still be problems in that its globular shape would magnify the sun's rays, causing discomfort to the inhabitants.

The animals in the picture on the bottom left-hand side of page 31 are, from left to right, a leech, a great diving beetle, a mayfly larva, a water slater and (centre) a freshwater shrimp. Note: these animals are not drawn to scale.

No escape (page 31)

If the pond in the picture is left in its present state, all the wildlife in it will die. The pond needs to be cleared of rubbish, and the mud and other debris at the bottom removed. The water will then gradually clear, and plants and animals will slowly begin to recolonise it.

Now try these

- 2 Fish have a streamlined shape with no limbs, ears or eyelashes to hinder their progress. They are covered with smooth scales which overlap like the tiles on a roof. The water slips by these easily. Each fish has a powerful muscular tail to propel it, and fins to steer with.
- 3 Frogs have become rarer partly because until recently large numbers were killed for students to dissect. The most important reason, though, is the pollution or drainage of ponds or their use as rubbish tips. The number of frogs could be increased if farm and village ponds were cleaned out and if more ornamental ponds were constructed in gardens.
- 4 Some of the bigger fishes found in ponds include carp, roach, perch, gudgeon, common bream and pike.
- 5 Unlike all other liquids, when water freezes it expands slightly so that the ice floats on the surface. The thin layer of ice first formed grows thicker by the addition of layers beneath. The fish and other animals in a pond are able to continue with their life below the ice, rather than being frozen to death.

Expected results of activities and experiments

Keeping pond animals (page 30)

It is not possible to predict what animals the children will find and want to study. A good reference book is essential for this work.

Extending the learning

- 1 Set up an aquarium to demonstrate how the organisms living in it eventually achieve a 'balanced' state. Full details are given in Science 5/13: *Minibeasts* (Macdonald Educational) or in *Animals in the Home and Classroom* by Terry Jennings (Pergamon Press).
- 2 As the children will have noticed, pond water often contains the tiny plants called algae. Ditches, farm puddles and the stale water in glass flower vases often look green because of algae. These simple plants can also be cultured if a jar of rain water is left on a sunny windowsill, when the water will eventually go green. The children can examine some of the green water with a microscope, and draw or describe what they see.

Checking (pages 32–33)

Thinking

- 1 Pond animals depend upon plants for food, shelter and protection, for nesting material and, to some extent, for the production of oxygen.
- 2 Pond plants depend upon the animals partly for their dung and urine, which help the plants to grow, and to a small extent for the dispersal of their seeds.
- 3 The leaves of plants which grow under water are often fine and narrow, so that they do not buoy the plant up to the surface where it would dry out and die.
The leaves of plants which float on the surface of the water are broad so that they remain floating, however much the water level changes, while at the same time they can trap the maximum amount of sunlight. The waxy coating on such leaves as those of the water lily waterproofs them, and helps to keep them afloat.
- 4 The back feet of a frog are webbed to give a greater thrust when the animal is swimming (cf. a frogman or a diver's flippers).
Other water animals with webbed feet include ducks, geese, swans and otters.
- 5 Fish in an aquarium frequently die from the effects of over-feeding. The surplus food quickly decays, polluting the water and poisoning the fish.
- 6 Assuming a constant uptake of water at 80 litres an hour, the swan mussel would take in 1,920 litres in a day and 13,440 litres in a week. The swan mussel does not empty the pond because it passes the water out at the same rate as it is taken in.
- 7 Most of the water in a pond comes from rain, although some may drain into the pond from the surrounding land. Ponds do overflow after prolonged heavy rain, but normally the excess water soaks into the surrounding ground.
- 8 The mud in and around a pond gives support to the plants, and provides them with the mineral salts they need. Many water animals hide in the mud to escape their enemies or the cold.
- 9 As well as the obvious kinds of protection, the water in a pond protects its inhabitants from extremes of temperature.

Doing

- 1 An 'amphibian' is an animal which lives both on land and in water. The word is also applied to certain tanks or other vehicles which are adapted for use both on land and in water. The *Amphibia* is a division of the Animal Kingdom, and includes vertebrate animals such as frogs, toads and newts which, although they can live on land, have to return to water to breed.
- 2 Frogs have a smooth, shiny skin and long muscular hind legs. They move by leaping or jumping. Toads have a rough, warty skin and much shorter hind legs. They move by crawling or running.
- 3 The only swan to breed in Britain is the mute swan, which nests on the ground near water. The nest is constructed from sticks and reeds. There are usually 5 to 7 eggs, each about 10.9 to 12.4 cm long, the largest egg of any British bird. The young swans, or cygnets, are light brown or grey in colour, and are able to fly

when they are about 4 months old. Swans eat mainly water plants, but take some small frogs, fish and insects. Strictly speaking, they are omnivores.

The other two species of swan, the Bewick's and the whooper, are winter visitors to Britain.

- 4 Water snails eat mainly living and decaying water plants. Sticklebacks eat mainly worms, insects, tadpoles and small crustaceans.
1 week-old tadpoles feed mainly on tiny algae.
2 to 3 week-old tadpoles are beginning to eat water fleas and other tiny water animals.
Frogs eat insects, slugs, snails and earthworms.
Dragonflies eat flying insects up to the size of butterflies; their young, or nymphs, are also carnivores and feed on anything from tiny insect larvae to sticklebacks and large tadpoles.
Water voles are herbivores, feeding on grass, reeds and other plants growing near and in the water.
Great diving beetles, and their larvae, eat other insects, tadpoles and small fish.
- 6 Normally the 'empty' jar (containing air) warms up and cools much quicker than the one containing water.
In winter, ice forms on the surface of a pond. Once a layer of ice has formed at the surface, the water below is sealed off from the colder atmosphere and from further loss of temperature, except in prolonged cold conditions.
- 7 1 A potted plant (d) is not a community.
2 The carnivores are (a) dragonfly larvae
(b) sticklebacks
(d) water scorpions
3 The herbivores are (a) gnat larvae
(c) water vole
(d) newly-hatched tadpoles
- 8 A large shallow pond will dry up before a smaller deeper one. It is the area of water at the surface which is critical, since it is from there that the water evaporates (as water vapour) into the atmosphere.
In the experiment described, the water evaporates fastest from the shallow dish which has a large surface area in relation to the volume of water.
- 9 a Because the animals and plants which live in a pond depend upon each other, the pond is an example of a *community*.
b The water vole is a *herbivore* because it feeds on water plants.
c In sunlight the plants in a pond make *oxygen* which is used by the animals when they breathe.
d The tiny plants in pond water which are almost too small to see are called *algae*.
e Because it feeds on smaller water creatures the great diving beetle is a *carnivore*.
f The larvae of caddisflies are *camouflaged* because they live in a small home made of tiny stones, sticks and leaves, and are hard to see in the pond.
g A pond skater can walk on the surface of the water because water acts as if it had a *skin* on it.
h Fish use their mouths and *gills* when they breathe.
i Ponds which do not last long and which dry up in hot weather are said to be *temporary*.
j The eggs of frogs hatch into small fish-like animals called *tadpoles*.

Going further

The picture (page 33) shows one of the egg rafts of a gnat.

The gnat eggs will hatch into tiny larvae or 'wigglers'. These in turn change into pupae from which the adult insects emerge.

In the evening at most times of the year it is possible to see swarms of adult gnats or mosquitoes. Catch some of these with a net, and examine some of the (dead) insects with a hand lens. Look particularly at their mouthparts which are adapted to piercing the skin and sucking the blood of their victims.

Going further – some other suggestions

- 1 Draw a large picture of a section of a pond. Ask the children to draw or cut out from magazines, small pictures of water plants and animals. Stick these in the part of the pond where the organisms would live in nature.
- 2 Keep two or three water snails in a large jar of pond water with some water plants. Watch how the snails feed. How do they move about inside the jar?
- 3 Investigate the effect of water pollution on algae – see *The Young Scientist Investigates: Pond Life* by Terry Jennings (OUP).
- 4 Make a pond bottle garden – see page 26 of *The Young Scientist Investigates: Pond Life* by Terry Jennings (OUP).

Interdisciplinary activities

Art and craft

Make mobiles using fish shapes.

Draw a large outline of a swan and make a collage using tissue paper.

Make model boats of wood, plasticine or polystyrene.

English

The Wind in the Willows by Kenneth Grahame.

Aesop's Fable: *The Crow and the Pitcher*.

Seven Minute Tales by Rhoda Power (Evans).

Swallows and Amazons by Arthur Ransome.

Geography

Maps and map-making, including making a contour map of a pond.

Fish farming.

Malaria and mosquitoes.

Examine Ordnance Survey maps, and plot the distribution of ponds and lakes in the vicinity of the school.

Dew ponds.

Gravel pits, clay pits and quarries.

Oases and water holes in the desert.

Health and hygiene

The domestic water supply.

Mosquitoes and malaria.

History

The origins and uses of farm ponds, village ponds and dew ponds.

Medieval fish ponds, decoy ponds and duck ponds.

Moats around medieval castles and houses.

The village pond and local justice – ducking stools, witches etc.

Ponds and the drovers.

Mathematics

Capacity and volume.

Measuring the areas and volumes of irregular shapes.

Graphs of temperature changes.

Scale drawing.

Drawing spirals (snail shells).

Weighing wet and dry objects.

Weighing objects in air and in water.

Music, drama and PE

Water safety.

Buoyancy aids when swimming.

Music from bottles filled with water to different levels.

Handel's Water Music.

Religious education and social studies

Noah's Ark.

Holy water and baptism.

Five loaves and two fishes.

Water shortages in the Third World.

Theme: Structures, Forces and Energy

Unit 5: Houses and other buildings

Aims of the Unit

- a To examine the problems involved in planning and constructing a house.
- b To examine the additional problems involved in constructing tall buildings.

Science background

Before a housing estate is built, a surveyor will examine the building site and make a plan of it, showing where the electricity, gas and water supplies are located. The detailed plans of a house are drawn up by an architect, using a scale of 1 cm representing 1 metre. Certain details are drawn much larger than this, however. On his drawings the architect notes the materials to be used, although these are described in more detail on a document known as the specification. The architect's drawings then have to be sent to the local housing authority or planning authority, for permission to build the house and to ensure that the house complies with local and national building regulations.

Once these formalities have been attended to, the builder marks out the position of the house on the building plot. The corners of the house are marked by pegs, and short lengths of board are used to show where the foundation trenches and walls will go. The foundation trenches are then dug and filled with concrete. The first bricks are laid on this concrete, producing a low wall which marks the outline of the house and its ground floor rooms. The soil is cleared from within these foundation walls, and the whole area is filled with concrete.

The construction of the brick walls then continues. The layers of bricks are overlapped so that they 'bond' properly. When the walls are about 15 cm above ground level, a layer of waterproof material, the damp-proof course, is built into the walls to stop moisture from the ground being drawn up the walls.

Each external wall is made of two layers: usually there is an outer layer of bricks and an inner layer of breeze blocks or building blocks, with a space, the wall cavity, in between. This helps to keep the damp and cold out of the house. Sometimes the wall cavity is filled with an insulating material. At intervals the inner and outer walls are joined by metal 'ties'. These give additional strength to

the walls. As the walls rise, frames for the doors and windows are built into them. Metal or reinforced concrete beams, called lintels, are placed above the window and door frames, to carry the brickwork and other loads pressing down on these openings.

The roof of the house is based on a timber frame, on which a layer of waterproof felt is fastened, followed by the tiles or slates. Again, the roof space may be lined with insulating material to keep the heat in the house in winter. In Britain, most roofs are sloping, or pitched, to allow rain and snow to run off.

Large buildings are constructed in much the same way as houses. The main difference is that large buildings are usually constructed on a framework made of steel or reinforced concrete. The floors, which are built before the walls, rest on beams whose ends are supported by vertical columns. The walls themselves are no more than screens, or cladding, supported on beams at each floor. Of course, the foundations of tall buildings have to go much deeper, and be more substantial, than those of a house.

Books for the children

The Young Scientist Investigates: *Structures* by Terry Jennings (OUP).

Science in a Topic: *Houses and Homes* by Doug Kincaid and Peter S. Coles (Hulton).

Oxford Junior English: *4 Homes and Shelters* by Oliver Gregory (OUP).

Books for the teacher

Science 5/13: *Structures and Forces* (Macdonald Educational).

Make and Find Out (4 books) by Keith Geary (Macmillan).

Materials and organisation

The advantage of this topic is that it can be carried out anywhere, town or country, and at any time of the year. A building site is never far away, where hopefully the children will be able to observe a few of the stages in the construction of a house or some other building.

A set of plans for a house or housing estate would be very instructive, and could perhaps form part of a display of building materials on the Science Table. House plans can often be obtained, on loan or as a gift, from a local

estate agent or a building contractor.

Materials and equipment:-

Lego or some other toy building kit
clean bricks of different kinds
blotting paper or paper towels
sugar cubes
polythene
string
metal nuts or other weights (for plumb lines)
rulers
flat pieces of wood 30 to 40 cm long
pieces of transparent plastic tubing (eg toothbrush tubes)
clay or plasticine
washing-up liquid
sticky tape
matchboxes
pieces of stout card
yoghurt pots
weights (or coins)
matchsticks
tins (the same size) with lids
thermometers
cotton wool or newspaper
rubber bands

Houses and homes (pages 34–35)

Lesson objectives

- a To briefly examine the history of houses and homes.
- b To describe the planning of a house and the construction of the foundations.

Setting the scene

Possible starting points:

- 1 A visit to a building site.
- 2 An examination of the shapes used in the construction of houses in the vicinity of the school (mainly triangles, squares and rectangles).
- 3 An examination of the fabric of the school building.
- 4 A collection of bricks and other building materials on the Science Table.

New words

Foundations – the lowest part or base of a building, which supports the weight of all the other parts above.

Surveyor – a person who prepares plans of building sites and roads, or who makes maps.

Architect – a designer of buildings.

Class management

If the class are to visit a building site, a preliminary visit will be necessary so that the teacher can ascertain what the children will see and can discuss any safety arrangements.

Some large urban building sites have a special viewing platform for visitors.

In many ways, unless two or more visits to the building site can be arranged, it is better if the visit takes place after the work for this Unit has been started.

Safety precautions

None for the classroom work, but the safety precautions for a visit to a building site will have to be discussed with the site manager.

The children should be warned of the dangers of trespassing on a building site.

Answers to questions in the text

Houses and homes (page 34)

People began to build huts rather than continuing to live in caves because, as the population increased, there were not enough caves to go round. In addition, caves were very localised in their distribution, and there were few in the lowland areas where the soil could be cultivated relatively easily.

Building materials are heavy and expensive to transport. As far as possible, materials which are available locally are used to build a house to keep the costs down.

Most nocturnal animals need a home in which to spend the daytime asleep. Many animals also need a home where their young can be born and reared in safety.

The home of a rabbit is a burrow system called a 'warren'.

The burrow system of a badger is known as a 'set', while that of a fox is called an 'earth'. A bee nests either in a hollow tree, a hole in the ground if it is a bumble bee or, in the case of a honey bee, a specially constructed hive.

A squirrel's home or 'drey', is constructed of twigs, dried grasses and leaves, and built high in a tree.

How foundations work (page 35)

Mrs. Wise's chair did not sink into the soft ground, because the planks she placed under the chair legs spread the weight over a much greater area. In this, the planks acted like the foundations of a house, which spread the weight of the walls over a bigger area.

Now try these

- 1 Building materials are heavy and expensive to transport about the country. As a result, local building materials are used wherever possible, and this accounts for the different building materials seen in different parts of the country, eg. stone and slate in Wales, flint in East Anglia, granite in Scotland and on Dartmoor, and so on.
- 2 Some of the objects made from glass which can be found in the home or classroom include windows, doors, bottles, tumblers, jars, dishes, bowls, vases, light bulbs, oven-ware, thermometers, mirrors, pictures, ornaments, aquaria, clock glasses, oven doors, spectacles, telescopes, hand lenses, cameras and microscopes. In addition, from fibre-glass (glass drawn out into fine threads) are made certain kinds of curtains and the insulation for roofs and attics.
- 3 Bricks are made from clay. Although suitable clay for brick-making is found in many of the lower-lying parts of Britain, most present-day brickworks are concentrated in Bedfordshire and Cambridgeshire. All but a few specialised bricks are now made mechanically. A machine presses the clay into rectangular moulds. The bricks are dried for a short time and then baked in large ovens called kilns. The colour of the final bricks depends partly on the chemicals present in the clay and partly on the supply of

air during baking. Colours may also be produced by dusting the surface of the bricks with chemicals before they are fired.

- 4 Cement is made by burning a mixture of one part of clay to three parts of limestone. The resulting substance is ground into a fine grey powder.

Concrete is a building material made by mixing together cement, sand, gravel or crushed stone, and water. The resulting mix can be poured like porridge into moulds or wooden frames. After about thirty minutes it starts to harden into a grey rock-like material. Often the concrete is strengthened by embedding steel rods in the mixture while it is still soft. This type of concrete is called *reinforced concrete*.

Mortar is another building material. It usually consists of a mixture of sand together with either lime or cement or a mixture of the two. Enough water is added to the mixture to produce a pasty substance that can be used to bond bricks together in a wall before it sets hard.

- 5 Plastics are used in an increasing number of ways in building modern houses. The drainpipes and guttering are almost always made from plastic materials, when formerly these were made of cast-iron. The internal water pipes, waste-pipes, ball-cocks and much more of the plumbing are often made from plastics. Once these would have been made from copper or some other metal. In some houses the door- and window-frames are made of plastic instead of wood or metal. The electrical fittings, once made of brass are now made of plastics, so are many of the door and cupboard handles. Often the kitchen cupboards, kitchen table and work areas have a washable plastic surface, while the kitchen and bathroom floors may be made of washable plastic tiles. The wall-cavities and roof space are sometimes filled with a plastic foam to insulate the house.

Expected results of activities and experiments

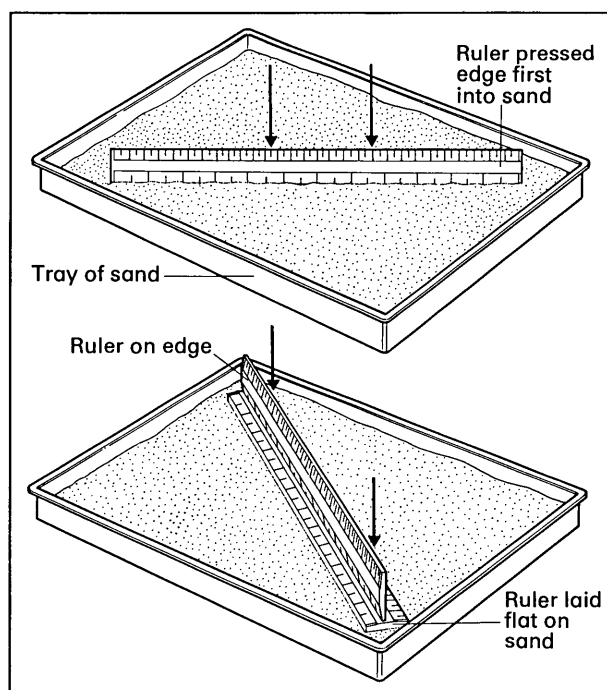
The children will find it easiest if, for their first attempts at drawing plans, they choose relatively simple structures such as mobile classrooms, cloakroom blocks or garages or, quite simply, their own classroom.

Extending the learning

- 1 Why do houses have foundations? The children can carry out this simple experiment to see how foundations work.

Fill a tray or large baking dish with 3 or 4 cm of sand. Spread the sand smooth and flat. Ask the children to pretend that a 30 cm ruler is a wall, and to push the ruler into the sand, edge first. They will notice that the ruler is easy to push into the sand. They should now lay another 30 cm ruler flat on the top of the sand to act as a foundation, and then try to push a second ruler down, edge first, onto it. They will now notice that it is much harder to push the rulers into the sand. This experiment could also be tried with walls made of Lego, with and without foundations.

- 2 Discuss with the children how snowshoes enable the wearer to walk across soft snow (they spread the wearer's weight over a much larger area).
- 3 Make a display of photographs and drawings of houses from all parts of the world. Compare the different styles



of building and the different materials used.

- 4 Make a display of drawings, photographs and manufacturers' leaflets to illustrate modern building methods and materials. Some of the subjects that could be included are cavity wall insulation, double glazing, replacement windows, roof and wall insulation, damp-proof courses, and fitted kitchens and bathrooms.
- 5 Make a study of the homes of animals.

Walls and roofs (pages 36–37)

Lesson objectives:

- a To explain how the wall of a house is built so as to be strong but waterproof.
- b To examine the construction of a house roof.

Setting the scene

Possible starting points:

- 1 Examine the walls of the school and see how they were built.
- 2 Examine the different types of walls in houses near the school.
- 3 Ask the children to draw a brick wall from memory, and then to compare their drawings with the real thing. Alternatively, use one of the introductions listed for the previous lesson and not already used.

New words

Frog – the name given to the hollow in the upper surface of a brick in which the mortar is placed.

Bond – the way in which bricks are overlapped when a wall is built to give greater strength.

Absorb – to soak up, take up or suck up (usually used in connection with a liquid or a gas).

Damp-proof course – a layer of waterproof material near the bottom of a wall which stops water soaking up the bricks from the ground.

Class management

Most of the work can be done by the children sitting at their desks. The damp-proof course activities should be done by the children working in small groups.

Safety precautions

None.

Answers to questions in the text

Walls and roofs (page 36)

The hollow or 'frog' in the brick has mortar put in it by the bricklayer, so that the brick sticks to the ones above it.

The bricks in a wall overlap to give the wall strength. There are no straight lines of joins down the wall. One way to test the strengths of different walls made from Lego or some other toy construction kit, would be to build several walls containing the same number of bricks bonded together in different ways. A golf ball or tennis ball is then rolled down a sloping plank so that it hits one of the walls. The other walls are then tested in the same way.

The pieces of metal put at intervals between the inner and outer walls are called 'ties'. They hold the two walls together, making the whole structure stronger.

In the picture, the cavity between the inner and outer walls is being filled with a fibre-glass insulating material. This process, called cavity wall insulation, helps to reduce the heat loss from the house during the winter.

The roof (page 37)

Most houses and other smaller buildings have a pitched or sloping roof so that water and melting snow run off them.

The tiles on a roof overlap so that rainwater runs straight down the roof, rather than being able to get under the tiles into the roof space. The pipes which go round the roof are gutter pipes, or guttering. Downpipes from these, carry rainwater away from the roof into the drains or, in country areas, to a 'soakaway' in the garden.

Now try these

- 1 Thatched roofs look attractive and their excellent insulating properties mean that they keep out the noise and keep the house warm in winter and cool in summer. They have the disadvantages that they can be a fire-hazard, they need skilled and expensive repair or replacement at regular intervals, and they can attract mice, birds, insects, spiders and other 'lodgers' to the annoyance of the house occupants.
- 3 Double glazing is used in many windows and the glazed panels of doors. It consists of two sheets of glass with a layer of still air or a gas sealed between them. Double glazing reduces the heat loss from a building and also helps to keep out traffic and aircraft noise.
- 5 Pipes are used in houses and school buildings to carry rainwater from the roof, to distribute the central heating, to carry the hot and cold water supplies and to carry away waste water and sewage. Often the electrical cables are also carried in pipes or tubes, while the supplies of gas or heating oil travel along pipes. Chimneys from fires and boilers are also a form of pipe.

Expected results of activities and experiments

How much water does a brick absorb? (pages 36–37)

It is not possible to predict the results of this activity, but it will be found that bricks do vary considerably in the amounts of water they absorb.

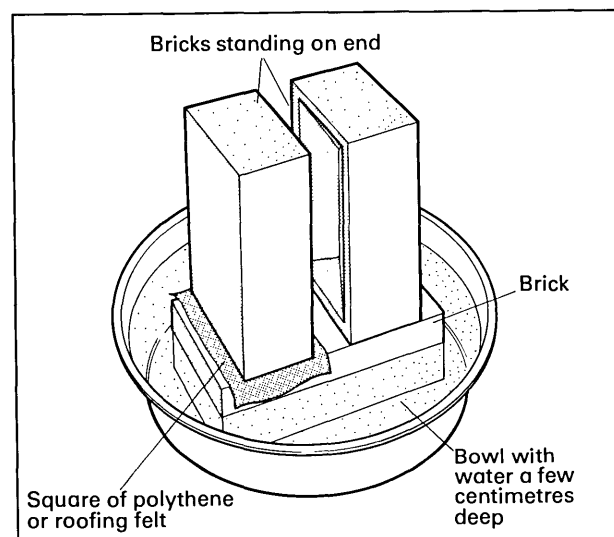
The damp-proof course (page 37)

In order to make this activity work effectively, it is suggested that the sugar lump 'brick wall' be constructed in a shallow dish or tray. Water should then be added carefully to a depth of no more than 4 or 5 mm.

Extending the learning

- 1 *The damp-proof course* As we saw on page 36 of Course Book 1, to stop damp rising through the walls of a house from the ground, the builder makes a damp-proof course. The children can have another demonstration of how a damp-proof course works if you take three clean bricks.

Put one of the bricks in a bowl, and carefully pour in water until it comes a few centimetres up the side of the brick. Stand another brick on end on top of the brick in the bowl. Stand a third brick on end on a square of polythene or roofing felt.



Leave the bricks for a day or two. What happens to them? What happens to the level of water in the bowl? (Normally water will rise up the first brick and then begin to make its way up the length of the brick which is standing on end. However, the layer of polythene or roofing felt acts as a barrier, and water does not rise up the brick standing on it. As the bricks absorb water, the level of water in the bowl falls.)

Test other materials to see whether they would make a good damp-proof course.

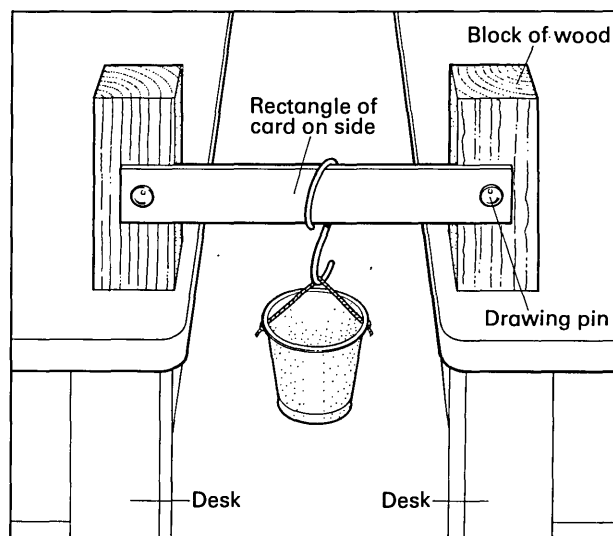
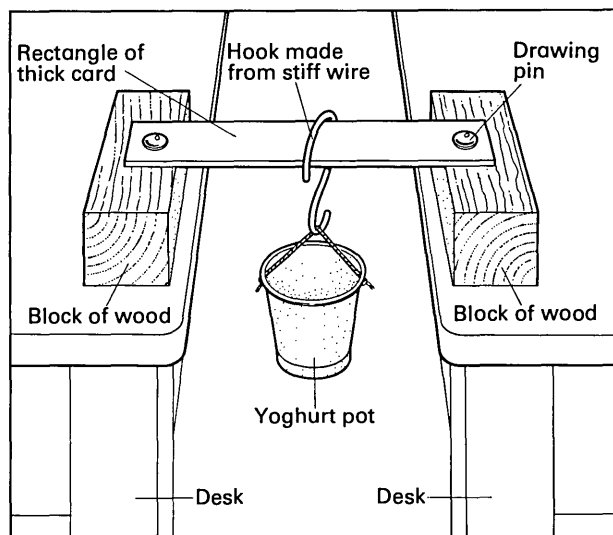
In a real wall, the bricks are joined by mortar. If you can, put a layer of mortar between the bricks and let it set, before you repeat the above experiment.

2 *Joists*

Look at the joists (the horizontal wooden beams) in the picture of the roof of a house on page 37 of Course Book 1. Why do you think they are laid on their edges and not on their sides?

What you need: Two joists, both the same size, and made from thick card. They should be about the size of a 30 cm ruler. You will also need: a piece of stiff wire; a clean yoghurt pot; two blocks of wood; two drawing pins; weights, marbles or beads.

What you do: Fix each end of one of the card joists to a block of wood using a drawing pin, as shown in the picture. Put two desks or tables close together and rest the blocks of wood on them as shown.



Make a hook from wire and a handle for the yoghurt pot. Hang the yoghurt pot from the cardboard joist. Carefully put weights (or marbles or beads) in the yoghurt pot. How many weights does it take before the cardboard joist begins to bend?

Now do the experiment again with the second joist laid on its edge. How many weights does it take before the joist begins to bend? Is it more or less than before? (It takes many more weights to bend the joist fixed on its side than it does the one lying flat.)

3 Testing the strength of concrete

This experiment is described on page 30 of *The Young Scientist Investigates: Materials* by Terry Jennings (OUP).

Ideally the moulds used to contain the concrete should produce a bar of concrete about 30 cm long and about 3 cm wide and 3 cm deep. Grease the inside surfaces of the mould a little so that the concrete does not stick. It is best to carry out the testing of the strength of the concrete on the playground, so that the floor of the classroom is not damaged.

Usually it is found that the strongest concrete is

obtained by mixing 1 part of cement to 2 parts of sand and 3 or 4 parts of gravel. However, when such small moulds are being used, it is not always easy to obtain really fine gravel. Ideally the individual pieces should be pea-sized. It may be better for the children to experiment with various ratios of cement and sand, omitting the gravel. Suggested ratios of cement to sand to try are: 1:20, 1:10, 1:3, 1:1, 3:1, 10:1, 20:1.

Tall buildings (pages 38–39)

Lesson objectives

To examine the problems involved in the construction of tall buildings.

Setting the scene

Possible starting points are:

- A visit to a building site where high-rise flats or an office block is being built.
- Examine the practical problems involved in constructing a model tower using Lego, building blocks or playing cards.
- An examination of a local church tower, including the buttresses that were used to strengthen the walls and to counterbalance the outward thrust. It would also be instructive to examine the beams in the church roof.

New words

Piles – the lengths of timber, reinforced concrete or steel which are driven into the ground to form the foundations of a tall building or the supports for a harbour wall or quay.

Cladding – the bricks, steel sheet, glass or concrete panels used to fill in the spaces between the steel or concrete frame of a tall building.

Plumbline – a weighted cord used by surveyors and builders to show that a surface is upright or vertical.

Spirit level – a device containing a small glass tube which encloses a liquid with an air bubble in it. It is used to ensure that surfaces are horizontal, and sometimes also that they are vertical.

Class management

Apart from the visit, most of the work can be done by the children at their desks. It is suggested that the children work in pairs to use the plumbline or spirit level, and that they record their findings so that a class exchange of information can take place when everyone has had a turn.

Safety precautions

The safety precautions detailed earlier about visits should be noted. If the children want to use the spirit level or plumbline on windows and glazed doors, they should be warned to exercise extreme care. If possible the teacher should supervise.

Answers to questions in the text

Tall buildings (page 38)

A nail knocked a long way into a piece of wood is very

hard to pull out again because it rubs against the wood. This rubbing action is called friction, and is described later in Course Book 1 on pages 62–63. The piles of a tall building stay in the ground because of friction.

Now try these

- 1 Metal plates or ‘ties’ like those shown in the picture, are put on the walls of old houses to prevent them from sagging or bulging. An iron rod is put right through the house and fixed at each end by one of these metal plates. The rod is heated until it expands, and then the two ends are screwed tight. When the rod cools it contracts to its original length, pulling the walls of the house inwards.
- 2 The answers to this question will very much depend on the children’s ingenuity and imagination. Whatever the design of the house or block of flats, though, it will need very substantial foundations, probably in the form of reinforced concrete piles sunk into the marsh.
- 3 The simplest method of estimating the number of bricks used in the construction of a house, is to first count the number of bricks in one square metre of the house wall, and then to find the total area of wall, also in square metres. The two figures are then multiplied. Of course, allowances will have to be made for the doors and windows.

Expected results of activities and experiments

A plumbline (page 39)

Very few walls and door and window frames are exactly vertical, as any adult who has ever had to hang wallpaper will already know.

Extending the learning

- 1 If someone has a small tent, this could be erected on the playing field or in the classroom, and attention could be paid to the various structures and forces holding the tent in position, particularly the guy ropes, tent poles and tent pegs. The angles at which the guy ropes give the greatest support could be measured.
- 2 Use Meccano, Lego or another model construction kit, to see how a lift works. Most lifts have a pulley system over which the cables that raise and lower the car run, and a counterweight to reduce the amount of power needed to raise and lower the car.
- 3 Make a study of some other structures associated with towns and villages, including roads and railways. Model railway and road systems are a good way of examining some of the problems involved in constructing the real things.

Checking (pages 40–41)

Thinking

- 1 The advantages of wood as a building material are that it is relatively cheap, it is light and easy to fix, and has good insulating properties. The disadvantages are that it needs regular painting or preservation treatment, it is attacked by various fungi and insect pests, it burns readily, and is not available everywhere because of the

growing scarcity of trees, and particularly of broad-leaved trees.

The advantages of bricks are that they are strong and relatively cheap, they have good insulating properties, are fire-resistant, they need no painting or preservation, and are very long-lasting. The disadvantages of bricks are that they have to be laid individually, and therefore it takes quite a long time to build a large structure, when compared with wood or concrete. Bricks are not available everywhere, because of the cost of transport when clay is not found locally.

- 2 Tall office blocks and high-rise blocks of flats are built because of the scarcity and expense of building land in towns and cities.
- 3 Woodwork is painted to keep it waterproof, and to discourage the attacks of wood-boring insects and the fungi that cause decay.
- 4 Basically planning controls are required to prevent the unnecessary loss of agricultural land and the destruction of attractive landscapes, and to ensure that buildings receive sufficient light and heat and have adequate water supplies, drainage and electricity.
- 5 The glass cladding on buildings is relatively cheap, and large areas can quickly be covered. The occupants of the building have excellent views of the surrounding area. However, glass buildings often have poor insulating properties, and are very hot in summer and cold (or difficult to heat) in winter. The glare of the sun and lack of privacy for the occupants can also produce problems. Finally there is the danger of injury or death from falling against or through the glass.
- 6 Small tiles or slates are light and easy to fix. A single concrete slab would need enormously strong roof supports, and would be difficult to fix in place, and yet not be particularly waterproof or attractive to look at.

Doing

- 4 The lintel acts like a bridge over the top of an opening for a door or window. It has to be strong enough to withstand the compression effects of the bricks or building blocks laid above it, as well as the weight of the roof.
- 6 Facing bricks often have decorative outer surfaces and are used on the outside faces of the building. Common bricks are cheaper and are not finished to the same high standard as facing bricks. They are used in situations where they are not normally visible, eg. for the internal walls of buildings.
- 7 Most of the modern replacement windows are made either of aluminium or of the plastic material, PVC. Sometimes the aluminium has a PVC or other plastic coating to give a white finish to it. Aluminium and plastic windows are used because they do not rot or warp like wood, or rust like steel window frames. They also need no painting.
- 8 Plastic house guttering is light and easy to fix and does not rust or need painting.
- 9 Air-bricks, like the one in the picture (page 41), are put in buildings which have wooden floors. They allow air to circulate under the floors, so preventing the timbers from rotting.
- 10 Slate is a hard, strong rock that can be split into flat,

smooth sheets. Slate is obtained from open quarries or from mines. Most comes from North Wales, but some is found in north Cornwall, parts of the Lake District and in northern Scotland. Slate roofs are now very expensive since a great deal of skilled manual work is involved in the preparation of the individual slates. Mass-produced tiles are cheaper and more widely available.

- 11 It was probably the ancient Egyptians who discovered that sand and ashes heated together changed into the hard, brittle and transparent substance we call glass. Nowadays most glass is manufactured by heating together a mixture of sand, soda ash and limestone.
- 12
 - a Bricks are made from *clay*.
 - b A house has to be *warm* in winter and cool in summer.
 - c The person who makes a plan of a building plot is called a *surveyor*.
 - d An *architect* draws the detailed plans of a new house.
 - e The *foundations* of a house spread the weight of its walls over a greater area.
 - f The hollow in a brick is called the *frog*.
 - g The *damp-proof course* of a house stops moisture rising up the walls from the ground.
 - h The two walls of a house are held together by metal *ties*.
 - i Nowadays the wall cavity and the roof of a house are often lined with an *insulating* material.
 - j A roof which slopes is called a *pitched* roof.
 - k Most tall buildings are supported on foundations called *piles*.
 - l The material used for filling the space between the steel or concrete frame of a tall building is called *cladding*.

Going further – some other suggestions

1 Roofs

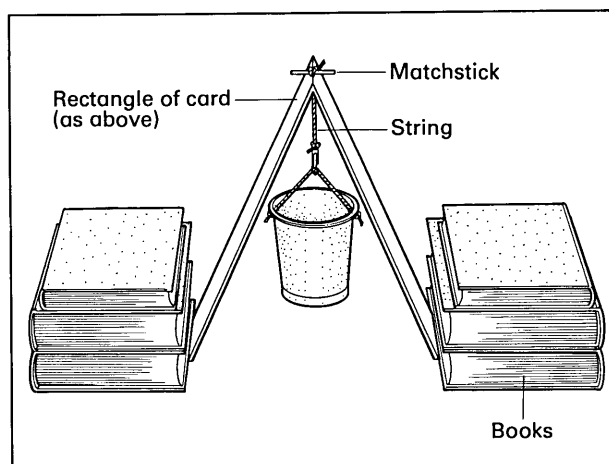
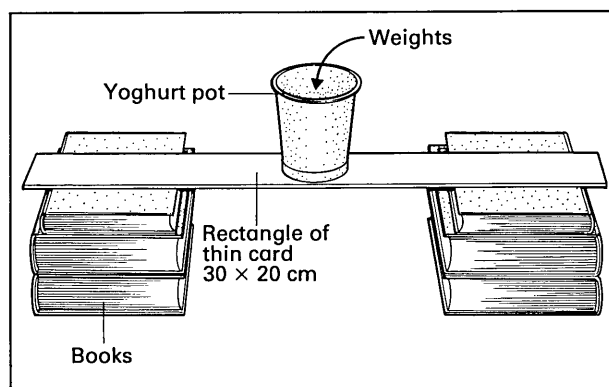
Which is stronger, a flat roof or a pitched roof? Carry out this experiment to find out.

What you need: Two rectangles of thin card, both the same size and measuring 30 by 20 cm. You will also need a yoghurt pot; some books; some weights (marbles will do); some thin string and a matchstick.

What you do: Lay one of the pieces of card between the two piles of books like this. Stand the yoghurt pot in the middle of the card and put weights in it one at a time. How many weights can you add before the flat roof collapses?

Leave the books exactly where they are. Fold the second sheet of card in half to make a pitched roof. Hang the yoghurt pot from the pitched roof and put weights in it. How many weights can you add before the pitched roof collapses? Is it more or less than before? Which roof would be the most waterproof, a pitched roof or a flat roof? How can you find out?

(It will be found that the pitched roof will support a greater weight than the flat roof. A pitched roof would also be the most waterproof, since rain and melting snow would run straight off it, rather than collecting in puddles as they would on a flat roof. One way of demonstrating this would be to make a flat roof and a



pitched roof as above, and cover them with polythene. Water could then be sprayed on the two roofs (outside!) from a watering can.)

2 How does insulation work?

The roofs and walls of houses are often insulated with a layer of warm material. What does this material do, and how does it work?

What you need: Two tins, both the same size, with lids; two thermometers; cotton wool or crumpled newspaper; rubber bands; hot water.

What you do: Make a small hole in the tops of both tins, large enough for the thermometers to go through. Stand the tins side by side. Wrap cotton wool or crumpled paper around one tin. Hold this insulation material in place with rubber bands. Pour an equal amount of hot water into both tins. The water should be hot, but not boiling. Put the lids on the tins.

Stand the thermometers in both tins. Take the temperature every 5 minutes as the tins of water cool down. Make a graph of your results. Which tin cools the quickest?

Do the experiment again and see which material, cotton wool or newspaper, is the best insulator of heat. (For this experiment, use water at about 80°C. It is suggested that the teacher pours out the water from a kettle, and that a child wears a pair of gloves while putting the lids on the tins.)

The tin which is not surrounded by insulation material will cool the quickest. Insulation materials contain a layer of trapped still air, which stops heat from escaping through them.

The Young Scientist Investigates

This science programme consists of two course books, twenty project books, a teacher's manual and a teacher's book of practical work.

Each course book consists of a number of units of work grouped under three concept headings:

Living Things

Structures, Forces and Energy Change

These units include: interdependence of living things; pond life; houses and buildings; materials; skeletons, muscles and movement; pushing, pulling, sliding and rolling; sun, moon, earth and stars; the seasons; science in the kitchen; growth; the senses; grasses; reproduction; wildlife in the city; bridges, dams and tunnels; movement; heat and light; the weather; decay; and pollution.

On each double-page opening there are a number of follow up activities, some which can be completed through an understanding of the text and some which require further, guided research. At the end of each unit of work is an opening containing further activities and simple experiments.

Teacher's Book of Practical Work

A collection of experiments, using simple materials, which extend the work in the course.

Teacher's Manual

The teacher's manual contains a guide for the preparation of all the lessons, advice on how to develop the themes introduced in the course, further work and experiments, and helpful science material.

Course Book 1

0 19 918171 3

Course Book 2

0 19 918172 1

Project Books

Birds	0 19 917037 1
Flowers	0 19 917039 8
Sea and Seashore	0 19 917041 X
Seeds and Seedlings	0 19 917040 1
Small Garden Animals	0 19 917036 3
Trees	0 19 917038 X
Energy	0 19 918159 4
Sounds	0 19 918160 8
Food	0 19 918161 6
Structures	0 19 918162 4
Everyday Chemicals	0 19 918163 2
Materials	0 19 918164 0
Water	0 19 918037 7
Air	0 19 918038 5
Rocks and Soil	0 19 918039 3
Electricity and Magnetism	0 19 918040 7
Light and Colour	0 19 918041 5
Heat	0 19 918042 3
Human Body	0 19 918208 6
Pond Life	0 19 918210 8

Teacher's Book of Practical Work

0 19 918219 1

Teacher's Manual

0 19 918185 3

Oxford University Press

ISBN 0 19 918185 3

It would be useful to discuss with the children why cotton wool or crumpled newspaper are not used to insulate roof spaces or wall cavities. The reason is that the materials used have to be fire- and damp-resistant. The latter is necessary to prevent water being conducted across the wall cavity into the interior of the building.)

Interdisciplinary activities

Art and craft

- Sketching houses.
- Model-making
- Designing rooms.
- Printing wallpapers and curtains.

English

- Homes in literature.
- Oxford Junior English: *4 Homes and Shelters* by Oliver Gregory (OUP).

Geography

- Homes around the world.
- Sources of building materials.
- Building construction in earthquake zones.
- Planning and surveying.
- Nomads and settlements.

Health and hygiene

- Fresh air, ventilation and warmth.
- Keeping the house clean.
- Water supply and waste disposal.

History

- Primitive homes, including caves, pits, lake dwellings and Saxon cruck-framed cottages.
- Roman villas.
- Castles and manors.
- Stately homes.
- Back-to-back houses and the Industrial Revolution.
- Garden cities, tower blocks and New Towns.
- Famous walls: Hadrian's Wall, the Great Wall of China, the Berlin Wall, the Western or Wailing Wall in Jerusalem.
- The window taxes.
- Sir Christopher Wren, Inigo Jones, Sir John Vanbrugh, Leonardo da Vinci, Michelangelo, and other famous architects.

Oxford Junior History, *The Invaders* by Roy Burrell (OUP).

Mathematics

- Estimating the number of bricks used in the construction of a house.
- Right angles and levels.
- Mortgages, interest rates, rent and rates.
- Shape, pattern, tessellation.
- Scale and plans.

Music, drama and PE

- Homes of great composers.
- Opera houses and concert halls.
- Theatres.
- Sports stadia.

Religious education and social studies

- Homes in ancient Palestine.
- Churches, synagogues, mosques, temples, and other religious buildings.
- Noah's Ark.
- Homeless people – refugees, vagrants, 'down-and-outs'.
- A Primary Religious Education Course: Book 1: *Nazareth*, Book 2: *Jerusalem* by Richard Hughes (OUP).

Unit 6: Materials

Aims of the Unit

- To examine some of the wide range of materials we meet in our everyday lives.
- To look at the distinction between natural and man-made materials.
- To examine the origins, properties and uses of wood, paper and the various fibres and fabrics.

Science background

The Concise Oxford Dictionary defines material as 'matter from which a thing is made.' By this broad definition, everything in the universe, including all living organisms, is made up of materials.

In this course, some of the common raw materials used by people are considered, and a distinction is made between natural materials which come from animals and plants or from the Earth's crust, and synthetic or man-made materials such as iron, glass and plastics, which are manufactured from other, natural materials.

In this Unit, we consider wood, a natural material, from the trunks of trees. Wood is a very versatile material. It is strong for its weight, tough, long-lasting, easy to work with, and attractive to look at, especially when polished. Wood is also a good insulator of heat and sound. From wood, wood pulp is made. This is wood which has been broken down into very small pieces. Wood pulp is a major raw material from which paper, cardboard, rayon and cellulose are made. The best trees for making wood pulp are the so-called softwoods – conifers such as pine and spruce.

The Unit also examines fibres and fabrics. The fabrics, or textiles, are made from fibres. Natural fibres, such as wool, cotton and linen, come directly from animals and plants, while man-made or synthetic fibres are made from petroleum chemicals or from coal.

Books for the children

The Young Scientist Investigates: *Materials* by Terry Jennings (OUP).

Science in a Topic: *Clothes and Costume* by Doug Kincaid and Peter S. Coles (Hulton).

Science Workshop by Irene Finch (Longman).

Books for the teacher

Science 5/13: *Working with Wood* (Macdonald Educational).

Teaching Primary Science: *Science from Wood* by Dorothy Diamond (Macdonald Educational).

Teaching Primary Science: *Fibres and Fabrics* by John Bird and Ed Catherall (Macdonald Educational).

Materials and organisation

This topic has many links with art and craft, and a wide range of materials and samples should be available to enable the children to have a rich choice of activities.

Materials and equipment:-

- samples of different kinds of timber (from a carpenter?)
- chipboard

plywood
 blockboard
 clean matchsticks or lollipop sticks
 fresh green sticks
 samples of coarse fabric eg. hessian
 hand lenses
 glue
 Sellotape
 thin string or wool
 large sewing needles
 stiff card
 samples of threads of different kinds eg. cotton, nylon,
 elastic, linen
 hooks made from bent wire
 30 cm rulers
 small iron washers or other weights
 squares of fabric of different kinds
 drinking straws
 clean jam-jars
 a watch or clock with a second hand
 dessert spoons
 rubber bands
 samples of different kinds of paper
 scissors
 long strips of wood
 drawing pins
 old newspapers
 washing-up bowls
 wallpaper paste or flour-and-water paste
 tissues
 microscopes

Help can also usually be obtained from the following sources (the teacher should write, not individual pupils):

Timber Research and Development Association,
 Hughendon Valley,
 High Wycombe,
 Bucks. (wood)

Wiggins and Teape Ltd.,
 Group Advertising Division,
 P.O. Box 88,
 Gateway House,
 Basing View,
 Basingstoke, Hants. (paper)

International Wool Secretariat,
 Education Department,
 Wool House,
 6, Carlton Gardens,
 London SW1. (wool)

Monsanto Textiles Ltd.,
 Public Relations Department,
 Monsanto House,
 10-18, Victoria Street,
 London SW1. (synthetic fibres)

Courtalds Ltd.,
 Public Relations Department,
 18, Hanover Square,
 London W1A 2BB. (synthetic fibres)

National Association of Paper Merchants,
 35, New Bridge Street,
 London EC4V 6BH. (paper)

Materials (pages 42-43)

Lesson objectives

- a To examine the origins of some common materials.
- b To study the origins and preparation of wood.
- c To examine some examples of manufactured wood.

Setting the scene

There are a number of possible starting points, including:

- 1 An exhibition on the Science Table of a variety of natural and man-made materials. The children could make lists of these materials and find as many ways as possible of grouping them into sets.
- 2 Start with a large growing timber tree, such as an oak, ash or beech tree, or a fallen tree, and discuss the uses we might make of its wood. At the same time, materials that can make satisfactory substitutes for wood could be discussed.
- 3 Start from art and craft work, such as making mobiles and models. For example, when papier mâché models have been made and dried and painted, the children may notice the similarities between the hardened papier mâché and wood.

New words

Materials – matter from which things are made.

Seasoning – the slow, careful drying of wood before it can be used to make things.

Conifers – trees which do not have proper flowers although they do have separate male and female parts. The female parts develop into cones which contain seeds. Most conifers have needle-shaped leaves like those of pine and spruce trees.

Kiln – a large oven in which materials like bricks, pottery, metals and cement are made or in which wood is seasoned.

Veneer – a thin layer of expensive wood which is stuck on to a cheaper wood.

Class management

Most of the work on this topic can be done by the children working at their desks.

Safety precautions

Careful supervision will be necessary if cutting instruments are used, particularly on wood.

Answers to questions in the text

Materials (page 42)

The car in the picture is likely to have been constructed entirely of man-made materials, including steel for the body, glass for the windows and plastic for the upholstery and fittings. The tyres on the car are made of rubber, but this was probably made from petroleum chemicals rather than being natural rubber.

The statue is made of marble, a natural material.

The tyre may be made of natural or man-made rubber (see above).

The watering can is made of painted steel, although it could have been made of plastic like the washing-up

bowl. Both, however, are man-made.

The flowerpot is made from clay, a natural material, but nowadays most flowerpots are made of plastic, as are the beaker and cup and saucer.

The clothing may have been made of cotton, a natural material, but again nowadays it is just as likely to be made of nylon or some other man-made material.

The cricket bat is made of wood, a natural material.

The watch is made of steel, a man-made material.

The rings are made of gold (a natural material), and the precious stones in them are also natural materials.

Wood (pages 42–43)

The upper picture shows a forest of broad-leaved trees in winter, the lower picture a forest of conifers. The broad-leaved forest is a natural one, with the trees of different kinds and sizes and different distances apart. The coniferous forest was planted by people, and the trees are all of the same kind (Corsican pine), the same size and the same distance apart.

The items shown in the illustration on page 43 which are made of wood are:

door, chair, table, pencil, ladder, boat, handles of chisels and saw, toy car, and violin. The books and papers on the table are made, indirectly, from wood.

Note: the items in this illustration are not drawn to scale.

Other kinds of wood (page 43)

It is often possible to tell whether furniture has been veneered if you examine the edges of doors and drawers. The joins of the separate veneers are usually clearly visible.

Plywood is made by sticking together thin sheets of wood. These are arranged so that the grain of one runs at right angles to the next. Plywood has a wide variety of uses, including sailing boats, doors, furniture, packing cases, toys and table tennis bats.

Blockboard is made from lengths of wood glued together between thin sheets of wood, like a sandwich. It is used to make doors and furniture.

Chipboard is made from tiny chips of wood which have been mixed with glue and pressed into large boards. Chipboard is used for the upstairs flooring of many houses, and also, when covered with a veneer, for furniture.

Replacing wood (page 43)

In schools and houses, many surfaces of tables and worktops have been partly or completely replaced in recent years by plastic materials such as Formica. These are easy to keep clean, and withstand frequent wetting better than wood. Plastic materials also need no painting or varnishing. The handles of many tools and utensils are now made of plastic instead of wood. These handles are lighter and slimmer to hold than wooden ones, and much cheaper to make. In the case of kitchen utensils, plastic handles are better able to withstand washing in hot water than wooden ones.

Now try these

- 1 Things which may have wooden handles include garden spades, forks, rakes, hoes, trowels, brooms, brushes, shears, hammers, chisels, screwdrivers (usually plastic nowadays), hand drills, mallets, wooden spoons, some cutlery, kitchen knives, rolling pins, some saucepans and frying pans, corkscrews.
- 2 After about a week of being kept in a warm room, a green stick will have lost a considerable amount of water, and so its weight will have decreased. The stick

may even appear thinner. If wood is not dried or seasoned properly before use it may shrink, warp or split, and be more liable to decay. Seasoning makes wood harder and stiffer so that it keeps its shape better.

- 3 Paints and varnishes preserve wood by keeping water, fungi and wood-boring insects out. Creosote and wood preservatives such as 'Cuprinol' are sprayed or painted on wood for use outdoors, particularly in the case of fences and telegraph poles where the wood is likely to be damp for long periods. These preservatives contain chemicals that kill any wood-rotting fungi and insects they come into contact with.
- 4 It is not possible to generalise about the results of this activity, other than to say that not all blocks of wood of equal size float to the same depth, nor do all of them float the same way up.
- 5 Again it is not possible to generalise about the exact results of this activity. If two lollipop sticks are glued together with their grain running in different directions, they may be *more* than twice as strong as one of the lollipop sticks on its own.

Extending the learning

1 *Experiments with wood*

What you need: Small blocks or off-cuts of different kinds of wood (perhaps from a carpenter); a washing-up bowl; a hammer and small nails; scales; poster paint and a paint brush; a hand lens.

What you do: Look at the different kinds of wood with a hand lens. Look at the different patterns or grain on them.

Wet each block of wood with water. Describe what happens to the appearance of each of them.

Try floating the blocks of wood in a bowl of water. Which floats the best? Do any kinds of wood sink?

Weigh some of the blocks of wood before you float them. Leave them in the water overnight. Then wipe them dry and weigh them again. Which kinds of wood have taken up the most water?

Find out which block of wood is the hardest and which is the softest. Carefully knock a nail into each of the blocks (do this in the playground or on an old table or a proper carpenter's bench). Which block of wood does a nail go into the easiest, and which is the hardest to knock a nail into? Which wood is the easiest to scratch with a nail, and which is the hardest?

Paint your blocks of wood with poster paint. Which kind is the easiest to paint and which is the hardest? Why are some of the blocks of wood hard to paint?

If you had large pieces of the timber you used in the experiment, which kind would make the best workbench? Which kind would make the best boat? Which kind would be best for wood carving?

(It is not possible to predict the results of this experiment, but interesting comparisons could be made if the children were provided with a range of hardwoods, such as oak and beech, and of softwoods such as pine and, if possible, balsa wood.)

- 2 Collect some wooden lollipop sticks. Wash them in warm soapy water and dry them. Encourage the children to use thread and the lollipop sticks to make model rafts. Get them to float the rafts in bowls of water. What weight of plasticine will each raft carry?
The children could make other rafts with twigs of the

same length as the lollipop sticks. What weights will these rafts carry when they float? More complicated rafts with buoyancy tanks or floats underneath could also be made. Cigar tubes make excellent buoyancy tanks.

- 3 Investigate how splinters are formed and how they can be prevented. Which kinds of wood splinter the most?
- 4 Burn small pieces of different kinds of wood, eg. matchsticks and lollipop sticks, and examine the ashes formed. Strict supervision and small groups are needed for this activity.
- 5 Make charcoal (see Science 5/13: *Working with Wood* (Macdonald Educational)).
- 6 Why is wood sometimes used for the handles of saucepans and frying pans? If the experiment on page 31 of *The Young Scientist Investigates: Materials* is carried out, the children will discover that wood, along with plastics and some other materials, is a poor conductor of heat.
Other activities and experiments are detailed in *The Young Scientist Investigates: Trees and Materials*, both by Terry Jennings (OUP).

Fibres and fabrics (pages 44–45)

Lesson objectives

- a To examine some properties of fibres and fabrics.
- b To compare the strengths of different fibres and threads.
- c To compare the action of water on different fabrics.

Setting the scene

There are a number of possible starting points including:

- 1 A collection of different fabrics on the Science Table.
- 2 A discussion of different methods of classifying fabrics, including colour, strength, texture, man-made or natural, and so on.
- 3 A nature walk to collect raw sheeps' wool for spinning into thread.
- 4 A visit to a textile mill or a demonstration at school of spinning or weaving.
- 5 A comparison of the extent to which different clothes are wetted on a rainy day.

New words

Fibres – long thin hair-like strands of material.

Fabric – a material generally woven from yarns or threads which have been spun from fibres.

Class management

With the exception of the experiment to test the strength of fibres, all the work on this topic can be done by the children sitting at their desks. Ideally the work should be taught in the order shown on pages 44 and 45, but if insufficient materials are available then it is possible for different groups to work at different activities at the same time.

Safety precautions

None

Answers to questions in the text

Fibres (page 44)

It is not always easy to identify fibres and fabrics from the labels on clothes. A confusing mixture of names of the fibres, common names of the fabric and trade names is often used. Material, made from silk fibres, for instance, may be described as chiffon, while woollen fabrics may be labelled as tweed or twill. Cotton fibres may be woven into fabrics known variously as poplin, denim or calico. (Denim is so called because it was made in Nimes – de Nimes.) With the man-made fibres, the situation is even more confused. Materials made from rayon fibres are often sold under the trade name Vincel, while di-acetate and tri-acetate fibres are made into fabrics known by the trade names Dixel and Tricel respectively. Nylon and polyester fibres are sold in the form of fabrics known by the trade names Enkalon and Celon, while acrylic fibres appear in fabrics under a variety of trade names, including Acrilan, Courtelle, Orlon and Teklan.

Now try these

- 2 Some of the things which might be made of wool include suits, dresses, blankets, socks and stockings, rugs and carpets, dressing gowns, coats, jumpers, cardigans and vests.
- 3 People who live in hot countries or who play games in the summer wear white or light-coloured clothing, because it is cool to wear since it reflects the sun's rays. By contrast, black or dark-coloured clothing is warm because it absorbs the sun's rays.
- 4 From animals come fibres and fabrics made from silk, wool and camel and goat hair. From plants come linen, cotton, jute and hemp. Other fibres and fabrics, probably the majority used nowadays, include nylon, polyester, acrylic, rayon and other man-made or synthetic materials.

Expected results of activities and experiments

Testing the strength of threads (page 45)

It is not possible to predict the exact results of this experiment. However, to give a variety of strengths of threads, it is suggested that the samples tested should include cotton (relatively weak), shirring elastic (to give the greatest degree of stretch), polyester thread (relatively strong compared with cotton thread), and linen carpet thread (virtually unbreakable). Single-strand (monofilament) fishing line is available from angling suppliers in various breaking strains.

It will be found that human hairs differ greatly both in their appearance under a microscope and in their breaking strains. Figures varying from 50 g to 100 g are not unusual.

Water and fabrics (page 45)

Again it is not possible to predict the exact results of this experiment. They will depend upon the fabrics used. With some fabrics, such as towelling, the water enters the spaces between the fibres and threads, and is thus absorbed. Only when the material is saturated will water start to pass through. Some fibres, such as Terylene are water-

repellent. This means that rain does not soak through them, although air can pass through. Some other fabrics, such as cotton, attract water, which then passes through them quite easily. The children could classify their materials according to whether they absorb, repel or attract water.

It would be an interesting follow-up to the above experiment to rub wax on a fabric through which water has been shown to pass easily, and then to repeat the experiment.

Extending the learning

- 1 How easy is it to wash different fabrics, using hot and cold water, soap and detergents?
- 2 Carry out a fair test on the crease-resistance of different fabrics. One method would be to take equal-sized pieces of the different fabrics, to fold them to the same extent, and then to leave them individually under bricks or some other equal weights, for the same length of time. Then compare the degree of creasing and how permanent the creasing is.
- 3 Keep silkworms in the classroom. A brief account of the care and management of these animals is given in *Animals in the Home and Classroom* by T. J. Jennings (Pergamon Press).
- 4 *Which are the hard-wearing fabrics?*

What you need: Some pieces of different fabrics, all the same size (old pieces of trousers, jeans, shorts, shirts, jackets and blouses are ideal). You also need a small block of wood; pieces of sandpaper all the same size and the same grade; drawing pins; a board; a hand lens.
What you do: Use the drawing pins to fasten a piece of sandpaper to the board.

Wrap one of the pieces of fabric around the wooden block. Rub the fabric on the sandpaper once. Look at the fabric with a hand lens. Can you see any signs of wear?

Rub the same piece of material on the sandpaper five times and then ten times. Look at it with the hand lens after each series of rubs. Record what you see.

Now do the experiment again with other fabrics and a new piece of sandpaper for each one. For your experiment to be fair, you must rub each fabric in the same way and press the same amount each time.

Which of the fabrics is the hardest wearing? Which fabric wears the most?

Whereabouts on your clothes does most wear occur? Where would you need to use the hardest-wearing fabric if you were making your own clothes?

(Expected results: Generally fabrics made from cotton and pure wool are found to have fairly poor wearing qualities. The addition of synthetic fibres, such as nylon or polyester increases their durability considerably.)

Presumably most children will consider that most wear on their clothes occurs on the elbows, knees and on the seat. These are the areas where the hardest-wearing fabrics would be needed.)

A modification of the above experiment would be to compare the amount of wear which occurs when different fabrics are rubbed with a small nail which has been knocked through a small block of wood.

Paper (pages 46–47)

Lesson objectives

- a To demonstrate the multiplicity of uses of paper.
- b To demonstrate that paper is made from fibres.
- c To compare the properties of different kinds of paper.

Setting the scene

Possible starting points include:

- a A display of different kinds of paper on the Science Table. If possible, examples should be included of newspapers, comics, magazines, writing paper, sugar and cartridge papers, cardboard, manilla card, tissue paper, brown paper, corrugated paper, grease-proof paper, waxed paper, tracing paper, wallpaper, toilet paper, paper handkerchiefs, blotting and filter papers, litmus paper, rice paper, heat-resistant paper, crêpe paper, linen card, cartons of various kinds, sticky paper, postage stamps, banknotes.
- b Devise ways of comparing the strengths of different kinds of paper, or of seeing how well different paper tissues absorb water.
- c Find out which, of several kinds of paper, make the best paper aeroplanes.

New words

Bleach, bleaching: the process for taking the natural colour out of things, to make them white.

Class management

All of the work on this topic can be done by the children sitting at their desks. It may be necessary to divide the class up into groups to carry out the various activities and experiments, if the supply of materials is limited.

The easiest papier mâché models to make are those which involve simple shapes, such as owls, penguins, seals and human heads.

Safety precautions

The children will require some form of protective clothing, and the desks will need covering, when papier mâché is made.

Some forms of wallpaper paste (usually those sold for vinyl wallpapers) contain a chemical fungicide. These should not be used for work with children.

Answers to questions in the text

Paper (page 46)

Most paper is made from wood pulp, but paper can also be made of other materials such as cotton and linen. The leaves of Esparto grass, a tall feathery grass which grows in Spain and North Africa, is used for making fine quality paper. And of course, new paper can be made from waste paper or even old rags. (The advantages of recycling paper could be discussed at this point – it saves not only energy but also valuable and scarce trees.)

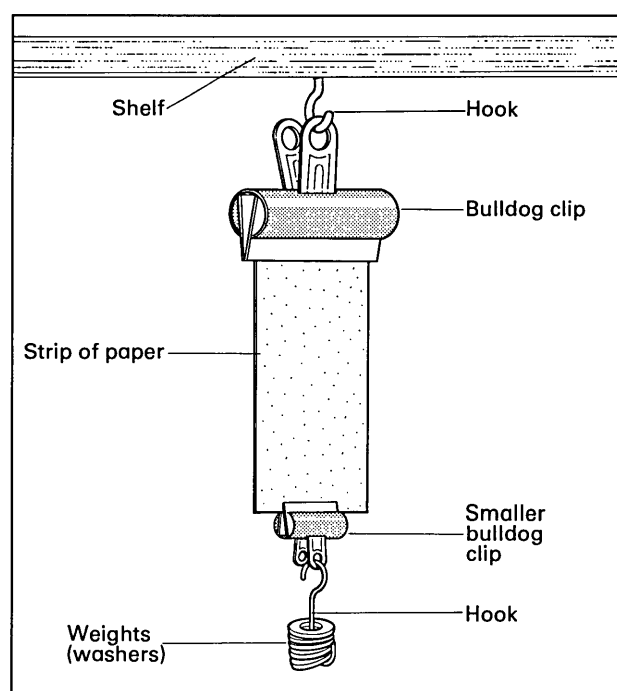
Different kinds of paper (page 46)

If a wide variety of different samples of paper has been collected, the children will notice, with a hand lens, that some kinds appear dull, while others are glossy. Some

papers are glazed while others are unglazed. Some coarse papers contain brown or black specks or other impurities. In coarse grades of papers the fibres are large and easily seen, particularly along torn or cut edges; in the finer grades of papers the fibres are very small and difficult to see. Some papers are virtually opaque when held up to the light, others are translucent. Some kinds of paper also have a distinct watermark which is visible when they are held up to the light.

Now try these

- 1 One way to test the strength of strips of different kinds of paper all the same size, would be to suspend one of the strips from a bulldog clip fixed to a hook in a shelf. Attach small weights to a second, smaller, bulldog clip suspended from the bottom of the strip of paper until the paper breaks.



- 3 Most of the wood pulp from which paper is made comes from softwoods or conifers, such as pine and spruce. These trees are used because they grow quickly and because their wood, being relatively soft, is easy to break down into its constituent fibres. About 80 per cent of the world's wood pulp and paper come from the northern coniferous forests of Canada, the United States and Scandinavia.

Expected results of activities and experiments

How well do different kinds of paper absorb water? (page 47)

It is difficult to predict the exact results of this experiment, but if blotting paper or filter paper has been used, then the water will quickly rise to the top of the strip. With waxed paper, greaseproof paper or the highly glazed forms of writing paper, very little absorption of water will occur.

Extending the learning

1 Making paper

As we have seen, most paper is made from wood fibres.

It is not easy to get the fibres from wood without the use of caustic soda and other dangerous chemicals, but it is possible to re-use the fibres from soft-tissue toilet roll.

Put about a litre of water into a bowl and add about 12 sheets of toilet tissue to it. If possible use toilet tissues of different colours so that the fibres show up more easily. Stir the tissues thoroughly until they break up and spread throughout the water. Look at some of the fibres with a hand lens or microscope.

Dip a sheet of fine wire gauze, about 15×10 centimetres, into the fibres. If you cannot get a piece of wire gauze, you could nail a piece of muslin (or a piece of a pair of tights) tightly onto a small wooden frame.

Lift the gauze out of the bowl and shake it gently so that the water drains away.

Turn the gauze over and gently press the layer of fibres on to a piece of felt. Cover the fibres with a second piece of felt or a piece of blotting paper, and roll it firmly with a rolling pin or a large bottle.

Carefully remove the felt or blotting paper. Leave the home-made paper on the felt in a warm room to dry. Then peel the paper off.

The secret of successful paper-making lies in getting a thin and even layer of fibres on the wire gauze, and then transferring the fibres to the felt. This comes with practice.

Try making new paper from old newspapers, blotting paper, thin card or paper towelling.

- 2 Investigate how quickly the different forms of paper dropped as litter decay away. This experiment is described on page 31 of *The Young Scientist Investigates: Materials* by Terry Jennings (OUP). Other experiments or activities using paper are also described in this book.

Checking (pages 48–49)

Thinking

- 1 Man-made materials are often cheaper than natural ones, since they are mass-produced and their production is not affected by the vagaries of the weather, the attacks of pests, and so on.
- 2 There are many reasons why we wear clothes: to keep us warm or cool; to keep us dry or clean; to protect us from dangers, such as fire, chemicals, radiation or pressure; to look smart or attractive; as a uniform, and so on.
In general, light-coloured clothes reflect the sun's rays and are cool to wear, while darker coloured clothing is warm because it absorbs the sun's rays.
- 3 It is largely a matter of opinion which fabrics are uncomfortable to wear. Generally it is those fabrics which are rough or hairy if worn next to the skin.
- 4 Chipboard is often cheaper than planks of wood made direct from conifers, because chipboard can be made from scrap wood or small pieces of timber, while planks can only be cut from large sections of tree trunk of uniform thickness and texture.

- 5 An example of another invertebrate animal besides the silkworm which makes fibres is the spider. This uses its fibres or gossamer both to make its web, for trapping insect food, and also for securing its eggs. It would be a useful exercise to examine spiders' webs with a hand

lens to investigate their detailed structure. Many moths and some butterflies also produce silk around their caterpillars or chrysalises.

- 6 A fair test to compare the wearing qualities of two different carpets must involve *identical* levels of wear. One method would be to fix two equal-sized pieces of the carpet securely in a busy doorway where they would receive equal amounts of wear. Alternatively, the two pieces of carpet could be rubbed an equal number of times by two blocks of wood with identical grades of sandpaper fixed to each.

Doing

- 1 Natural forests of broad-leaved trees are homes for many more kinds of wild life than man-made forests of conifers. For example, more than 400 species of insect alone feed on the main native British forest tree, the oak.
- 2 Silkworms are the larvae or caterpillars of the silk moth. The female moths are made to lay their eggs on cards which are stored throughout the winter. In the spring, the cards are placed on trays and covered with mulberry leaves, on which the caterpillars feed. Loose twigs are placed in the trays when the caterpillars are ready to turn into pupae. Silk is obtained by unwinding the silken threads on the outside of the cocoons the caterpillars spin around themselves when they pupate.

Silkworms are relatively easy to rear in the classroom if supplies of fresh mulberry leaves are readily available.

- 4 The picture shows (from left to right) the timbers of oak, elm, walnut and sapele. They are wet below and dry above.

Usually water does make the grain show up better. Clear varnish is used to give wood a permanent 'wet' look.

- 5 The tree in the picture is 12 years old.
- 6 The thin sheets of wood in plywood may be the same or different, but they are arranged so that the grain on one sheet is at right angles to the grain on the next. It is this feature which gives plywood its strength.
- 8 **SAFETY PRECAUTION:** Clear varnish should not be used or stood near naked flames or heat. Ensure there is adequate ventilation when using it.
- 9 **SAFETY PRECAUTION:** The burning tests should be carried out on a completely clear table or bench, well away from loose papers, curtains, clothes or other materials which could be set alight. Strict supervision will be needed of children with long hair. If there are any doubts about the ability of the children to carry out this experiment, it would be safer for the teacher to demonstrate and discuss it with the whole class.

The children will find that fibres such as Tricel and Dicotel melt and burn quickly, leaving a black, lumpy residue. Wool and silk burn slowly, leaving a black ash. Nylon, Polyester, Terylene, Dacron, Acrilan and Orlon also burn slowly. By contrast, cotton, linen and rayon burn quickly and quietly. Hair shrivels rapidly when burned, producing a characteristic smell.

- 10 Woodworms are the larvae of the furniture beetles, a family of 28 different kinds of destructive wood-boring beetles, including the notorious death watch beetle. In forests, these insects have a useful function in hastening

the decay of dead tree trunks and branches.

Unfortunately, they have also taken to attacking the timber in buildings.

Termites are often incorrectly called 'white ants'. They live in hot countries, including Africa and Australia, in large social groupings, similar to those found in ants. The chief food of most termites is wood and, if they get into buildings, they can quickly destroy floors, roof timbers and furniture. Normally, though, like furniture beetles, they feed on decaying trees and shrubs.

- 11
 - a Some materials are *natural*, some are man-made.
 - b Stone, clay, *sand*, gold, coal and oil are some natural materials found in the ground.
 - c Wood comes from the *trunks* of trees.
 - d Leather, fur, silk and *wool* are materials which come from animals.
 - e When wood is dried slowly and carefully, it is said to have been *seasoned*.
 - f The thin layer of expensive wood glued onto a piece of cheaper wood is called a *veneer*.
 - g Fibres are long, thin *threads* of material like hairs.
 - h Paper is made from wood *pulp*.
 - i The *wasp* is an insect which makes a nest of paper.
 - j Originally all our silk was made by *silkworms*.

Going further – some other suggestions

- 1 Each child could make a collection of small pieces of different fabrics. These could be mounted on sheets of paper and labelled.

- 2 *Why do we paint or varnish wood?*

Is it just to make the wood look better?

What you need: Two blocks of wood, both the same size and the same kind; gloss paint or clear varnish; a paint brush; a set of scales; a bowl of water.

What you do: Give one of the blocks of wood a coat of paint or clear varnish. Let the paint or varnish dry properly. If possible leave it overnight.

Weigh both blocks of wood and then leave them in a bowl of water overnight. Wipe both blocks of wood dry, and weigh them again.

Has the weight of either block of wood changed?

Why do you think wood is painted or varnished?

What would happen to wood after a time if it was not painted or varnished and was left outside?

Note the SAFETY PRECAUTIONS regarding the use of varnish above. Gloss paint should also be used only where there is adequate ventilation.

Expected results: The untreated block of wood will absorb water and gain weight. Wood is painted or varnished partly to improve its appearance, and also to prevent this absorption of water and to deter fungi and wood-boring insects.

Untreated wood left outside, would soon absorb water and be attacked by decay organisms and wood-boring insects, and would quickly rot.

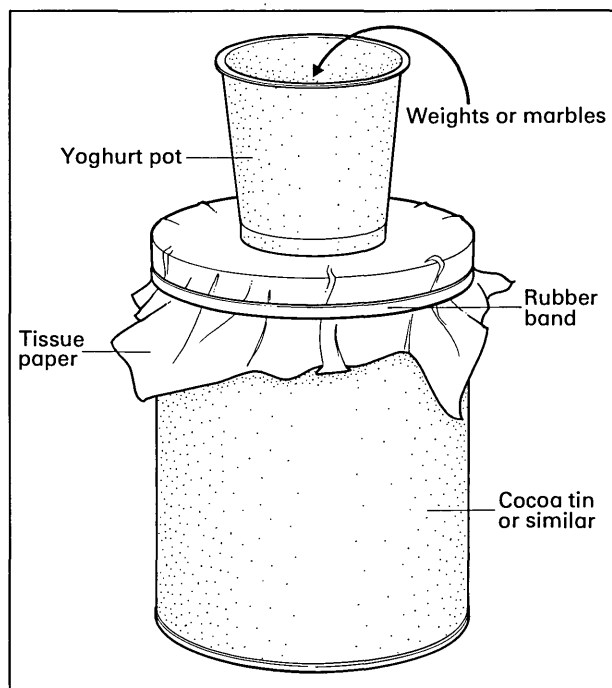
- 3 *Measuring the strength of paper*

Here is a simple experiment to compare the strengths of different kinds of paper. Perhaps you could compare the strengths of different kinds of tissues to see if what the makers say about them is true.

What you need: Squares of paper or tissues all the same

size; rubber bands; a tin without sharp edges; a yoghurt pot; weights or marbles.

What you do: Fix a square of paper or tissue over the top of the tin with rubber bands. Stand the yoghurt pot in the centre of the piece of paper. Put weights or marbles in the yoghurt pot, one at a time. How many weights do you have to add before the yoghurt pot falls through to the bottom of the jar?



Test the strength of other papers and tissues in this way. Which is the strongest? Which is the weakest?

Is a strong piece of paper or tissue always the best? (Strength is not always the most important factor. In the case of toilet paper softness is also vital.)

- 4 **Grow flax and cotton** Seeds of the perennial blue flax (*Linum usitatissimum*) can be obtained from seed merchants and grown in the school garden. Cotton seeds can also be grown in the classroom (see *Nature Study and Science* by I. E. Finch (Longman)).

Interdisciplinary activities

Art and craft

- Dyes and dyeing fabrics.
- Making articulated puppets from short lengths of cane, and dressing them.
- Wood-cuts.
- Collages from sawdust, shavings and pieces of fabric.
- Mobiles.
- Wood carving.
- Costumes for a play.
- Making patterns with wood.
- Making and using charcoal.
- Fashion drawing and design.
- Spinning, weaving and knitting.
- Embroidery.
- Tie and dye.
- Simple batik.

English

- The Emperor's New Clothes.
- Costuming a play.
- Poems about colours.

Oxford Junior English: *4 Homes and Shelters* by Oliver Gregory (OUP).

Geography

The Young Geographer Investigates: *Temperate Forests* by Terry Jennings (OUP).

The Young Geographer Investigates: *Tropical Forests* by Terry Jennings (OUP).

The countries that produce plant and animal fibres.

Sheep farming and the wool industry.

The textiles and paper industries.

Map work of possible routes taken by imported timber, fabrics and fibres on their way to Britain.

National costumes.

The cotton-growing industry of the United States of America.

Health and hygiene

How easy are fabrics to clean?

The importance of clothing in different climates.

History

The development of spinning and weaving.

Wooden ships.

The Bayeux Tapestry.

Historical events during the life of a large tree.

The wool trade in the Middle Ages.

The Lord Chancellor and the Woolsack in the House of Lords.

Clothes through the ages.

Military uniforms throughout history.

Oxford Junior History: *The Middle Ages* by Roy Burrell (OUP).

The Footsoldier/The Horsesoldier by R. Hook and M.

Windrow (OUP).

Mathematics

Measuring and cutting angles

Age and rate of growth.

Estimating and costing.

Buying and selling clothes.

Measuring ourselves.

Drawing patterns.

Comparisons of the sizes and weights of different clothes.

Music, Drama and PE

Making xylophones and tapping sticks.

Wooden musical instruments – violin, viola, guitar, woodwind etc.

Sound-effects.

Songs about clothes.

Special clothing for PE and games.

Costuming a play.

Religious education and social studies

Noah's Ark.

Clothes in the Old and New Testaments.

Ritual costumes in different religions.

Living In the Time of Jesus of Nazareth by P. Connolly (OUP).

Unit 7: Skeletons, muscles and movement

Aims of the Unit

- a To consider the way in which animals are classified into two main groups: vertebrates and invertebrates.

- b To examine the functions of the skeleton.
- c To look at the structure and functions of bones and muscles.
- d To study the way in which the bones and muscles of birds are adapted for flight.

Science background

A number of small animals, including earthworms, jellyfish, sea anemones and leeches, have no skeleton. Some other animals, including crabs, lobsters and crayfish, have external skeletons, consisting of hard protective shells which completely cover their bodies. The big disadvantage of these external skeletons is that as the animal grows it quickly becomes too large for its case, and every so often this has to be shed. Then, until a new, larger skeleton has grown, the animal is completely defenceless.

Most fairly large animals have an internal skeleton, consisting of a system of bones and other supporting materials, inside their bodies. The individual bones gradually increase in size as the animal grows. We humans, like dogs, cats, horses, mice, birds and fish, have such an internal skeleton. The skeleton has a number of functions. It protects the important organs of the body, such as the brain, heart, lungs and spinal cord. The skeleton also gives support to the rest of the body, acting like a girder framework around which the softer parts are built. In addition, most muscles are attached to bones that provide a firm anchorage against which the muscles can pull, so allowing movement to occur. Finally red blood cells are made in the marrow of some of the long bones.

All the animals with an internal skeleton have a vertebral column or backbone, consisting of many individual bones, or vertebrae. Animals with such a backbone are called *vertebrates*. Those animals with either no skeleton or with only an external skeleton are known as *invertebrates*.

Muscles work by contracting. Since they cannot push, but can only pull on bones, muscles work in pairs. In the upper arm, for example, one muscle, the biceps, contracts to raise the arm, while its opposite number, the triceps, relaxes. When the arm is lowered, then the triceps contracts, while the biceps relaxes. Most of the muscles in the body, including those that move the limbs, can be controlled when we wish, and are known as *voluntary muscles*. The muscles of the stomach, intestines and arteries are known as *involuntary muscles*, since their movement takes places without our having any conscious control of them. The heart is made of a special kind of muscle, known as cardiac muscle, which is in continuous movement from before birth until death. All muscles contain a large number of blood vessels, which bring to them the food and oxygen needed to provide the energy for movement.

Birds have a number of adaptations to their muscles and skeleton to enable them to fly. The wings are moved by two pairs of flight muscles, which lie across the breast. The muscles are large and powerful, and they need a strong support so that they can work efficiently. To this end, the vertebrae are fused together for extra strength, and the ribs are joined together to make a rigid support for the breastbone. This has a deep keel to which the muscles are firmly attached. Some of the bird's bones contain air spaces to reduce their weight.

The bird's wing is shaped so that air moves faster over

the upper surface than over the lower one. In this way the bird achieves 'lift' as its wings push against the air on their down-strokes.

Books for the children

The Young Scientist Investigates series: *Birds, Structures, The Human Body* by Terry Jennings (OUP).

The Clue Book: *Bones* by Gwen Allen and Joan Denslow (OUP).

Books for the teacher

Science 5/13: *Structures and Forces, Holes, Gaps and Cavities* (Macdonald Educational)

Materials and organisation

The teaching of this topic would be greatly enhanced by a visit to a museum to examine and compare the skeletons of different vertebrates, and to look at examples of invertebrates. It is possible to buy plastic replicas of the skeletons of humans and other animals, and these would provide a useful talking-point.

Materials and equipment:

- clean bones of different kinds
- earthworms
- garden snails
- jam-jars
- drinking straws
- sheets of stiff paper
- Sellotape
- coins or weights
- stiff card
- rubber bands
- brass paper fasteners
- scissors
- tape measures
- matchsticks
- corks, clay or plasticine
- string
- short sticks (about 30–40 cm long)
- clean feathers
- hand lenses
- rulers
- hacksaw
- strips of smooth wood (40–50 cm long)
- tape

All about backbones (pages 50–51)

Lesson objectives

- a To show how animals are classified into two main groups on the presence or absence of an internal skeleton and backbone.
- b To examine the functions of a skeleton.

Setting the scene

Possible starting points include:

- 1 Finding different ways of grouping a collection of pictures of animals into sets.

- 2 A collection of seashells, or skulls or other bones.
- 3 Real or plastic replicas of skeletons.
- 4 Have the children feel their own backbones and locate individual vertebrae. Ask what would happen if the backbone was made of just one long bone (we would be unable to bend).

New words

Skeleton – a bony framework which supports, gives shape to, and protects the body of an animal.

Invertebrate – an animal with either no skeleton at all or with just a shell or tough skin on its outside.

Vertebrate – an animal with an internal skeleton, including a backbone.

Vertebra – one of the individual bones of the backbone (plural: vertebrae).

Class management

All of the work on this topic can be carried out by the children sitting at their desks.

Safety precautions

None.

Answers to questions in the text

All about backbones (page 50)

The animals with no bones or other form of skeleton usually protect themselves by hiding in holes, burrows or crevices. Many of them are found in water, because the water supports their bodies. It is noteworthy that the largest invertebrate animals, squid, cuttlefish and octopuses, live in the sea.

The animals with a hard skeleton on the outside include crabs, lobsters, crayfish, king crabs, prawns, shrimps and sea urchins. If shells are included, then we also have snails, cockles, mussels, oysters and all the other seashore molluscs. The children may mention tortoises and turtles as having hard shells on the outside. This is true, but it should be pointed out that these animals also have an internal skeleton with a backbone, i.e. they are vertebrates. Contrary to popular belief, snakes also have an internal skeleton with a backbone.

The picture shows the shell of a pearly nautilus, a relative of the octopus and squid, which is found on the sea bed only around Fiji and the Philippines. Since the shell is a coiled spiral, the children might expect the animal's body to be that shape too. But in fact there are partitions across the shell, and the animal's short fat body fits in the last and roomiest chamber.

The picture (page 50) shows a ladybird, two barnacles, a butterfly, a starfish and a woodlouse. There are too many other invertebrate animals to be able to list them here. However, the group of invertebrate animals with the greatest number of species in it is the insects, with more than 722,000 known species, followed by the molluscs (snails, slugs, cockles, mussels, oysters etc) with 80,000 species, spiders and their relatives 30,000 species, crustacea (crabs, lobsters, shrimps, etc) 25,000, worms 20,000, millipedes and centipedes 8,000, and microscopically small animals more than 20,000 species.

Bones and skeletons (page 51)

Again there are too many vertebrate animals to be able to list them, but they fall into five broad groups: fishes, amphibians (frogs, toads, newts and salamanders), reptiles (snakes, lizards, tortoises, turtles, crocodiles, alligators), birds, and mammals (all the animals, including humans, which have hair or fur on their bodies, and which feed their young on milk).

The skeletons in the picture are of a rabbit, pigeon, frog and rat. These skeletons are similar to ours in that they have the same arrangement of skull, backbone, ribs and limbs. They differ in that all but the pigeon walk on all-fours, while the rabbit and rat have the backbone extended into a well-developed tail. In addition, the skeletons are roughly the shapes of the actual animals.

The skull protects the brain, the inner parts of the ears, the nasal organs and, to some extent, the eye balls. The ribs and breastbone protect the heart, lungs and main blood vessels. In addition the backbone protects the spinal cord, while the pelvic girdle gives some protection to the intestines and, in females to the reproductive organs and any developing babies in the womb.

Now try these

- 1 In order to support its massive weight, the elephant's legs are short and stocky, like four thick pillars, and it has an immense backbone to which the legs and skull are attached.
- 2 Invertebrate animals which have a shell on the outside of their bodies include snails, cockles, mussels, whelks, winkles, oysters, scallops, clams, limpets, barnacles, crabs, lobsters and crayfish. Tortoises and turtles are not invertebrates. As well as the shell on their back, they also have a bony skeleton inside their bodies.
- 3 The backbone of an animal is made of small pieces of bone (called vertebrae), which swivel against each other. This arrangement is strong but flexible. At the same time the backbone can protect the spinal cord which passes through the individual vertebrae.
- 4 The snail moves up the sides of a jar by contracting and relaxing its muscular 'foot'. It makes its movements easier, particularly over rough surfaces, by secreting a mucus ('slime') trail which the foot can slide over.
- 5 An earthworm moves by anchoring the bristles at the back end of its body to the ground, while making itself long and thin. It then releases the rear bristles and anchors those at the front end of its body, before pulling up its rear end, thus making itself short and fat. These processes are repeated over and over again.

Extending the learning

- 1 Make a collection of seashells, and any snail shells that the children find, for the Science Table. Do not collect any shells with living animals in them. Wash the shells in warm, soapy water, rinse them in clean water and dry them. To give the shells a 'wet' look, rub them with a little light lubricating oil. Display the shells in matchboxes, cardboard trays or cigar boxes. They look best if stuck to squares of card using quick-drying glue. On each piece of card write down the name of the animal which made the shell and where it was found.

Encourage the children to look at each shell carefully to see how it was made and where the animal lived. Let

them find out all they can about the life of the kind of animal which made each shell.

- 2 If you have fish for dinner, save the skeleton. Wash it carefully in a shallow dish of soapy water, and use a paint brush to sweep away any pieces of the flesh which remain. Dry the skeleton and let the children examine it with a hand lens. The real enthusiasts in the class might like to try to reassemble the skeleton, using quick-drying glue.

- 3 Make a large collection of pictures of vertebrate animals. Ask the children to classify them into the five main groups of vertebrates (fishes, amphibians, reptiles, birds and mammals). Ask the children what features they think the members of each of these groups have in common. (Fish live in the sea or in fresh water; their bodies are covered with scales; they swim by means of fins. Most fish lay eggs without shells which are covered with jelly.)

Amphibians live on land and in fresh water, but they lay eggs covered with jelly in the water. The eggs hatch into a larval or tadpole stage. Amphibians have a moist skin with no scales on it.

Reptiles live mostly on land, although some live in the water. Their bodies are covered with scales and they lay their soft-shelled eggs on land.

Birds all have wings, modified front legs, with which most of them can fly. All birds have bodies covered with feathers, and all lay eggs covered with hard shells.

Fishes, amphibians and reptiles are all cold-blooded, that is their body temperature is the same as that of their surroundings. Birds are warm-blooded, which means they keep a constant body temperature, whatever the temperature of their surroundings.

All mammals (except whales, porpoises and dolphins) have hair or fur on their bodies. All have young that are born alive (except for the duck-billed platypus and spiny anteater, which lay eggs), and the young are fed on milk from the mammary glands. All mammals are warm-blooded.

- 4 Keep slugs, snails or woodlice in captivity for a short time. Make a pitfall trap to see which invertebrate animals are present in the garden or school grounds. These and other activities and experiments concerned with invertebrates are described in *The Young Scientist Investigates: Small Garden Animals* by Terry Jennings (OUP).

Bones and muscles (pages 52–53)

Lesson objectives

- a To examine the structure of long bones.
- b To look at why most muscles work in pairs.

Setting the scene

Possible starting points include:

- 1 Examining a *clean* long bone obtained from the butchers.
- 2 Examining a large wallchart or model of the human skeleton (or a real one if it can be obtained).
- 3 Looking at how a string puppet works.

New words

Marrow – a substance found inside the hollow long bones of the body. Marrow is where part of the blood is made.

Class management

Apart from the activity concerned with measuring the expansion of the chest, the work in this section can be done by the children at their own desks.

Safety precautions

If bones from the butchers or elsewhere are examined it is essential that these are clean. If possible they should be boiled and any meat removed before they are examined by the children. If the bones are reasonably clean already, they should be soaked in a disinfectant solution. The children should always wash their hands after they have handled the bones, and particularly before they touch food.

It is very difficult to hold a bone still while it is cut across to see the marrow. Unless a large vice is available, it is safest to ask the butcher to cut a bone for you.

Answers to questions in the text

Long bones (page 52)

Hollow cylinders are used because they are strong but light in the scaffolding used by builders, in some bridges (including the Forth Railway Bridge in Scotland), in many street lights, in rotary clothes driers, most tent poles, in the legs of photographic tripods, many fishing rods, some steel garden tools, and in bicycle frames, baby buggies, wheel chairs, many ironing boards, and tubular steel furniture.

Muscles and movement (page 52)

The muscle in a joint of meat is the red or lean meat. Its red colour comes from the many blood vessels which carry food and oxygen to the muscle to provide the energy for movement.

Moving your ribs (page 53)

The average chest expansion for children is quite small. Many fit and healthy men have a chest expansion of only about 10 cm.

The muscles which raise the ribs fill in the spaces between the ribs. (They are known as intercostal muscles.)

Exercises (page 53)

The athletes in the picture have particularly well-developed leg muscles.

Now try these

- 1 When it is in the sea, the water supports much of the whale's massive weight. If it becomes stranded on land, the whale's weight soon crushes its lungs and other internal organs, and it quickly dies.
- 2 The various holes and cavities in a bone show the places where air circulates in the bone (sinuses), and also where blood vessels, nerves and lymph (a watery fluid) pass through it. Of course, long bones are hollow and the cavity contains marrow where the red blood cells are made.
- 3 Most animals, including lions, dogs, cats, rats and mice, carry objects in their mouths, gripping them with their teeth. Apes, monkeys and their relatives are able to

carry things in their fingers, as we humans do. Most birds carry food and nesting materials in their beaks, but some large birds of prey, including eagles and ospreys, carry their food with their talons, the hooked claws on their feet.

- 5 The most stable arrangement of the four legs on a model animal is with the legs splayed slightly outwards, rather like those on a vaulting horse.

Expected results of activities and experiments

Long bones (page 52)

It will be found that a cylinder of paper is much stronger than a flat sheet of paper of the same size.

Make models (page 53)

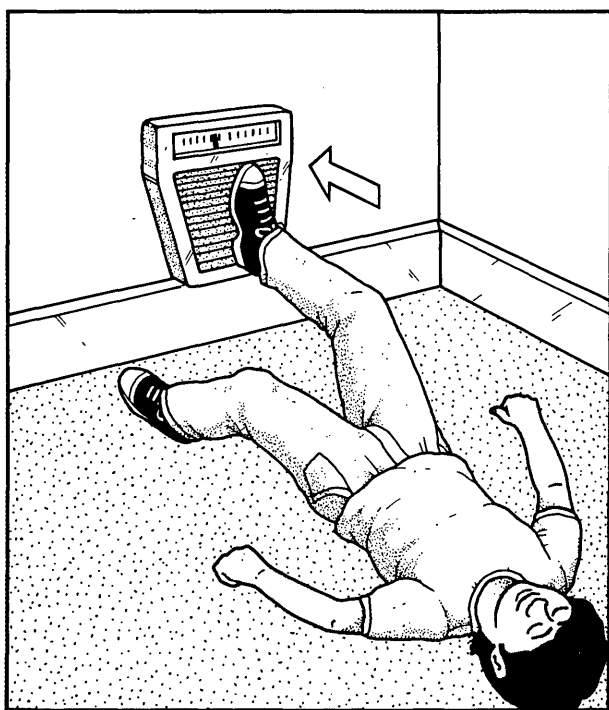
The rubber band 'muscle' in front of the upper arm has to be pulled to raise the forearm. The rubber band behind the upper arm has to be pulled to lower the forearm.

The 'muscle' under the chin of the model head makes it nod forwards. The 'muscle' behind the head makes the chin and head rise up.

Some people may find it more instructive to operate these models using short lengths of string instead of rubber bands. Then it is possible to see how each 'muscle' alternately shortens (contracts) and then lengthens (relaxes).

Extending the learning

- 1 Arm-wrestling not only gets rid of some of the children's surplus energy, it also enables them to use their free arm to see which muscles in the other arm are being used to try and push their partner's arm down.
- 2 *How hard can you push with one foot?*
What you need: A pair of bathroom scales. Ask a friend to work with you.
What you do: Stand a pair of bathroom scales against a wall like this:



Put one foot flat against the scales. Push the scales as hard as you can. Ask your friend to read the scales while you are pushing them.

Try to feel which muscles in your leg are helping you to push. Record how hard you pushed.

Do the experiment again. This time use the other foot. With which foot did you push the hardest?

Now let your friend have a turn. Which of you pushed the harder with the left foot? Which of you pushed the harder with the right foot?

Now hold the bathroom scales in both hands, and see which of you can grip the hardest. Which muscles are you using to grip the scales?

(The children will find that they use their calf and thigh muscles in pushing on the bathroom scales with one foot. The muscles of the forearms are used in gripping the scales.)

- 3 Sometimes the bones which are moved by a muscle are a long way from the muscle. Then the muscle pulls on a string-like tendon, the other end of which pulls on the bone. In some ways the tendon acts like the cable on a bicycle's brakes.

Ask the children to look carefully at the backs of their hands while they waggle their fingers. Can they see the tendons moving? Can they find the muscles the tendons are joined to? (in the forearm) There is another thick tendon behind the knee. Can the children find that?

Bird flight (pages 54–55)

Lesson objectives

- a To examine the adaptations of a bird's skeleton and muscles to the needs of flight.
- b To look at the structure and function of a bird's wing.

Setting the scene

Possible starting points include:

- 1 A collection of feathers.
- 2 A collection of wings taken from (recently) dead birds.
- 3 A visit to a collection of birds in a zoo, wildlife park or aviary.
- 4 Watching birds in the school grounds, perhaps at a bird table if it is winter time.

New words

Streamlined – something which has a smooth, slim shape, so that air or water moves over it easily, is said to be streamlined.

Class management

All of the work in this section, other than the activity to show how a bird achieves 'lift', can be carried out by the children at their desks.

Safety precautions

Care is necessary to ensure that the children wash their hands thoroughly after handling feathers or bird's wings, and particularly before they touch food.

Answers to questions in the text

Bird flight (pages 54–55)

Of the birds in the picture, the swallow and house martin are able to fly fast, because they have streamlined bodies and long, narrow swept-back wings (cf. those of military fighter aircraft).

The eagle has long, broad wings to provide maximum lift to enable the bird to soar through the air. The deeply slotted wing-tips smooth out the turbulence caused by air currents.

The pheasant has short, broad wings which enable it to rise rapidly from the ground, but its large body in relation to the area of its wings means that it soon tires.

The moorhen's flight is weak because again its wings are relatively small in relation to the weight of its body. It also lacks the pheasant's long tail to help it to twist and turn through the air.

Wing muscles (page 55)

As well as feeling the action of the breast (pectoral) muscles, the children may also notice that our breastbone is a smooth strip of bone, whereas that of a bird is ridged to provide attachment for the much larger flight muscles.

Now try these

- 2 The birds that are unable to fly all have relatively small and weak wings. The large flightless birds such as the ostrich of Africa, the rhea of South America and the cassowary and emu of Australia, live on the open grassy plains or in bushy country. They are protected from their enemies by their large size and their ability to run fast. Ostriches and cassowaries can also deliver a lethal kick. The New Zealand kiwi is camouflaged by its brown colour, and it remains hidden in the forest by day, only coming out at night to feed. The other large group of flightless birds is the penguins. These are confined to the southern hemisphere. The wings of penguins are reduced to paddles, and although these birds are ungainly on land, they are excellent swimmers both on the surface and underwater.
- 4 It is not easy to wet a large feather by pouring cold water over it. The water seems to run off the feather. If the feather is washed in warm, soapy water, dried, and then has cold water poured over it, the feather is soon wet right through. This is because the soap dissolves the natural oils which waterproofed the feather.

When oiled seabirds are cleaned with soap and water, they have to be kept in captivity until after the next moult when new waterproof feathers have grown. If the birds were put straight in the sea, they would soon be wetted right through to the skin and would quickly die of cold. In addition, with waterlogged feathers, the birds would be unable to fly.
- 5 The wings of a bird consist of its front limbs which are covered with rows of overlapping feathers. The bat's long arms, and its hands with its very long fingers, are covered with a very thin membrane which forms the wings. The membrane extends to the tiny legs of the bat and often to the tip of its tail as well. Both the bird's and the bat's wings contain bones, as well as muscles, since these animals are vertebrates. By contrast the membranous wings of an insect have no bones, but they do contain a system of tiny tubes, called veins. Usually insects have two pairs of wings (one pair in birds and

bats) and these are attached to the middle section, or thorax, of the body.

Expected results of activities and experiments

How wings lift a bird (page 55)

If the string is held taught so that the model wing can slide freely, when the children run with it they will notice that the wing rises up the string as it develops lift. This is because the air has to travel further (and therefore faster) over the upper surface of the wing than it does over the lower surface. Because of this, the air above the wing has less pressure than the air below it. It is this difference in air pressure which causes the wing to develop lift.

If the children run with the wing at an angle to the moving air, i.e. with the front edge of the wing slightly raised, then even more lift is produced.

Extending the learning

- 1 *Make a collection of feathers* The best time to do this is in the late summer or early autumn when the birds are moulting. Then large numbers of feathers can sometimes be found. Encourage the children to collect clean and neat feathers only.

Let the children examine the different feathers with a hand lens. They can draw the feathers to show their structure. Ask the children to run a feather up and down through their fingers. They will notice how the web of the feather becomes dishevelled and then quickly restored to its proper shape as the hundreds of tiny barbules equipped with minute hooks link together. That is why birds run their feathers through their beaks.

Mount some of the best feathers on sheets of paper or card. Stick the shaft of the feather with Sellotape. Label each specimen with the name of the bird it came from, what kind of feather it is, and where and when it was found.
- 2 Some children might like to try to reassemble the skeleton of a chicken. The bones should be thoroughly cleaned by boiling, and joined with quick-drying glue. Thin wire will be needed to fix the vertebrae together and to reinforce the limb and neck bones.
- 3 Study how the wings and beaks of birds work together to catch food. See *The Young Scientist Investigates: Birds* by Terry Jennings (OUP).
- 4 Make and fly paper darts and model parachutes. See *The Young Scientist Investigates: Air* by Terry Jennings (OUP).

Checking (pages 56–57)

Thinking

- 1 The main advantage of an external skeleton is that, since it completely encases the animal, the whole of the animal's body is protected.
- 2 Animals with an external skeleton are never very large because such a skeleton is heavy and limits the activities of the animal. Lacking lungs as they do, there would also be problems for large invertebrates in obtaining sufficient oxygen.

- 3 The mole's adaptations to a burrowing life include its enormous hands for digging, short tail bearing sensitive hairs, movable sensitive snout, and tiny eyes buried in fur. The mole's short fur does not lie down in any particular direction, so the animal can easily move forwards or backwards through its narrow burrows.
- 4 Gliding is flight without the power of an engine or the action of muscles. Flying is a controlled movement through the air which is powered by engines or muscles. The so-called flying fish and flying squirrels actually glide through the air.
- 5 The fast animals and the strong animals mentioned have the same basic pattern – four legs, tails and so on. However, the fast animals have long legs and slender bodies, while the stronger animals have shorter legs and a generally stockier build.
- 6 A string puppet is jointed like our own skeleton. The strings are pulled because of the action of human muscles. Indeed this is another similarity between our bones and muscles and a string puppet, because when our muscles contract they may pull on string-like tendons which in turn pull on bones. The difference of course is that a string puppet only works because of outside forces. It cannot provide its own energy.
- 7 Muscles can only contract, resulting in a pulling action. They cannot push. As a result, one muscle is needed to bend the bones at a joint, and another muscle is needed to straighten it.
- 8 The only bone of the skull which moves is the lower jaw bone.
- 9 There are more than 200 joints in the human body, but not all of them are movable, though. There are a number of joints in the skull and pelvis, for example, which are immovable.
- 10 The muscles over which we have no control include the heart, and the muscles which push the food through the digestive system. Each hair also has a tiny muscle attached, which can make the hair 'stand on end'. We cannot control any of these muscles.
- 11 Other animals which make a tube around themselves include peacock worms and sand mason worms on the seashore, and the larvae of caddisflies (see page 29 of Course Book 1) in fresh water. Although not all of them produce tubes as such, corals could also be included here.

Doing

- | | |
|-------------------|---------------------|
| 1 skull – g | backbone – b |
| ribs – j | thighbone – f |
| shoulder bone – a | lower leg bones – i |
| collar bone – d | upper arm bones – h |
| knee-cap – c | lower arm bones – k |
| hips – e | |

Arms and legs are built on a similar pattern with one bone down to the elbow or knee joints, and then two thinner bones running parallel down to the wrist or ankle joints. Hands and feet are also built on the same basic pattern.

- 2 On most people each upper arm bone is longer than the lower arm bones. Likewise, the thighbone is usually longer than the two lower leg bones. However, there are exceptions, and this is another good example of the way in which people differ.

- 3 The ways in which a fish is adapted to moving through water include its streamlined body, overlapping scales, fins for steering and keeping the fish upright, and the flattened tail to propel it through the water.
- 4 **SAFETY PRECAUTION:** for this activity, it is essential that the pieces of wood are smooth and free from splinters and sharp edges. If in doubt, wrap strips of cloth around the pieces of wood to be used. Ensure that the tapes are not tied too tightly.
The children will find that it is much more difficult to move with their elbow and knee joints immobilised.
- 5 a The earthworm and jellyfish are examples of *invertebrates*.
b Animals with an internal skeleton and a backbone are called *vertebrates*.
c Each bone in your backbone is called a *vertebra*.
d Your *ribs* protect your heart and lungs.
e When a muscle *pulls* it becomes shorter and fatter.
f The knee and elbow are examples of *joints*.
g Bones are made of *calcium*.
h All the bones in your body make up your *skeleton*.
i The *skull* protects the brain.
j The soft, fatty substance inside bones is called *marrow*.

Going further

Cutting a bone in half (page 57)

SAFETY PRECAUTIONS: Ensure that the children wash their hands thoroughly after touching the bone. Strict supervision will be necessary when sawing the bone in half. Ideally the bone should be fixed in a vice or clamp before cutting. If these are not available, maybe the local butcher will cut the bone for you.

Collect bones

SAFETY PRECAUTIONS: Again ensure that the children wash their hands thoroughly after handling bones. It is a wise precaution to discourage the children from bringing to school bones of doubtful origin, or the carcasses of dead animals.

Other suggestions

- 1 Ask the children to find out which muscles they use in writing or drawing. (Those in the forearm below the elbow.)
- 2 Observe and compare the movement of pets and other domesticated animals.
- 3 Study the movement of fish in an aquarium.
- 4 Study an earthworm as it moves across a sheet of paper. Observe how its muscles contract and relax, altering the shape of the body. If possible, place an earthworm on a smooth surface, such as glass or Formica and observe the difficulty the worm has in moving when it is not able to grip with the bristles on each of its segments.
- 5 Make and fly model aircraft, gliders and kites.

Interdisciplinary activities

Art and craft

Models of skeletons and animal homes.
Model aircraft, gliders and kites.

Collages of birds, insects and flight.
Bird mobiles.
Making string puppets.

English

The Snow Goose by Paul Gallico.
Jonathan Livingston, Seagull by R. Bach.
Kes by B. Hines.

Geography

Physical differences between people of different races and from different climates, eg. Eskimos, pygmies.
Fossil skeletons and the work of palaeontologists.

Health and hygiene

Broken bones and X-rays.
First Aid.
Calcium and healthy bones and teeth.
Proteins and body-building.
Exercise, muscle tone and posture.

History

People and the use of the muscle power of animals throughout history.
Prehistoric animals and fossils.

Mathematics

The speed and distance travelled by animals on land, in the water and in the air.
Athletic and sporting records.

Music, Drama and PE

'Dry bones' (traditional song).
Exercise and body-building.
A string puppet theatre.
School records for athletics events.

Religious education and social studies

Birds of the Bible.
Insects of the Bible.
Plagues of locusts.
The story of Samson.
Rickets and poor living conditions.

Unit 8: Pushing, pulling, sliding, rolling

Aims of the Unit

- To demonstrate the nature of forces.
- To show that weight is a force caused by the way in which the Earth pulls an object downwards.
- To examine some of the properties of the resisting force known as friction.

Science background

The concept of force is a basic one of physics. It is difficult to define what a force is, and some of the textbook definitions are almost incomprehensible. But for our purpose here we can simply define force as being 'any push or pull'. It is much easier to say what a force does, rather than to say what it is, and there are many examples around us which show the properties of forces. For instance, a force acting on an object may change its size or shape (eg. squeezing a lump of clay), or it may set it in motion (pushing a small trolley). If the object is already in motion, a force will change the speed or direction of that motion (eg. applying the brakes on a car). Even weight is a force. It is the force with which the Earth pulls an object

downwards. The force of attraction of the Earth, sometimes called the pull or force of gravity, is the weight of the object.

Forces always exist in pairs. When you push a heavy box, it pushes back at you with an equal but opposite force. If the box moves, it does so because your feet exert a force against the ground, and the ground exerts an equal but opposite force against your feet. If that force is greater than the force exerted by the weight of the box on the ground, the box will move.

Another kind of force is friction. It is a rubbing action between two surfaces and it tends to make moving objects slow down. Even a bullet moving through the air, and a speedboat slicing through the water, experience friction. However, friction also tends to prevent stationary objects, like the large box described above, from starting to move when they are pushed or pulled. Friction tends to retard movement and to waste energy. It also causes wear. In machine parts we try to reduce this frictional wear as much as possible by the use of oil and other lubricants.

However, friction also has its uses as, for example, when we walk. In this case the friction between our shoes and the floor enables us to push downwards and backwards against the floor. At the same time, the floor pushes upwards and forwards against our shoes. The two forces are opposite in direction but equal in strength. Without them it would not be possible to walk or run. The brakes of cars, bicycles and other vehicles work because of friction, and it is also this force which enables the tyres of vehicles to grip the road and the wheels of railway rolling stock to grip the track.

Whenever objects slide or roll past one another, the friction between them changes some of the energy of movement into heat. This heat is another waste of energy. Friction is very much reduced not only by lubricants, but also by the use of wheels or rollers.

Books for the children

The Young Scientist Investigates: *Energy* by Terry Jennings (OUP).
Science in a Topic: *Moving on Land* by Doug Kincaid and Peter S. Coles (Hulton).
Science in a Topic: *In the Air* by Doug Kincaid and Peter S. Coles (Hulton).

Books for the teacher

Science 5/13: *Structures and Forces* (Macdonald Educational).
Science 5/13: *Change* (Macdonald Educational).
Science 5/13: *Science from Toys* (Macdonald Educational).
Experiencing Energy: *Book 1 Moving Things* (The Association for Science Education).

Materials and organisation

Children have a genuine interest in moving things. The work on this topic will be greatly enhanced if every opportunity is taken to examine model cars, toy trains and other moving everyday objects to see what pushes and pulls are involved in their actions.

Materials and equipment:

ping-pong balls
drinking straws

plasticine
 rubber bands
 pencil erasers
 sheets of paper
 magnets
 steel ball-bearings
 toy cars
 paper clips
 elastic
 string
 yoghurt pots
 cup hooks
 a plank of wood
 strips of card
 Sellotape
 10 g weights
 marbles
 conkers
 long nails
 bricks or pieces of concrete
 spinning tops
 washing-up bowls
 2p coins
 ribbon
 Lego bricks and wheels
 rulers

Forces (pages 58–59)

Lesson objectives

- To examine some examples of forces, and to show that a force has strength and direction.
- To show that forces can change the speed and direction of the movement of an object.
- To show that not all forces cause changes in movement, but that some change the shape or size of objects.

Setting the scene

Possible starting points include:

- A collection of pictures showing moving objects.
Discuss with the class whether pushes or pulls are involved.
- Experiment with a toy train and measure the maximum weight of trucks or carriages the engine can pull.
- Experiment with inflated balloons. Discuss with the class why a balloon will travel across the room when the air inside is released.
- Bring a bicycle into the classroom and examine it to find out how it works.
- Consider where the forces in playground see-saws, roundabouts and slides come from.

New words

Forces – a general name for pushes and pulls of all kinds.

Class management

Apart from studying the forces exerted by a bicycle, the work on this topic can be carried out by the children at their own desks.

Safety precautions

If the activity to study the forces exerted by a bicycle is carried out, to avoid accidents it is best to choose a relatively small bicycle so that the rider's feet will touch the floor easily and comfortably.

Answers to questions in the text

Pushes and pulls (page 58)

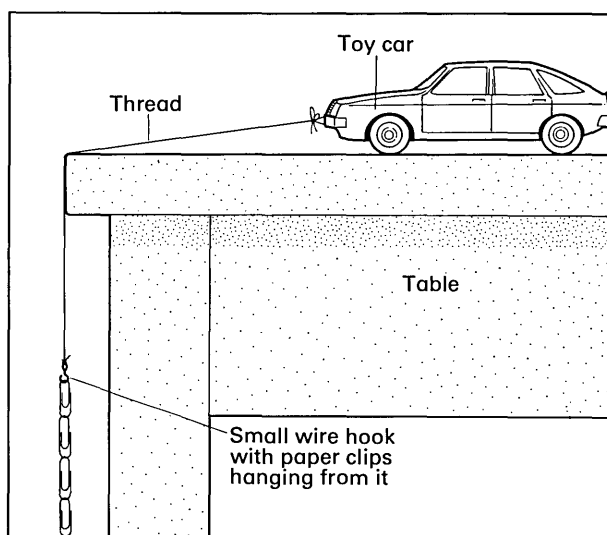
The picture shows a car being *pushed*, an earth-moving machine *pushing* a heap of soil, a child throwing a ball (a kind of *pushing*), and the hot gases coming from the engines of a jet aircraft *pushing* it into the air. In addition, there is a blackbird *pulling* a worm from the ground and a toy engine *pulling* two carriages.

However, it should be remembered that for each push there is a push of equal strength in the opposite direction, and for each pull there is an equal but opposite pull, e.g. the child attempts to push the car forwards, and the car pushes back at the child. Similarly, the engine pulls the carriages forwards, and the carriages pull back on the engine.

We can gain some indication of the strength of forces by looking at the size of the object being pushed or pulled, and the speed with which it is moved. In the picture the strongest force is probably that created by the engines of the jet aircraft. The weakest force is probably that of the blackbird pulling the worm.

Now try these

- During a tug-of-war contest the main forces are pulls and friction. Each side tries to pull towards it the weight of the opposing team and the rope. Each side also has to try to overcome the force created by the rubbing action or friction (see pages 62–63) of the feet of the opposing team.
- The force with which gravity (the pull of the Earth) pulls on an object is called the *weight* of the object. As a result, when we weigh something on a pair of scales, a spring balance or a weighing machine, we are measuring the force with which the Earth's gravity pulls on that object.
- A simple way to measure the force necessary to move a toy car across a table top would be to attach a spring



balance to the front of it, and to read the force (in grammes) necessary to move the car. Alternatively, a thread could be tied to the front of the car and hung over the edge of the table. A small wire hook is tied onto the thread. Weights (eg. paper clips) are hung on the hook until the car just starts to move.

- 5 This experiment is similar to the one with the bicycle described on page 59. The greaseproof paper is laid on a smooth floor, and the piece of card is rested on it. If a child stands on the card, the force (his weight) is acting downwards. As the child strides forwards, the piece of card slides back, showing that part of the force is now pushing backwards.

Expected results of activities and experiments

Changing the direction of a ball (page 58)

The force of the air coming out of the straw pushes the ball and makes it start to move. When the ball is moving, it can be stopped by blowing at it from the opposite direction to that in which it is moving. The harder the ball is blown, the faster it will move. The ball can be made to slow down by ceasing to blow it, or by blowing gently in the opposite direction to that in which it is moving. The ball can be made to change direction by blowing it from the side.

When the ball is allowed to run off the edge of the table, the change in direction of movement takes place immediately it is over the edge of the table. Since the ball now moves downwards, a new force must be either pushing or pulling it towards the floor. (In fact it is the pull of gravity which makes the ball fall downwards.)

Not all forces cause changes in movement (pages 58–59)

The plasticine can be squashed into a ball or almost any other shape, pulled out so that it is long and thin, or broken into many pieces.

The rubber band can be pulled so that it stretches. If it is stretched enough then the rubber band may break. Being elastic, the rubber band will resume its original shape and size if it is stretched slightly and then released.

A pencil eraser can be bent and, if the person is strong enough, stretched or broken.

A sheet of paper can be crumpled into a ball or torn into many pieces.

Studying the forces exerted by a bicycle (page 59)

When the bicycle is standing upright, it is pushing downwards. You may be able to tell because the piece of card buckles slightly under the weight of the bicycle. In any case, very little effort is required to hold the bicycle steady.

If, while one child holds the bicycle steady, the other turns the pedals with his or her *hands*, the rear wheel of the bicycle will turn, pushing the piece of card backwards. This shows that, while the bicycle's weight is still pushing downwards, it is also now pushing backwards. If the bicycle was free to go, it would move forwards.

If a child now sits on the bicycle seat, the downward force would be the weight of the bicycle plus the weight of the child. If the child pedals the bicycle it will move forwards but because of the greater weight involved, the card may be held in place rather than sliding backwards.

The force of a magnet (page 59)

How near the magnet has to be brought to the steel ball-bearing to make it move, depends upon the strength of the magnet. Once the ball-bearing is moving, it can be stopped by holding the magnet on the opposite side of the ball-

bearing to the direction in which it is moving.

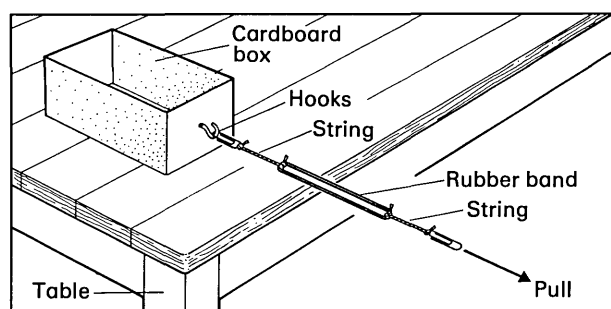
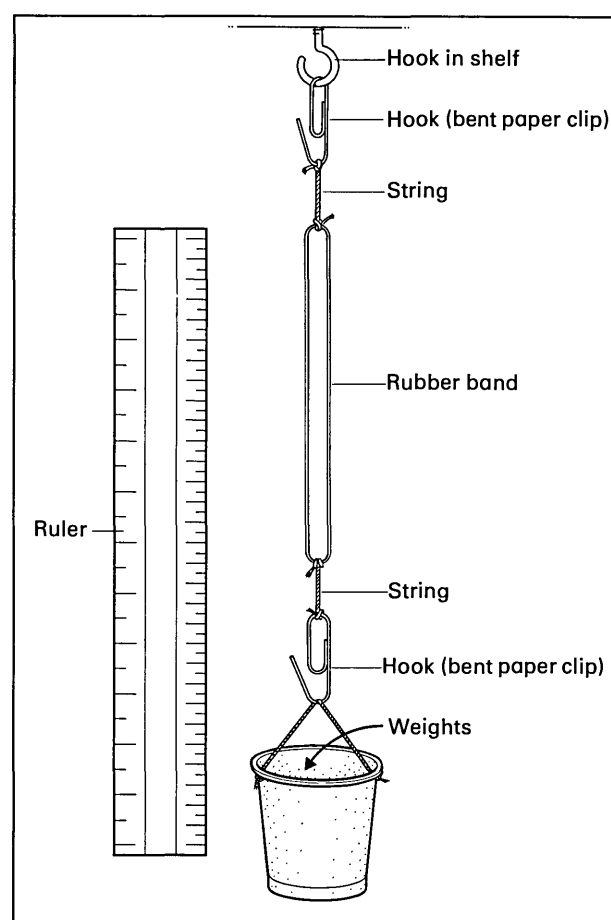
It is easiest to make the ball-bearing go faster or slower or to change direction, if the magnet is held underneath a table top or sheet of card or hardboard on which the ball-bearing is resting.

Extending the learning

1 *Comparing the strengths of forces*

What you need: Some large rubber bands (all the same size); a pair of scissors; thin string; paper clips; a ruler; two identical small boxes; small wooden blocks; round pencils; toy cars; two boards, both the same size; two spring balances.

What you do: Tie a piece of string tightly to each end of two rubber bands. Make hooks from two paper clips, and tie one to each rubber band as shown in the picture.



Use the rubber bands to make fair tests of different forces. See how much each force makes the rubber bands stretch. Measure the rubber bands with a ruler.

The more the rubber band stretches, the greater the force pulling on it.

Compare the forces needed to make the two cardboard boxes slide. Have one box empty and the other loaded with small wooden blocks.

Put the same weight of wooden blocks in both boxes. Compare the forces needed to move the two boxes when one box is sliding and the other one is rolling on round pencils. Which is easier, rolling or sliding?

Compare the forces needed to pull a toy car along the table and to lift it straight up.

Try pulling identical toy cars up sloping boards, one steeper than the other.

In each part of the experiment, say why there is a difference in the strength of the forces.

(Expected results: This experiment depends upon the elasticity of rubber bands. Strong rubber bands will be needed and they should not be stretched beyond their elastic limit. Spring balances or strong elastic could be substituted for the rubber bands.

The small box loaded with wooden blocks requires a bigger force to pull it along than does the empty box.

The box sliding along the table requires a greater force to pull it than the box which is rolling on round pencils.

It requires less force to pull a toy car along the table, when it is rolling on its wheels, than it does to lift the car straight up.

The steeper the slope, the greater the force which is required to pull a toy car up it.)

- 2 *Is it easiest to push an object along or to pull it?* It is not easy to give a direct answer to this. A lot depends upon how easy or difficult it is for the person or object doing the pulling or pushing to grip, ie. it depends upon the amount of friction. Experiment with the number of trucks or carriages a toy engine can push and pull. On the playing field you could also experiment with a heavy grass roller.
- 3 *Which balls are the best bouncers?* See page 29 of *The Young Scientist Investigates: Materials* by Terry Jennings (OUP).
Further experiments and activities will be found in *The Young Scientist Investigates: Energy* by Terry Jennings (OUP).

Gravity (pages 60–61)

Lesson objectives

- a To show that the Earth pulls objects towards it, with the force we call gravity.
- b To demonstrate that the greater the mass of the object, the greater the force of gravity on it.
- c To show that the downward force an object exerts is called its weight.

Setting the scene

Possible starting points include:

- 1 Weigh different objects, and ask the class what causes objects to differ in weight.
- 2 Repeat Galileo's experiment, on a smaller scale.
- 3 Display different kinds of weighing machines, manufactured and home-made, on the Science Table.

- 4 Hold contests on the playing field to see who can throw a ball the highest. Ask the class why the ball comes down again instead of going up and up.

New words

Gravity – the pull or attraction between the Earth and any other object.

Class management

Gravity, like force, is a difficult abstract concept for children to grasp. However, although they cannot be expected to understand what causes gravity, the children can be exposed to as many examples as possible of the effects of gravity.

All of the work on this topic can be carried out by the children at their own desks.

Safety precautions

Care is necessary, to avoid injury to onlookers or damage to property, if Galileo's experiment is repeated or if experiments are carried out to see how high balls can be thrown.

Answers to questions in the text

Gravity (page 61)

The free-fall parachutists in the picture are being pulled down to the ground by the force of gravity. Their parachutes will ensure that the people fall slowly and do not hurt themselves.

It is the thrust of the hot gases coming from the rocket's motors which push it upwards away from the Earth. This thrust has to be greater than the pull of gravity if the rocket is to leave the Earth, and the motors have to burn for long enough to ensure that the rocket rises so high that it goes out of reach of the pull of the Earth's gravity.

Comparing the strength of forces when things fall (page 61)
The marble which fell 50 cm executed the stronger force on the mud. You could tell by the fact that it made a larger depression in the mud than the marble dropped from 25 cm.

If both marbles were dropped from the same height they would both hit the mud with the same force.

If a large marble and a smaller one were dropped from the same height, the larger one would hit the mud with the greater force, creating a bigger depression in the mud.

You could test the children's understanding of this experiment by asking them, if a brick was going to fall on their feet, would they rather it was a large one or a small one? Would they rather the brick fell from a height of 1 metre or 2 metres?

Now try these

- 1 The children should appreciate that what we call weight is the measure of the force of gravity on an object. An object weighed at sea-level and then again at the top of a high mountain, will show a slight loss in weight because the pull of gravity decreases the further from the centre of the Earth one travels.

While a spacecraft is on Earth, its occupants are subjected to the normal force of gravity. As the spacecraft rises higher and higher above the surface of

the Earth, the pull of gravity diminishes as the distance from the centre of the Earth increases. Eventually the pull of gravity on the astronauts is so remote that they feel absolutely weightless and objects in the spacecraft float around them.

- 2 If you dropped a stone and a coin at the same moment, they would hit the ground together because the pull of gravity on them is the same. However, a paper handkerchief has a large surface area in relation to its low weight, and would be affected by the resistance of the air more than the coin would. As a result, the coin would reach the ground first.
- 3 At this point it is probably not a good idea to go into the difference between mass and weight. It is sufficient for children to understand that weight is the downward force exerted by an object. The mass of the moon (its 'weight') is smaller than that of the Earth, and as a result its gravity is less (about one-sixth). By contrast, the sun is much larger than the Earth, and the pull of gravity there is 28 times that on the surface of the Earth. It follows from this that since the masses ('weights') of the other planets are different from that of the Earth, their gravities will also differ.
- 4 Air does indeed weigh something. The weight of the air is the cause of the force we call air pressure. If you lay a ruler on a table, with roughly half of the ruler projecting over the edge, the slightest touch on this end of the ruler will send it falling to the floor. If, however, the part of the ruler on the table is covered with a large sheet of thin card or a smoothed-out sheet of newspaper, much more effort is required to knock the ruler to the ground than is due simply to the weight of the card or newspaper. In fact, the force holding the ruler on to the table is the weight of the air pressing down on the card or newspaper.
It is also possible to weigh an empty balloon or beach ball, and then inflate it and weigh it again. The increased weight is due to the air inside. An accurate weighing machine is essential, though.
- 5 Bullets from guns do not travel in a perfectly straight line. Over a short distance they appear to travel in a straight line but, if it were possible to make a slow-motion film of a bullet it would be seen to travel through an arc, gradually moving nearer and nearer to the surface of the Earth under the influence of gravity.

Expected results of activities and experiments

Make a simple weighing machine (page 60–61)

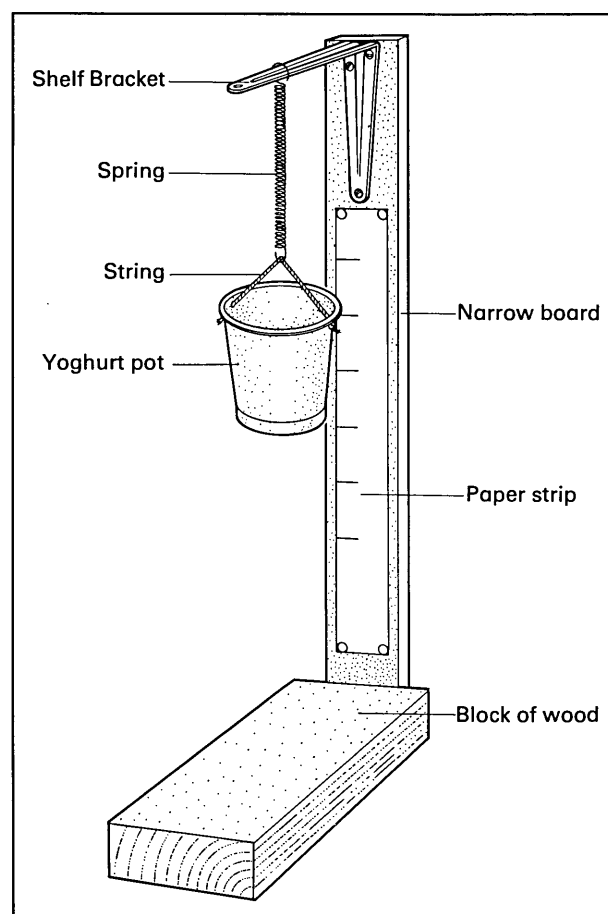
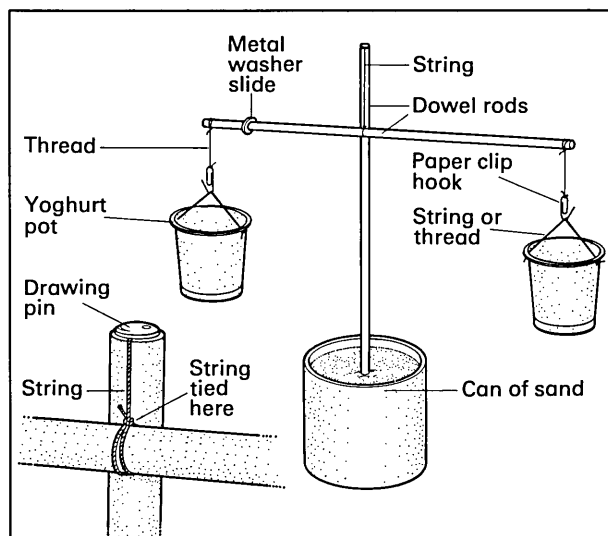
Up to a certain limit, known as the elastic limit, the more weight that is added to the rubber band or elastic, the more it stretches. It stretches in proportion to the weight of the objects added, so that each additional 10 g weight produces the same amount of stretch. Beyond the elastic limit, the rubber or elastic is permanently stretched and does not return to its original length when the load is removed. A spring balance uses the same principle as that demonstrated by this experiment, and if some springs can be obtained, the experiment could be repeated using these instead of rubber bands or elastic.

Extending the learning

- 1 Examine the various kinds of spring balances and scales. Find out how they work. Test the accuracy of the

different kinds of balances and scales by adding standard weights.

- 2 Encourage the children to make simple scales and balances like those shown below.



- 3 Investigate how much of a tablet of soap is used when the hands are washed. Which weighs more, a dry sponge or the amount of water it can absorb? (The water) What happens to the weight of a candle as it burns? (It decreases steadily, because particles of black carbon, water vapour and the gas carbon dioxide are produced and pass into the air.)

Friction (pages 62–63)

Lesson objectives

- a To show that friction tends to make a moving object slow down and stop. It also tends to prevent pushes and pulls from moving a stationary object.
- b To demonstrate some of the advantages and disadvantages of friction.

Setting the scene

Possible starting points include:

- 1 Ask the class what it is that holds certain objects in place, eg. a knot in a shoe lace, a picture hook in the wall, a screw in the door, the sheets of paper in a clipboard and the nut on a bolt.
- 2 In frosty weather, discuss with the class why it is difficult to walk on icy pavements or, at any time of the year, why it is dangerous to spill oil or drop banana skins on the pavement.
- 3 Set up a model train set and see how many trucks or carriages the engine will pull. Then rub a *little* oil or grease on the tracks and again see how many trucks or carriages the engine will pull (it will pull a smaller load because the engine wheels are unable to grip the track, since the oil or grease reduces the friction).
- 4 Ask the class why it is easier to move a heavy object on wheels or rollers than it is to slide it along (there is less friction).

New words

Friction – the rubbing or resistance when one object slides against another.

Class management

All the work on this topic, except for the experiment with the ramp and toy cars, can be carried out by the children at their own desks.

Safety precautions

The children should be warned of the possible dangers of playing with matches.

Answers to questions in the text

Friction (page 62)

Michael's car has the most friction since it travelled the shorter distance. It would be interesting to know whether Michael's car would travel further if the wheels were oiled, so reducing the friction.

If Carolyn and Michael put another book underneath the plank, both cars will go further because the pull of gravity on them is greater.

If Michael and Carolyn played this game on a carpet, instead of on a smooth floor, the cars would go a much shorter distance because of the increased friction of the carpet on the cars.

Friction slows moving objects (page 62)

It is not always easy to distinguish between sliding and rubbing. For instance, the bolt on the gate slides shut, but then it also rubs against its socket to keep the gate closed.

The car tyres rub against the road surface, while the car wheels turn on their axles.

The runners of the sledge slide across the snow, while the child's feet and body rub against the sledge.

As well as the bolt on the gate (see above), the parts of the hinges slide over each other when the gate is opened or closed.

The skates slide over the ice.

The feet of the boy trying to push the piano rub against the floor, while his body rubs against the end of the piano. The castors of the piano turn on their axles, a movement which, like the turning of the car wheels, is probably a combination of rubbing and sliding.

Friction makes heat (page 63)

When the hands are rubbed together on a cold day, the friction between the two layers of skin makes heat which warms the hands.

When a match is rubbed against the side of the box, the friction produces heat which causes the chemicals in the head of the match to catch alight.

Now try these

- 1 Everything which has moving parts, and all clothes, shoes etc, wear out because of friction, given sufficient time and use.
- 3 The tip of a nail rubbed backwards and forwards across a piece of concrete feels hot because of the action of friction.
- 4 As a spacecraft enters the Earth's atmosphere it becomes very hot – indeed red hot – because of the friction of the air on the spacecraft. The American Space Shuttle is covered with ceramic tiles over its aluminium body. These are able to withstand temperatures as high as 1260°C, and they insulate the occupants of the spacecraft from the tremendous heat. In addition, the nose of the spacecraft and the leading (front) edges of its wings, which get the hottest of all during re-entry, are insulated with a special carbon material that protects them up to 1650°C.
- 5 When you write or draw with a pencil, you are using a pushing force to hold the pencil against the paper. The friction between the paper and the point of the pencil causes the point to wear away, leaving a mark on the paper. In this sense friction is being useful, although if the person writes or draws for a long time, it is the need to press on the pencil to create the friction which makes his hands tired. The pencil has to be sharpened from time to time because friction has worn away the point.

Extending the learning

- 1 *Will a marble spin longer in air or in water?* Spin a marble on the bottom of an empty bowl. See how long it spins. Now put water in the bowl to a depth of about 1 cm. Spin the marble in the bowl again. How long does it spin? Is it more or less than before? Now put about 2 cm of water in the bowl and spin the marble again. How long does it spin? Half fill the bowl with water and spin the marble again. How long does it spin?

To see what is happening to the water, spin the marble in the bottom of a bowl containing about 2 cm of water and quickly sprinkle a little talcum powder on the surface of the water while the marble is still spinning. What happens?

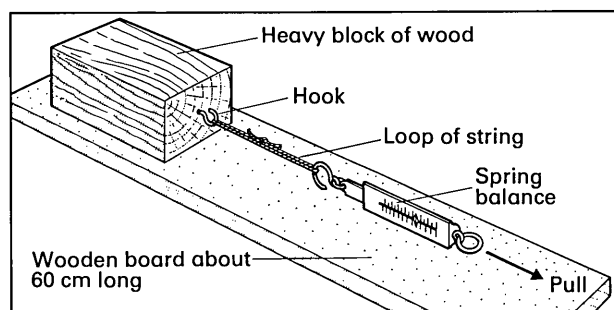
(Expected results: How long the marble spins depends upon how hard the child twists it, and how smooth the marble and the bottom of the bowl are. But the marble will probably spin longer in the air than in the water, because there is less friction between the marble and the air than there is between the marble and the water. When talcum powder is sprinkled on the surface of the water, the children will notice that the water is turned by the spinning marble. The deeper the water, the more water the marble has to turn.)

- 2 *Is there less friction with some materials than with others?*

What you need: A spring balance; a wooden board about 60 centimetres long; string; a heavy block of wood with a screw eye, hook or bent nail in one end; sand; sandpaper; drawing paper; polythene sheet; drawing pins; oil; water.

What you do: Tie a short loop of string to the hook or screw eye in the wooden block. Place the block at one end of the board.

Use the spring balance to pull the string so that you can measure the force needed to pull the wooden block to the other end of the board.



Use drawing pins to fasten a sheet of polythene over the board. Repeat the experiment. What force is needed to pull the block of wood to the end of the board? Is it more or less than before?

Now repeat the experiment on other surfaces including paper, sandpaper, a sprinkling of sand on the board, and water. You could also thinly smear the surface of the wood with oil.

Is there less friction in some materials than others? If so, which surfaces have the most friction, which have the least?

(Expected results: The children will find that different surfaces do have different amounts of friction. The most force will be needed to move the block over sand or sandpaper. If the board used is already smooth, then wetting it with water or oil will reduce its friction still further.)

If a heavy block of wood is not available, a brick could be rested on a block of light wood for this experiment. Alternatively a wooden or cardboard box containing building blocks, stones or marbles could be used.)

- 3 Investigate sailing boats and the streamlining of boats. (See pages 13 and 30 of *The Young Scientist Investigates: Energy* by Terry Jennings (OUP)).
Investigate paper darts. (See *The Young Scientist Investigates: Air* by Terry Jennings (OUP)).

Checking (pages 64–65)

Thinking

- Because of the pushing action of the racket, the tennis ball goes faster.
By cupping his hands in front of the descending ball, the cricketer slows up and stops the ball. In a sense, he is pushing the cricket ball to slow it down.
A change in the level of the rocks makes water cascade over the waterfall. It is the pull of the Earth's gravity which makes the water drop down to its new level.
- The boy will move forwards, away from the wall. The wall doesn't move because of its enormous weight and because it is fixed all round. Although the children may find this hard to believe, the wall pushes the boy as hard as he pushes the wall.
- In cold snowy weather, a sledge slides easily over the surface of the snow, because the snow immediately underneath its runners turn to ice because of the weight of the sledge. By contrast, wheels have to push their way *through* the snow, and they no longer turn so easily or grip as efficiently as on a dry, firm surface.
- Traffic lights and road signs are not in themselves forces. They merely instruct drivers and riders to take actions which involve the application of forces on the steering wheel or handlebars, brakes or pedals of their vehicles. These forces in turn cause the vehicles to change speed or direction.
- Assuming that both are of a convenient size to hold in the hand, the 100 gramme ball could be thrown the highest, since less force is needed to propel it than is needed for the 200 gramme ball.
- The men on the parachutes are pulled to the ground by the Earth's gravity. When the parachutes open the resistance of the air slows up the parachutes so that the men do not fall too quickly and hurt themselves.
- Grit is often spread on roads during icy weather to increase the friction between the wheels of vehicles and the road surface. This enables the wheels to grip better.
- The heat produced by the friction between the hands and the rope when sliding down the rope, is sufficient to burn the hands badly.
- When a tiled floor is wet, the friction between the soles of shoes and the floor is reduced, so that it is easy to slip and fall.
- The boy could move the heavy box more easily if he placed it on wheels or rollers.
- By fixing a length of hose to the tap, Mr. Brown had increased the distance the water had to travel. This increased distance results in greater friction between the running water and the sides of the hose, and consequently reduces the rate of flow.
- By crawling over sand in a zig-zag fashion, the snake increases the friction between its body and the sand, and is thus able to sustain a better grip.
- The runner has spikes on her shoes to enable her to obtain a better grip on the ground (ie. to increase the friction). She uses the starting blocks to push against, when she lunges forward at the start of the race. The harder the athlete pushes on the starting blocks, the harder they push back, and the quicker the start to the race.

Doing

- 2 A top will spin for a shorter time under water than it will on a dry surface, assuming the force used to start it was the same in both cases. The difference is because there is greater friction between the water and the top, than there is between the air and the top.
- 3
 - a Pushes and pulls are called *forces*.
 - b Forces can make things move faster or *slow* them down.
 - c Forces can make things change *direction*.
 - d Forces can *change* the shape and size of things.
 - e Things have weight because of the force of *gravity*.
 - f Friction is another name for *rubbing*.
 - g Wheels and rollers *reduce* the amount of friction.
 - h When things are rubbed against each other, they usually become *warmer*.
 - i A large ball and a small ball dropped from an open window will hit the ground *together*.
 - j Oil and grease are *slippery* substances that reduce friction.

Going further

- 1 Sellotape the end of a piece of ribbon to a 2p coin. Wrap the ribbon around the coin. Throw the coin and the ribbon. How far do they go? Now throw the coin and ribbon again. This time do not wrap the ribbon around the coin. How far do the coin and ribbon go this time? Is it more or less than before? Why is this? (Assuming the force of the throw is equal in both cases, the coin will travel less far when the ribbon is trailing behind the coin, because of the increased friction between the coin and ribbon and the air.)
- 2 Which is easier, sliding or rolling?
What you need: Some Lego bricks and wheels; a yoghurt pot; some thin string; some weights (or marbles will do); a ruler.
What you do: Make a small trolley using Lego bricks. Then take the wheels off it and put them inside the trolley.
Put the trolley exactly 60 centimetres from the edge of the table. Fix the string and yoghurt pot to it. See that the pot hangs over the edge of the table.
Add weights, one at a time, to the yoghurt pot. How many weights do you have to add to make the trolley *slide* to the edge of the table?
Fix the wheels back on the trolley, and again put it 60 centimetres from the edge of the table. Add weights to the yoghurt pot. How many weights do you have to add to make the trolley *roll* to the edge of the table? Is it more or less than before?
Which is easier, sliding or rolling? Why, at the beginning of the experiment on sliding, were the wheels put inside the trolley? Could they not have been left on

the table?

(Expected results: rolling is easier than sliding, ie. fewer weights are needed to move the trolley. The wheels are put inside the trolley to ensure that the weight of the trolley is the same in both parts of the experiment, in other words to ensure that the experiment is *fair*. This and similar experiments could also be carried out using a spring balance to pull the trolley along. The weight needed to move the trolley can then be read directly from the balance.)

- 3 Experiment with parachutes. See The Young Scientist Investigates: *Air* by Terry Jennings (OUP).

Interdisciplinary activities

Art and craft

Working models.
Drawings of cars, bicycles and railway engines.
Friezes of transport through the ages.

English

Chitty, Chitty, Bang, Bang by Ian Fleming.
Three Men on the Bummel by Jerome K. Jerome.
Around the World in Eighty Days by Jules Verne.

Geography

Transport in developed and undeveloped countries.
Methods of transport in different climates.
The force of the wind and the Beaufort Scale.
The tides and the moon.

Health and hygiene

Road safety.
Exercise, muscle tone and posture.

History

Humans and the muscle power of animals.
The wheel.
19th century inventions: railways, bicycles and cars.
Famous names in transport – Ford, Daimler, Benz, Diesel.
Mangonels, catapults, bows and arrows and other siege weapons.

Mathematics

Speed, distance, time and acceleration calculations.
Traffic counts.
Braking and thinking distances of drivers and motor vehicles.

Music, drama and PE

Coronation Scot by Eric Coates.
Dramatised stories of Marco Polo, Gulliver, Scott of the Antarctic, etc.
Field and track events in athletics.
The use of starting blocks in track events.
Ball control in football, hockey etc.

Religious education and social studies

Methods of transport in the Bible lands.
Pilgrimages.

Theme: Change

Unit 9: Sun, moon, stars and planets

Aims of the Unit

- a To show that the sun is a star, and that the orbit of the Earth around the sun causes the changes we know as night and day.
- b To describe how observations made from the Earth and from space missions have taught us many things about the moon.
- c To examine the differences between stars and planets.

Science background

The study of the stars and planets – astronomy – is the oldest science. Throughout history, people have studied the changes which take place in the skies above.

Stars seem to form recognisable patterns, or constellations, in the sky, and these slowly turn during the night. In addition the star positions seem to change from one night to the next. We now know that it is not the stars which are turning, but the Earth itself.

Although the stars are much too far away for it to be possible to send space probes to them, by analysing the light which comes from the stars, scientists can determine what they are made of and what their temperature is. Most stars have been found to consist largely of hydrogen gas, together with a good deal of helium and other elements, and all give off tremendous amounts of light and heat. One star is much closer to us than all the others. This star is our own sun. The energy which the sun pours out as heat and light comes from nuclear processes, rather like those which occur when an atomic bomb explodes. Although the sun is the nearest star to the Earth, it is still 150,000,000 kilometres away. The other stars are much further away, and the light from many of them takes years, sometimes hundreds of years, to reach us.

Also in our solar system are nine planets, of which the Earth is one. Each of these planets moves in its own orbit around the sun. As the Earth orbits the sun it also rotates on its own axis, an imaginary line through the centre of the Earth between the two poles. One complete rotation of the Earth on its axis takes 24 hours, and produces the changes we know as night and day. The Earth takes one year to complete a single orbit of the sun. As a result of the Earth's passage around the sun, we have the changes we call the seasons. These are caused by the fact that the

Earth's axis is tilted about 23.5° from the perpendicular. For part of the year, the North Pole is tilted towards the sun, while the South Pole is tilted away from it. At that time, places in the southern hemisphere experience the short days and lower temperatures of winter, while the northern hemisphere has summer. Six months later, the North Pole is tilted furthest away from the sun, while the South Pole is at its nearest to the sun. The southern hemisphere then experiences summer, while in the northern hemisphere it is winter.

Several of the planets have satellites or moons. These moons, like the planets themselves, shine because they reflect the sun's light. Our own moon takes a month to orbit the Earth. That explains why the phases of the moon occur in a regular sequence every 29.5 days. It is this orbit of the moon which also makes it difficult for spacecraft to travel there from the Earth. The journey takes three days, and to reach its moving target, a spacecraft has to aim for the spot in space where the moon will be three days after the spacecraft was launched.

Books for the children

The Young Geographer Investigates: *Our Universe* by Terry Jennings (OUP)

Let's Investigate: *Sky and Space* by Susan Blackford (Blackie)

The Young Scientist Book of *Stars and Planets* (Usborne)

The Young Scientist Book of *Spaceflight* (Usborne)

The Young Scientist Investigates: *Light and Colour* by Terry Jennings (OUP).

Books for the teacher

Science 5/13: *Time* (Macdonald Educational)

Science 5/13: *Change* (Macdonald Educational)

Science 5/13: *Using the Environment: 1 Early Explorations* (Macdonald Educational)

Astronomy Today by Dinah Moché (Kingfisher Books)

Materials and organisation

Practical work on this topic is vital, and it may be necessary to set the children the task of observing the moon, stars and planets for homework. In this case, they will have to be warned not to go out at night unless in the company of a responsible adult. Alternatively, a visit to a planetarium will provide valuable secondhand experience of the heavenly bodies.

Materials and equipment:

pictures of parts of the solar system, spacecraft, rockets etc.
thermometers
balloons
large and small torches
candles
black paper
salt
blackboard chalk
large pieces of card
a globe
a desk lamp
plasticine or Blu-tack
pins or matchsticks
hand lenses or magnifying glasses
cardboard tubes, cardboard boxes or large tins
masking tape
rubber bands
silver paper
glue
shoe box lids, or similar
star charts cut from national newspapers

Sunshine and shadows (pages 66–67)

Lesson objectives

- To examine the changing length and position of shadows during the day as the Earth turns on its axis.
- To describe the structure of the sun and its role in providing most of the Earth's energy supplies.
- To show how the rotation of the Earth on its axis leads to the changes we call night and day.

Setting the scene

Possible starting points include:

- Study the length and position of shadows throughout the day, as described on page 66 of Course Book 1.
- Examine a sundial and try to tell the time by it.
- Record the temperatures in the playground in sunshine and in the shadows.
- Make a display of pictures on the Science Table showing sunrises and sunsets.
- Make a study of those animals which are active by day (diurnal), and those which are active at night (nocturnal).
- Make a shadow theatre.

New words

Vitamin – a substance which helps to keep us healthy. Vitamins are named after letters of the alphabet. We need only tiny amounts of each vitamin.

Class management

Of necessity, the experiment on studying the length and position of shadows can only be done outside on a fine, sunny day. The remaining work can be carried out by the children at their own desks.

Safety precautions

The children should be warned never to look straight at the sun, as this can damage the eyes or even lead to blindness. It is even more dangerous to look directly at the sun through binoculars or a telescope.

Answers to questions in the text

Sunshine and shadows (page 66)

Neither of the children was completely correct. The Earth does travel around the sun, as Richard said, but it takes a year for the Earth to complete one orbit of the sun. In fact, the shadows move because the Earth spins on its own axis once every 24 hours, so that while some parts of the Earth are in sunlight (daytime), other parts are in shadow (night-time).

It is possible to tell the time on a sunny day using shadows, simply by repeating the experiment carried out by Judy and Richard. If the time when the stick made each shadow is recorded, then on subsequent sunny days it will be possible to tell, by the position of the shadow of the same stick, approximately what time it is. This is the principle behind a sundial.

The sun (pages 66–67)

A deficiency of vitamin D in the diet can lead to the disease of the bones and teeth known as rickets. This disease was once common in the industrial slums of cold cities, where tall buildings and smoke and other forms of atmospheric pollution prevented the sun's rays reaching the people's skins. Rickets can still occur in Britain amongst the people of Asian origin who wear long clothes which block sunlight from the skin. Certain foods also contain vitamin D, including cod-liver oil, milk, butter, cream, egg-yolk and liver, while margarine has vitamin D added to it during its manufacture.

Night and day (page 67)

The beautiful colours of sunrise and sunset are caused by dust particles and water droplets in the atmosphere. When the sun is at a low angle to the Earth, its rays have further to travel to reach us, and the rays are scattered by the dust and water droplets. Only the red and yellow rays of light reach our eyes. The sun itself may appear like a crimson sphere. The sunsets and sunrises over sandy deserts are often spectacular, because of the amount of dust in the air, and brilliant sunsets occur after dust storms and volcanic eruptions, even hundreds of kilometres away.

Now try these

- The time given by a sundial in summer is always an hour slow by our clocks and watches, because in summer British Summer Time is in force, and our clocks and watches are advanced by one hour.

The disadvantages of using a sundial for telling the time are that it is not portable, it is not accurate, and it can only be used when the sun is sufficiently bright to cast a shadow. A sundial cannot be used at night or in cloudy or overcast conditions.

- The sun will appear to rise in an easterly direction and to set in a westerly direction.
- The average temperature on the surface of the sun is about 6000°C, and there is little variation in this average temperature throughout the year. We experience differences in the heat of the sun because of variations in the distance of the sun from the part of the Earth

where we live, and because of differences in the angle at which the sun's rays strike the surface of the Earth.

- 4 A patch of sunlight on the floor or wall of the classroom will move as the Earth orbits the sun.
- 5 The thermometer under the black paper will show the highest temperature because black and dark colours absorb the sun's rays, while white and light colours reflect the sun's light and heat.

Extending the learning

- 1 *Night and day* It is possible to demonstrate to the children why we have night and day, if you obtain a globe and a powerful torch or a desk lamp. It will be necessary to work in a dark corner, or to draw the curtains if this is possible.

Shine the light from the desk lamp or torch on to the globe from the side. Turn the globe slowly in an anticlockwise direction. Let the children see how each country gradually moves into the light. Ask them to notice where it is dawn, where it is day, where it is dusk, and where it is night.

Stick a small piece of plasticine or Blu-tack on the part of the globe where the school is situated. Stand a pin or a matchstick in the plasticine or Blu-tack. Slowly turn the globe anticlockwise. When it is roughly midday at school, where else in the world would it be daytime? Where would it be midnight?

- 2 *Focusing the sun's rays* Normally the sun's rays spread out as they reach the Earth's surface. The children can make some of the sun's rays move towards each other, or converge, by using a hand lens or magnifying glass. The sun's rays will then form a very bright, hot point of light.

The children should hold the lens a few centimetres above a sheet of paper. See that the upper surface of the lens is pointing towards the sun. They should then slowly raise or lower the lens until there is a small bright point of light on the paper. If the children hold the lens steady, after a few seconds the sun's rays may burn a small hole in the paper.

This experiment demonstrates why it is dangerous to stare at the sun. The lens in each eye will focus the sun's rays on the back of the eye, and burn the delicate tissue there. Binoculars and telescopes will focus the sun's rays on the eyes in the same way. Discarded glass can also act like a lens, and can start a fire by focusing the sun's rays on paper or dried grass.

Further activities and experiments involving light and colour can be found in *The Young Scientist Investigates: Light and Colour* by Terry Jennings (OUP).

The moon (pages 68–69)

Lesson objectives

- a To explain the reasons for the moon's changing shape, or phases.
- b To describe the problems involved in reaching and exploring the moon.

Setting the scene

Possible starting points include:

- 1 A discussion on, or a display of pictures of, the latest moon landing or space probe.
- 2 Ask the children why people were unable to visit the moon before 1969. (The rockets and suitable fuels, space capsules, spacesuits, life-support systems, and suitable controls and computers had not been developed.)
- 3 Ask the children why we normally see the moon only at night. (The moon has no light of its own, but reflects the light from the sun.)
- 4 A visit to an observatory or planetarium.
- 5 A discussion of early ideas on how space travel might be possible eg. Bishop Godwin's swan-powered vehicle described in his book *Man in the Moon*, published in 1638, hot-air balloons in the 18th century, or Jules Verne's 19th century idea of a space capsule being fired from a large cannon.

New words

Astronaut – a member of the crew of a spacecraft.

Atmosphere – the huge layer of air around the Earth.

Crater – an enormous hole in the ground or in the surface of the moon or one of the planets.

Reflects – when light or heat rays 'bounce off' a surface, we say the surface reflects the light or heat rays.

Class management

All of the work described in this section can be carried out by the children sitting at their own desks. Any practical study of the moon will, of necessity, have to take place out of school hours.

Safety precautions

The children should be warned not to go outside to study the moon without permission. If possible they should be accompanied by a responsible adult.

Answers to questions in the text

The moon (page 68)

The picture shows the Earth seen from the moon. With the aid of an atlas it is just possible to pick out Africa, the Middle East, Pakistan, India, Spain, Italy, Turkey, Russia and the British Isles.

Although sounds cannot travel on the moon because there is no air, it is still possible for radio waves to be used. The astronauts were able to speak to each other with the aid of two-way radio sets. It was also with the aid of radio that the astronauts were able to communicate with their mission control at the Kennedy Space Centre in Florida, USA.

On the Earth, the samples of moon rock would have weighed six times as much as they did on the moon, because gravity on the Earth is six times as great.

Returning from the moon (page 69)

As a spacecraft enters the Earth's atmosphere from the moon, it gets red hot because of the friction, or rubbing action, of the air.

Parachutes will work only when there is air present. Therefore they cannot be used to slow down a spacecraft

until it is within the Earth's atmosphere. Because there is no air on the moon, parachutes cannot be used to slow a spacecraft down as it lands there. Instead, the rocket motors on the spacecraft are turned so that they point towards the surface of the moon. The rockets are then fired so that they gradually slow the spacecraft down.

Now try these

- 2 Some of the things which go up into the sky from the Earth include aircraft, rockets, weather balloons, hot-air balloons, gliders, hang-gliders, birds, insects and smoke.
- 3 An artificial satellite is sent into orbit by a large carrier rocket. Since the rocket has to overcome the Earth's gravity and to escape its atmosphere, it needs considerable power at the beginning of its flight. This is achieved by using a multi-stage rocket, each stage of which separates when it has used up its fuel supplies.
Satellites are usually packed with scientific instruments which are used to obtain information about the shape of the Earth, the nature of its atmosphere, conditions in space and details of other planets. Satellites can also be used in weather forecasting, to obtain information about crops and soils on Earth, and about military installations. Of great importance are the communications satellites which are used to help transmit television pictures and radio and telephone messages around the Earth, and which also help ships and aircraft to navigate.
- 4 If a balloon is blown up and then released, it will whizz across the room, pushed along by the air rushing from it. A space rocket leaving the ground works on a similar principle. Fuel and oxygen burn in its motors, creating a backward jet of gases which pushes the rocket skywards.
- 5 Very occasionally large meteorites do reach the Earth. However, when solid particles enter the Earth's atmosphere from space they are subjected to the friction of the air. They become very hot, and all but the largest usually burn up before they reach the ground.

Extending the learning

- 1 Use clay, plasticine, plaster of Paris or papier mâché to make a model of part of the surface of the moon. Paint the model. Make a model astronaut to stand on the surface of the moon.
- 2 Record the shape of the moon. Obtain a long, narrow sheet of paper or thin card. Draw 30 squares along it, all the same size. Inside each square draw a circle.
Ask the children to take it in turns to look for the moon each evening. Every evening they should draw the moon's shape, and then copy it into the appropriate circle the next day. The bright part of the moon could be coloured yellow, and the date written under each picture. There will, of course, be some evenings when clouds hide the moon. The circles should be left blank or shaded black on those evenings.
When the chart is completed, the children will be able to see that the moon's shape changes in a regular way. Hopefully they will gradually learn the names for the various phases of the moon.
- 3 Suggest that, on an evening when the moon is shining bright, the children study its position in the sky.

They should go into the garden or a bedroom, and walk around until they are standing at a place where the moon seems to be touching the top of a tree, pole or television aerial. They should put something on the ground or floor to mark the spot where they are standing, and make a note of the time.

The children should then return to the same place half an hour later, and stand exactly where they did before. They will now notice that the moon seems to be in a new position. Perhaps they could then predict where the moon will be after another half an hour, and then check to see if they were right.

- 4 On page 69 of Course Book 1, the children read that the moon's surface is scarred with pits and craters. Scientists believe these were formed by meteorites crashing into the surface of the moon. The children can see how these pits and craters were made if they fill a strong wooden or cardboard box with loose sand. This represents the surface of the moon.

The children should take it in turns to stand on a chair and drop marbles, golf balls or pebbles on to the sand. If they carefully remove the objects they have dropped, they can examine and draw the resulting craters. They can compare them with photographs of moon craters. The children could also find out which makes the largest crater, a large object or a small one.

Stars (pages 70–71)

Lesson objectives

- a To show that the closer a star is to the Earth, the larger and brighter it seems.
- b To demonstrate that groups of stars, or constellations appear in the sky as patterns that do not change shape from month to month or even from year to year.
- c To describe the relative positions of the planets around the sun.

Setting the scene

Possible starting points include:

- 1 Reading the story of the Star of Bethlehem.
- 2 Make mobiles with stars cut out from tinfoil.
- 3 A visit to a planetarium.
- 4 The poem 'Twinkle, twinkle little star.'

New words

Constellation – a group of stars that seem to form a picture in the sky.

Meteor – also called a 'shooting star', is a streak of light made by a solid particle which burns up as it enters the Earth's atmosphere from space.

Meteorite – a chunk of rock or metal that makes its way from space, through the air without burning up, to reach the Earth's surface.

Planets – those nine bodies, of which the Earth is one, which orbit the sun and have no light of their own.

Class management

The children will need to work in the evening, either outside or looking from an upstairs window, to observe the

stars. The experiment to show why some stars seem brighter than others will have to be carried out in a darkened room. It may be possible to vary the experiment by sitting the children at one end of the school hall or a long corridor, and having a child gradually walk away with a lighted torch.

Safety precautions

It will again be necessary to warn the children not to go out at night without permission.

Answers to questions in the text

Stars (page 70)

A shooting star is another name for a meteor. It has nothing to do with real stars. A shooting star is the light trail caused by small pieces of rock or metal which enter the Earth's atmosphere from space and burn up. A meteorite is a larger chunk of rock or metal that makes its way from space, passes through the air without completely burning up, and finally reaches the Earth's surface.

Planets (page 71)

The largest planet is Jupiter, which is bigger and heavier than all the other planets and their moons combined. It is larger in volume than 1300 Earths put together.

The smallest planet is probably Pluto, whose diameter is believed to be about one quarter of that of the Earth. Mercury is probably the second smallest planet.

The hottest planet to live on would be Mercury, which is the nearest to the sun, the coldest would be Pluto which is the most distant from the sun.

The planet with the shortest year is Mercury, which takes only 88 days to orbit the sun. The planet with the longest year is Pluto which takes 247 Earth years to complete one orbit of the sun.

Two planets, Mercury and Venus, are nearer to the sun than the Earth.

Now try these

- 2 Meteors are commonly known as 'shooting stars'. They are streaks of light seen in the night sky, and made by solid particles entering the Earth's atmosphere from space and burning up. A meteorite is one of these solid particles which is not completely burnt up and reaches the ground.

A comet is a mass of glowing particles of ice mixed with gas and dust, which circles round the sun. As the glowing particles stream away from the comet, they form what appears to be a tail.

Asteroids are minor planets. There are thousands of them, perhaps more than 40,000 altogether, and they orbit the sun between Mars and Jupiter. The largest asteroid exceeds 1,000 kilometres in diameter, but most are much smaller and are little more than irregular-shaped lumps of rock.

- 3 **SAFETY PRECAUTION:** Care will be necessary when using a lighted candle in the classroom. It is probably best to stand the candle in a tray or dish of sand or soil.

The children will notice that while the candle flame is hard to see in a sunny room, it appears much brighter and is very easy to see in a darkened room.

- 5 A planetarium is a working model which shows how the planets orbit the sun. Sometimes it also shows the stars.

The simplest kind of planetarium has the sun and planets represented by rotating metal balls. The other kind of planetarium has the sun, moon and planets projected as circles of light onto the curved ceiling of a specially constructed darkened room. The London Planetarium is of this second kind.

Expected results of activities and experiments

Watching the stars (page 70)

It is said that, even without the aid of a telescope, it is possible to see about 3000 stars on a clear night.

The children will notice that stars vary considerably in their brightness, depending on the size of the stars and how far away they are.

Not all stars are the same colour, although the differences are not easy to see. Some stars are reddish, others are orange or yellow. Some are bluish-white while, of course, many stars look white. These differences in colour are due to the different temperatures of the stars. The children may already have noticed that the objects which give off light and heat differ in colour. The heating element in an electric fire may start off by being dark red, and then become orange or even yellow, as the fire heats up. The filament of a light bulb rapidly becomes white hot. These observations give us a clue to the temperature of the stars.

Some stars do seem to have points on them, the way we often draw stars, and they twinkle as well. These effects are caused by movements of the Earth's atmosphere through which we look at the stars, rather than by movements of the stars themselves.

Why do some stars seem brighter than others? (page 70)

The children will notice that a large torch seems much brighter than a small torch at the same distance away. In addition they will find that a near light seems much brighter than one further away. This also applies to the stars. A near star seems brighter than a distant one of the same size, and a large star is brighter than a small star at the same distance.

The children may also have seen that car headlights seem to get brighter as the car gets closer. They seem to get dimmer as the car goes away. Also, a row of street lights do not seem to be of equal brightness. The near ones are much brighter than the distant ones.

Extending the learning

- 1 *Make a constellation viewer* Each child will need a length of cardboard tube, or a box or large tin can with both ends cut out. If a tin can is used, the cut ends should be hammered down to avoid any sharp edges and, as an added safety precaution, the ends should be covered with masking tape.

The children should cover one end of the tube with black paper, and hold this in place with a rubber band. They should then carefully poke tiny holes in the paper in the shape of one of the constellations, with each hole representing a star. If the viewer is now held up to the light the children will see the constellation as it appears in the night sky. If they slowly turn the tube they will understand why the constellations do not always appear the same way up in the sky.

- 2 *A model of some constellations* Put a large sheet of black paper on a display board and stick on it small stars cut from silver paper. Arrange the stars in the shapes of

some of the well-known constellations.

The children could make smaller versions of the above if they stick tiny stars on black paper mounted on the inside of the lid of a box about the size of a shoe box.

- 3 *Study the positions of the stars and planets* Every month certain newspapers, including *The Times*, *The Guardian*, *The Daily Telegraph* and *The Scotsman*, publish notes and maps of the night sky. Collect some of these maps, and mount each on a sheet of card. The children can use these maps to help them identify the positions of the stars and planets. Each card should be held above the head, with the map facing downwards. The 'North' on the map should be turned so that it is pointing towards the true North (use a compass to find this, if needs be).

Checking (pages 72–73)

Thinking

- 1 We can tell by the blue sky and distinct shadows that the sunshine is brightest and hottest in the left-hand picture. The grey sky and absence of shadows suggests that the sun was not shining when the right-hand picture was taken.
- 2 The way in which a ship progressively seems to disappear from the base upwards as it goes over the horizon is one indication that the Earth is round.
- 3 The sun does not always seem to set in exactly the same place because of the differences in the length of days between summer and winter.
- 4 We are not conscious of the fact that we are travelling at 1700 kilometres an hour as the Earth spins because we have been travelling at that speed, night and day, since we were born. In addition all the other objects and people around us are travelling at the same speed, and so appear to us to be stationary.
- 5 It is possible there are other planets besides the nine we already know about. If there are, they are so far away in space that they have not been discovered.
- 6 It would only be possible for people to live on the moon if a way could be found of either taking sufficient supplies of air, water and food there, or of actually manufacturing these substances on the moon.
- 7 The amount of moon rock had *not* changed even though it weighed six times as much on the Earth as it did on the moon. One way of showing that the amount of rock was unchanged would be to suspend the rock in water a) on the moon, and b) on the Earth again, and to show that the same amount of water was displaced on both occasions.
- 8 The sky on the moon appeared black, even though the sun was shining, because the moon has no atmosphere. It is the atmosphere around the Earth which deflects or 'scatters' the sun's rays and makes the sky appear blue.
- 9 The intense heat by day on the moon and the severe cold at night, are again due to the fact that the moon has no atmosphere, and in particular no clouds. During the day on Earth, the atmosphere reflects much of the sun's heat, and so the Earth does not get too hot. At night the atmosphere, and particularly the clouds, stop the Earth from losing too much heat and so becoming very cold. The coldest nights in winter are when the sky is clear of clouds. The hottest places on Earth by day are deserts, where there are no clouds to reflect the sun's rays. At night in deserts the temperature falls dramatically, again because of the absence of clouds.

Doing

- 1 The shadow will be long in the early morning, decrease in length towards midday after which it will lengthen. The shadow will be cast in a different place each time as the Earth moves around the sun.
- 2 Strictly speaking the sun does not always rise due east and set due west of a given point on the Earth. There are differences caused by the tilt of the Earth. During the short days of winter, the sun appears to rise and set in different positions from those of the long days of summer. However at any given *time* the sun is in roughly the same position during the summer or winter.
- 3 Of the children who are representing the planets, Mars has to move the least, and Pluto the greatest distance.
- 4
 - a The sun is a *star*.
 - b The *Earth* goes round the sun.
 - c The sun is a huge ball of white hot *gases*.
 - d Most of our *energy* comes from the sun.
 - e We have *night* and day because the Earth spins as it goes around the sun.
 - f Plants use *sunlight* energy to help to make their food.
 - g On a clear day a lot of sunlight is *reflected* by tiny specks of dust and droplets of water high in the air so that the sky seems blue.
 - h The only reason we see the *moon* at night is because it reflects the sun's rays.
 - i There is no *air* or water on the moon.
 - j The pictures stars seem to form in the sky are called *constellations*.

Going further – some other suggestions

How do different colours absorb or soak up the sun's rays?
What you need: Two similar thermometers; some sheets of paper all the same size but different colours.

What you do: Lay the thermometers near to each other in sunshine. What is the temperature?

Cover one thermometer with a sheet of black paper and the other with a sheet of white paper. Leave them in the sunshine for 15 to 30 minutes.

Now quickly remove the two sheets of paper. See what temperature each of the two thermometers says.

Under which sheet of paper was it warmest? Under which sheet of paper was it the coolest? Which colour paper absorbs or soaks up the most of the sun's rays?

Now try the experiment with sheets of paper of other colours. Also try a sheet of white rough paper and a sheet of white glossy paper.

What colour clothes would it be best to wear if you were cold? What colour clothes would you wear if you were hot?

What colour car would be coolest on a hot day? What colour car would be hottest on a hot day?

If you cannot do this experiment on a sunny day, you can always do it using the light and heat from a table lamp. See that the light falls equally on both sheets of paper, though.

(Expected results: The temperature under the sheet of white paper will be lower than that under the black paper. This is because light colours reflect the sun's rays, while dark colours absorb them. As a result, dark clothes make the wearer feel warm, and light coloured clothes make the wearer feel cooler. Similarly, on a hot day, dark coloured cars, and particularly black cars, become very hot while light coloured, and particularly white, cars are cooler.

This topic can be used to introduce a study of clothes and houses in different climates.)

Interdisciplinary activities

Art and craft

- Model-making of rockets and space craft.
- Patterns made with cut-out stars.
- Mobiles of stars, planets etc.
- Drawing ellipses.

English

- The Greek myth of Icarus.
- From the Earth to the Moon* by Jules Verne.
- The War of the Worlds* by H. G. Wells.
- The First Men in the Moon* by H. G. Wells.
- Professor Noah's Spaceship Paperback* by Brian Wildsmith (OUP).
- Poems about the solar system, eg. *Silver* by Walter de la Mere.
- Science fiction stories.

Geography

- Clothes and buildings in hot and cold climates.
- World climatic zones.
- Time zones and 'jet-lag'.
- Latitude and longitude.
- Weather satellites and communication satellites.
- Navigation by the sun and stars.
- Tides and the moon.
- For further ideas see *The Young Geographer Investigates: Our Universe* by Terry Jennings (OUP).

Health and hygiene

- Clean air and atmospheric pollution.
- Air and breathing.
- Pulse rates and health.

History

- Christopher Columbus and the flat Earth theory.
- Planets and gods in ancient history.
- Leonardo da Vinci, Galileo and Jules Verne.
- The Julian, Gregorian and World Calendars.
- Early clocks and the measurement of time.
- Stonehenge.
- Halley's Comet.
- The history of space exploration.
- The history of astronomy.

Mathematics

- Measuring diameter, radius and circumference.
- Time and its measurement.
- Temperature and sunshine records.
- Using a clinometer and plane table to plot the position of the sun throughout the day.

Music, drama and PE

- The Planets Suite by Gustav Holst.
- Popular songs which refer to parts of the Solar System.
- Make a shadow theatre.

Religious education and social studies.

- The Star of Bethlehem.
- The planets and astrology.
- The Magi.

Unit 10: The Seasons

Aims of the Unit

- To show that once a year the Earth revolves around the sun in a curved path, or orbit.
- To explain that, because its axis is tilted, as the Earth revolves around the sun, the lengths of day and night constantly change at most places.
- To show that changes in the length of day and night and in the slant of the sun's rays help to cause the seasons.
- To explain how the changes due to the seasons affect the lives of plants and animals.

Science background

As we saw in the last Unit, as the Earth revolves on its elliptical path around the sun, it also rotates on its own axis.

The Earth's axis is tilted at an angle of 23.5° from the perpendicular. On or about the 21st June, the summer solstice, the North Pole is tilted its nearest to the sun. It is then that places in the northern hemisphere have their longest day and shortest night, and summer begins. During the long days of summer, the midday sun is high in the sky and its rays beam straight down to the Earth. For places south of the Equator, June 21st marks the beginning of winter, and these places have their shortest day and longest night.

From June 21st onwards, the North Pole progressively tilts a little further away from the sun each day. As the tilt of the North Pole towards the sun changes, the number of hours of daylight also gradually decrease in the northern hemisphere (and increase in the southern hemisphere), and the sun seems to be less and less high in the sky.

The varying heat between summer and winter is caused chiefly by differences in the angle with which the sun's rays meet the Earth's surface, caused by the tilt of the Earth's axis. It is hottest when the sun's rays fall at right angles to the Earth's surface, when the sun appears to be directly overhead. To a lesser extent, the variation in heat between summer and winter is caused by the different lengths of day.

On or about the 21st December, the Earth is on the opposite side of the sun, and places in the northern hemisphere have their shortest day and longest night, the so-called winter solstice. At that time, the sun does not appear to climb as high in the sky, and its low slanting rays are spread over a much larger area, with a consequent decrease in their heating power. On that same date, places south of the Equator have their longest day and shortest night, as summer begins.

Spring and autumn are the transitional seasons, with conditions in-between those of summer and winter. Spring and autumn have as their turning points, March 20th or 21st and September 21st or 22nd, the so-called equinoxes (from the Latin for 'equal night'), when night and day are of exactly equal length.

There are also seasonal changes in the behaviour of plants and animals. Winter is a difficult time for all kinds of living things. Some animals sleep through the winter, or hibernate. Others migrate to warmer conditions. In Britain this is especially true of the birds which feed mainly on insects. However, other birds arrive here from places

further north to spend the winter. There is a reverse migration in the spring, with a large number of insect-eating birds arriving here to breed, while the winter visitors go further north to their breeding grounds.

Plants also show seasonal changes. Many die down in the autumn, having stored food in their roots. The deciduous trees lose their leaves in autumn, as the days become shorter and colder. In the spring, the sap begins to flow again, feeding the growing buds until they burst, the leaves open and flowering occurs. Other plants overwinter as seeds and, in the spring, with the return of warmer conditions, these begin to grow.

Books for the children

The Young Scientist Investigates series: *Trees, Birds, Flowers, Seeds and Seedlings*, and *Small Garden Animals* by Terry Jennings (OUP).

The Nature Trail Omnibus (Usborne):

Nature through the Seasons by Richard Adams and Max Hooper (Penguin).

Books for the teacher

Science 5/13: *Change* (Macdonald Educational).

Science 5/13: *Time* (Macdonald Educational).

Science 5/13: *Using the Environment 2, Investigations Part 2* (Macdonald Educational).

The World on your Doorstep by Peter Prosser (McGraw-Hill).

Materials and organisation

Ideally Unit 10 should be split between the four seasons. However, it is probably more realistic to deal with the Unit in one go, and to concentrate on the current season while comparing it with the other three. The subject can then be returned to at each of the other three seasons.

This is another topic where nature walks or other forms of first-hand outdoor experience are almost essential.

Materials and equipment

- a piece of board, roughly square in shape
- wooden strips
- a wooden post about 2 metres high
- old vegetable trays
- string or wire
- screw-eyes
- flower bulbs
- potting compost or bulb fibre
- flowerpots or bowls
- winter twigs of trees
- horsechestnut twigs with buds, or Brussels sprouts
- squared paper
- milk cartons, plastic bottles and fruit net bags
- large pie dishes or dustbin lids
- small maps of the world
- glue
- large sheets of paper
- pins
- salad cream jars or hyacinth vases
- newspaper or blotting paper
- sheets of card
- coffee jar lids or matchbox trays
- a plank of wood
- a variety of scrap foods for the birds
- mosses

- jam-jars
- cling-film
- a torch
- a globe

The seasons (pages 74–75)

Lesson objectives

- a To show that as the Earth orbits the sun, the Earth's axis is tilted.
- b To show that the differing angle at which the sun's rays strike the Earth, together with differences in the length of day, produce the seasons.
- c To examine some of the ways in which animals avoid or overcome the hardships of winter.

Setting the scene

Possible starting points include:

- 1 Discuss with the children their favourite season and why they prefer it.
- 2 Ask the children when each season begins (approximately the 21st or 22nd of March, June, September and December), and how they would know each season had started even if they hadn't looked at a calendar for a long time.
- 3 Discuss with the children the things people do in one season which they do not do in the others (eg. wear warmer clothing in winter, plant seeds in the spring, and so on). A table of these things could be drawn on the blackboard.
- 4 Make a display on the Science Table of things and pictures which typify the current season.

New words

Hibernate – animals which sleep through a great deal of the winter are said to hibernate.

Migrate – when certain mammals, birds, fishes and insects move from one place to another at certain times, they are said to migrate.

Seasons – the four periods of the year, Spring, Summer, Autumn and Winter which, because of changes in the Earth's axis towards or away from the sun, are marked by longer or shorter days and nights, and by changes in the weather.

Class management

All of the work on this topic can be carried out by the children working at their own desks.

Safety precautions

None

Answers to questions in the text

The seasons (page 74)

The sun is almost directly overhead at the Equator all the year round. Its rays spread very little, and are therefore, hotter. This can be demonstrated by shining a torch onto a globe in a darkened room. The torch should be held at

right angles to the equator of the globe. The children will see that a concentrated beam of light falls on the equator, but the rays strike the regions north and south of the equator obliquely and have very little power (or in the case of the sun's rays, very little heat).

Christmas day in Australia comes three or four days after the beginning of summer. The days are long, hot and sunny. Christmas day in Britain comes three or four days after the official start of winter, and the days are short, and usually very cold.

Autumn and spring have weather in between that of winter and summer, because the Earth at that time is travelling in between the point where the North Pole is nearest to the sun and the point where the North Pole is furthest away from the sun. During the spring the days gradually lengthen and the temperatures rise. In the autumn, the daylength gradually decreases and the temperatures fall.

There is little difference between the seasons at the Equator. Days and nights are of roughly equal length and there is often a monotony about the weather conditions.

Animals in winter (page 74)

In cold weather, birds fluff out their feathers. They do this to trap a layer of still, warm air around their bodies. This layer of warm air insulates the bird's body, keeping the heat in and the cold out.

Getting away from it all (page 75)

The main difference between hibernation and ordinary sleep is that hibernation occurs in response to low temperatures and the shortening of the days, whereas ordinary sleep may occur any time an animal is tired. In addition the hibernating animal's body temperature and its breathing rate and heartbeat fall to a very low level, so that it is not always easy to tell whether the animal is alive or dead. In ordinary sleep the body temperature falls, and so do the heartbeat and rate of breathing, but not to the same extent as in hibernation.

During sleep we become unconscious, that is to say we are not aware of what is going on around us. We need sleep so that we can rest and relax completely, and the body can make up the energy it has lost during the day. Without sleep a person will die quicker than without food.

Snoring is a noise made by the vibrations of the soft palate, the back of the roof of the mouth, as we breathe in and out while we are asleep. Snoring most often happens when the person is lying on his or her back. No one knows for certain why we dream. Dreams are made up of thoughts and feelings deep in our unconscious minds, including our worries, fears, desires and interests. We all dream, but not everyone remembers their dreams.

Other animals, including dogs and cats snore. It is probable that they also dream. It is not unusual, for example, for a dog's legs to twitch while it is asleep, or it may make quiet yelping noises, as if it is chasing something, or being chased, in its sleep.

Now try these

- 2 Contrary to popular belief, squirrels do not hibernate when winter comes. They build a domed nest, or drey, of twigs and leaves lined with grass. Squirrels store away surplus items of food, but they remain active all through the winter, except in the severest weather.
- 3 No one knows, or probably ever will know, why swallows gather together on telegraph wires in October before their flight south. It is probable that many heads

are better than one when it comes to navigation, and also the young birds can follow their elders on the flight to Africa. However, swallows are always sociable, and during the spring and summer they roost communally in reed beds and osier beds, sometimes in flocks of as many as a million birds.

- 4 Most shrubs and trees, and many herbaceous plants, produce their fruits and seeds in autumn. A table showing the methods of dispersal used by some of these plants is given on page 112 of this book.
- 5 The main differences between the seasons are in the lengths of the days and average temperatures, and in the plants and animals which are active.

Extending the learning

- 1 *Migrating birds* Obtain a map of the world. Glue this map on to a large sheet of card.

Ask the children each to choose a different summer or winter bird visitor to Britain. Let them make small coloured drawings of their chosen birds, and cut these out. Each child can then pin his or her drawing to one of the countries on the map the bird might have come from (use reference books to help with this). Another pin should be placed in the part of the British Isles where the children live. Join the two pins by a thread.

The thread shows the journey each bird might have taken if it flew in a straight line. Ask the children to work out, using the scale on the map, roughly how far the bird flies. What countries does it pass through? What are these countries like? Which seas, mountains, rivers, lakes and deserts does the bird pass over?

- 2 *Growing bulbs indoors* Hyacinths, daffodils, narcissi and early tulips are just some of the bulbs that can be easily grown indoors. So also can crocuses, although technically these are not bulbs but corms. Plant the bulbs or corms in the autumn to have flowers at the end of winter or in early spring.

Plant the bulbs in potting compost or bulb fibre in a shallow bowl. The bulbs can almost touch each other. Large bulbs should have their tips level with the top of the compost. Smaller bulbs, and corms, should have their tips just covered.

Give the bulbs a good soaking with water and put them in a cool, dark place. See that the compost stays damp.

When the shoots are sticking up 4 to 6 cm, move the bulbs to a cool windowsill. When the leaves are well grown move the bowl to a warm, sunny place. Keep the compost damp.

It is also possible to grow hyacinth bulbs in special glasses obtainable from garden centres. Alternatively a clean salad cream jar can be used. Fill the glass or jar with water, and rest the bulb on the top of it so that the base of the bulb just touches the water. Stand the container and bulb in a cool, dark place until the bulb has a shoot 4 to 6 cm long, then bring it out into the light. In this way the children can watch the roots of the hyacinth bulb grow, as well as its leaves and flowers.

Winter (pages 76–77)

Lesson objectives

- a To examine the ways in which plants are adapted to survive the cold conditions of winter.

- b To discover which small invertebrate animals hibernate.
- c To study the food and feeding of some common birds at a bird table.

Setting the scene

Possible starting points include:

- 1 Write the words WINTER and SUMMER on the blackboard. Ask the children to think of as many differences as they can between these two seasons.
- 2 Make a display of pictures showing winter scenes.
- 3 Ask the children why farmers and gardeners do not sow seeds in winter (mainly because it is too cold for seeds to germinate, but also because there is not enough light for young plants to be able to make their food and grow).

New words

Deciduous tree – a tree which loses its leaves in the autumn and grows new ones the following spring.

Evergreen tree – a tree which does not lose all its leaves in the autumn but, instead, loses them a few at a time throughout the year.

Class management

The work on 'Cosy corners' will involve the children in a considerable amount of moving about, and is probably best done in small groups. The other work can be done by the children sitting at their desks, including the observations on the bird table if this is sited within view of the classroom windows.

Safety precautions

Before the children search out 'cosy corners' around the school grounds, check for possible hazards such as broken glass or jagged metal on which injuries could occur. Warn the children accordingly.

Although they will not hurt the children, if eaten in moderation, remember that salted peanuts and dessicated coconut are dangerous to birds, and should not be put on the bird table or in a bird feeder. No form of antifreeze should be put in the birds' drinking water either. Perhaps rather surprisingly, it is dangerous to feed the birds bread, and particularly white bread, in the spring and summer when they are breeding. If the parent birds feed the bread to their young, it may swell up inside them causing pain and possibly death.

Answers to questions in the text

Cosy corners (page 76)

Some of the animals which the children may find include spiders, houseflies, blowflies, moths, beetles including ladybirds, earwigs, silverfish, gnats, mosquitoes, lacewings, house crickets, slugs, snails, woodlice, and small tortoiseshell and peacock butterflies. Some of these will be hibernating, while many of those found in buildings are probably more or less permanent residents there.

Bird tables (pages 76–77)

The bird table in the picture is much too short. A cat could easily jump on to it. The post should be at least 150 cm

high. In addition, the table top is not level, and the food would slide off.

There is no way the birds could feed from the whole coconut. It should be cut in two, and a half of it hung upside down for the birds to feed from.

A bird table should not be sited near a bush or tree in which cats, grey squirrels and other predators can hide, waiting to pounce on some unwary bird.

As mentioned previously, salted peanuts are dangerous to birds.

Although certain kinds of owls do fly in the daytime, notably the short-eared owl, they are unlikely to visit a bird table.

Now try these

- 1 Assuming they fly in a straight line, swallows and martins migrating from Britain to southern Africa, cover a distance of about 6,000 miles.
- 2 According to old pagan beliefs, holly is a holy tree and witches were said to avoid it. Holly's blood-red berries and spiky leaves have also been linked to Christ's crucifixion and crown of thorns. But it seems likely that holly was used long before Christian times to brighten people's homes during the flowerless and leafless days of winter.

In the past, ivy was similarly held to have magical powers, and at Christmas it was believed to keep a house free from demons. It was also supposed to give protection from drunkenness.

Mistletoe has many superstitions and legends attached to it. One is that it will bring happiness and good fortune as long as it does not touch the ground. This may account for its being hung up in our homes at Christmas time and why it is supposed to bring good luck to those who kiss under it. The Druids worshipped the oak, and when they found mistletoe growing on an oak tree they assumed it had great powers.

The Christmas tree originated in Germany. St Boniface, an 8th century English missionary to Germany, from Crediton in Devon, is said to have set up a fir tree bearing gifts to the Christ-child in place of the oak that was sacred to the pagan gods. Martin Luther is said to have started the custom of lighting the tree with candles, while Prince Albert, the German husband of Queen Victoria, introduced the Christmas tree into England in the 19th century.

- 4 Birds fluff out their feathers in winter to keep themselves warm. When the feathers are fluffed out, they trap a layer of warm, still air around the bird's body. This acts as an insulating layer, preventing heat escaping from the bird's body (a string vest uses the same principle). When a bird is hot, it flattens its feathers against its body, so that the rate of heat loss is increased.

Expected results of activities and experiments

Bird tables (pages 76–77)

The children should be encouraged to identify the birds visiting the bird table with the help of a reliable bird book containing coloured pictures. One such book is the *RSPB Guide to British Birds* by David Saunders (Hamlyn), but there are many others. The children may like to record the visitors to the bird table in the form of a diary, in which they note the date, time and prevailing weather

conditions, as well as information on the numbers and species of birds and their behaviour.

Extending the learning

- 1 **Collect tree leaves** Make a collection of evergreen leaves, fallen deciduous tree leaves, and leaf skeletons (found in woodland and under hedgerows, where leaves are decaying). Press the leaves between sheets of newspaper or blotting paper under weights for a week or so. Mount the leaves on a sheet of card and label them with the names of the species of trees the leaves came from, and where and when they were collected.
- 2 **Mosses** Mosses grow in moist places. They grow particularly well in winter when the weather is often wet. Mosses are easy to grow on the classroom windowsill. Collect two or three small clumps of mosses of different kinds (there are more than 600 species in Britain). Put three or four centimetres of moist soil or compost in the bottom of a clean jam-jar and, with the aid of a stick or spoon, plant the clumps of moss in it. Spray the mosses with clean water and cover the jar with cling-film or polythene in which a few air-holes have been punctured with a pin. As long as the air inside the jar is kept moist, the mosses will grow rapidly.

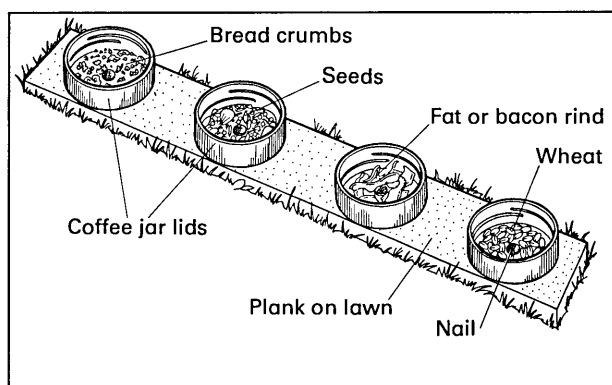
Larger moss gardens can be grown in old aquaria, pickle jars or large bottles.

If a microscope is available, it is very interesting to examine the leaves of the different species of moss with it.

- 3 **Which kinds of food do birds like best?**

What you need: A number of equal-sized containers such as coffee jar lids or matchbox trays; a bird table or a plank of wood; a variety of foods including breadcrumbs, cake or biscuit crumbs, seeds, cereals, fat and bacon rind.

What you do: Fasten the containers to the bird table or to the plank of wood. Place the plank on the ground in some place where it can be seen clearly from a window. Spread out the containers so that the birds have enough room to feed.



For several days in winter, put a few breadcrumbs in each container so that the birds get used to feeding from them. Then begin the experiment. Put equal amounts of a different kind of food in each container. Watch carefully and record what happens.

Which birds eat which kind of food? Which food do they eat most of?

Repeat the experiment over several days. Are the results the same each day? Can you work out a list of foods which are necessary to attract each kind of bird?

(It is not possible to predict the results of this experiment. Much depends upon the foods offered, the species of birds present, and their state of hunger. Nevertheless, if the experiment is repeated enough times, valuable results will be obtained. The children may also find that individual birds of the same species differ in their food preferences.)

Spring (pages 78–79)

Lesson objectives

- a To show how plants break the enforced dormancy of the winter and resume growth in the spring.
- b To describe some of the ways in which animals become more active in the spring.

Setting the scene

Possible starting points include:

- 1 A collection of tree twigs on the Science Table.
- 2 Stand some tree twigs, including horse chestnut twigs, in jam-jars of water on a sunny windowsill in early spring, and observe and draw the buds as they burst and the leaves unfold.
- 3 Repeat the 'cosy corners' activity described on page 76 of Course Book 1, and see which animals that were previously hibernating are now active.
- 4 Record the temperature on the playground at the same time each day, and plot these on a graph for a whole month. Show how the general trend of the temperature is upwards.

New words

Budscale scars – the marks around the twig of a tree which show the position of last year's terminal bud.

Leaf scar – the mark or hollow found on the twig of a tree which shows the position of a leaf before it fell.

Class management

All of the work on this topic, except for making the flower diary, can be carried out by the children at their desks. The flower diary is a longer-term project and could either be carried out by individuals with their own small version of the diary, or by volunteers from the class as a whole filling in a large chart displayed on the classroom notice board.

Safety precautions

For their own safety, and for the sake of the desks, the children should be provided with a small piece of board on which they cut *downwards* when examining the internal structure of buds.

Answers to questions in the text

Spring (page 78)

In spring there is plenty of moisture in the soil. This is partly because quite a lot of rain falls in the spring, but also because little of the water from the rain and snow which falls during the winter evaporates as a result of the low temperatures during that season.

The distance between the terminal bud on a twig and the budscale scars below it, or the distance between two sets of budscale scars, shows how much the twig grew in a single season. If the distance is great it means the weather during that growing season was probably warm and wet. If the distance is small, then the growing season was probably cold or very dry.

Now try these

- 1 The cuckoo differs from other birds in that it makes no nest of its own. In May or June the female lays her eggs in the nest of other birds, who find themselves the unwitting foster-parents of a young cuckoo. The cuckoo's egg is very small for her size and varies in colour, so that it may look very similar to the eggs of the foster-parents. The cuckoo removes one of the foster-parents' eggs from the nest and lays one of her own in its place.
- 2 One of the first signs of the approach of winter is the appearance in the shops of Christmas cards and gifts, and flower bulbs for autumn planting. The shops also start selling warm winter clothing, skiing holidays etc. The approach of spring is heralded by the appearance in the shops of Easter eggs, lighter summer clothing, swimming costumes, beachwear, garden seeds and implements, and package holiday offers to sunnier climates.
- 3 The changes in the seasons had a much greater effect on people until about 50 years ago, largely because many fresh foods were available only at certain seasons of the year. The advent of deep-freezers, refrigerators and refrigerated ships has meant that most foods are now available all the year round. In addition, air-conditioning and central heating now mean that indoors the climatic changes, so characteristic of the different seasons, are no longer as obvious.
- 4 Gardeners sow most kinds of seeds in the spring because at that time the soil is warm and moist and the seedlings have the whole of the summer with its long days to grow to maturity.
- 5 Three poems about the seasons are:
The Autumn by John Keats
Ode to the West Wind by Percy B. Shelley
When Daisies Pied by W. Shakespeare
Among the old sayings about the seasons are:
If St Bartholomew's Day (24th Aug.) be fair and clear,
Then a prosperous autumn comes that year.

If Candlemas (2nd Feb.) be fair and bright,
Winter will have another fight;
But if Candlemas brings cloud and rain,
Winter is gone and won't come again.

Ice in November to bear a duck,
The rest of the winter'll be slush and muck.

If it does not rain on St Michael and Gallus
(29th Sept. and 16th Oct.)
The following spring will be dry and propitious.

Expected results of activities and experiments

What is inside a bud? (page 78)
The toughest part of any bud is the budscales. These have

to protect all the delicate parts of the bud while they develop inside it throughout the winter.
Make a flower diary (page 79)
If possible a mixture of garden or cultivated flowers and wild flowers, including 'weeds', should be included on the chart. It will be found some garden weeds flower, and produce seeds, all through the year. This accounts for their success as weeds.

Extending the learning

- 1 Resident and migrant birds Encourage the children to list all the species of birds seen in their gardens or school grounds every week or every month for a whole year.
Record the results on a chart, like the one shown below. The completed chart will show the species of birds which are resident, and those that are summer or winter visitors. The children could use reference books to help them find out where the migrant species travel to or have come from.

Bird species	Month											
	J	F	M	A	M	J	JY	A	S	O	N	D
House sparrow	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Blackbird	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
House martin				✓	✓	✓	✓	✓	✓			

- 2 Why the sun's rays give more heat when the sun is overhead This is a simple experiment to show why the sun's rays give more heat when the sun is overhead as it is in summer. The children should work in a darkened room.
A torch should be held directly above a sheet of paper, and then switched on. The children will notice that the part of the paper where the light falls is very brightly lit. In the same way, when the sun is directly overhead in summer, it gives more heat and light.
Now the torch should be held in the same position as before, but the piece of paper should be held at an angle to the torch beam. The children will see that the light from the torch is now spread over a much larger area of the paper. The same amount of light is falling over a bigger area, and the area where the light falls is not so brightly lit as before.
When the sun's rays are slanting, as they are in winter, they also give off less light and heat. The same amount of heat is spread over a bigger area, and so it is not so warm.

Checking (page 80–81)

Thinking

- 1 Before there were deep-freezers and refrigerators, people either had to eat those few fresh foods that were available in the winter, or rely on foods that could be preserved by drying, pickling or salting.
- 2 Few plants actually grow on the ground in a wood during summer, because insufficient light reaches the ground. Many woodland plants, including bluebells, primroses and wood anemones grow and flower in early

spring before the leaves on the trees above are fully open.

- 3 Milk, like water, expands slightly as it freezes. When the milk expands there may not be enough room for it in the bottle. As a result it pushes up the top, as shown in the picture.
- 4 The ways in which people get ready for winter include buying warmer clothes, and stocking up with extra supplies of fuel. In some parts of the world with severe climates, people may stock up with food, while livestock farmers may bring their animals indoors or nearer to the farm.
- 5 Robins, starlings and blue tits are able to survive the winter, only because they become less specialised in their diet then. Many feed on the scraps of food put out for them by humans. They also search for earthworms and hibernating insects.
- 6 The things people do when winter goes and spring arrives include buying or wearing lighter clothing, spring cleaning their homes, and preparing their gardens for planting. There may be a change of diet from eating cooked foods to eating more salads and fresh fruit.
- 7 Although people may travel huge distances on holiday or on business, most do not make the regular movements of swallows, cuckoos, caribou and other migratory animals. However some of the nomadic tribes might be considered to migrate. The Norwegian Lapps, for example, follow elk herds and reindeer from their winter homes in the sheltered forests of the interior, to their summer homes along the coast of the Arctic Ocean and back again. The Bedouin of Arabia and North Africa, similarly follow their herds of camels and sheep from areas where there are permanent water holes and oases in the summer months, moving on in the autumn and winter to those areas where rain has fallen and the grass is growing.
- 8 One of the most widespread illnesses is the common cold. In most countries people do in fact 'catch cold' at any time of the year, not just in the winter. However colds spread rapidly from person to person in winter when, because of lower temperatures, people are confined in warm rooms with inadequate ventilation. The cold germs, or viruses, are spread in tiny drops of moisture which pass out of the bodies of infected persons during coughing, sneezing, and also talking and normal breathing. The viruses are breathed in by other people. Another common winter illness is influenza, also caused by a virus, and spread in the same ways.
- 9 Many birds such as robins and blackbirds which normally live fairly solitary lives, are forced by hunger in winter to come to bird tables and other places where humans put food down for them. There they may fight and squabble with other members of the same species. Many birds also fight during the breeding season when there is competition for mates and nesting sites. Such fighting often leads to the establishment of 'territories'.

Doing

- 1 Ways in which we can tell that autumn is getting near include:

Tree leaves begin to change colour.
Many tree fruits, berries and nuts ripen.

The cereal harvest is completed, and ploughing and resowing begin.

Swallows, martins and other summer migrant birds begin to depart.

Fieldfares, redwings and other winter migrant birds begin to arrive.

The days become noticeably shorter, and the temperatures lower, particularly at night.

Christmas cards, decorations and gifts are already on display in many shops.

- 2 A warm-blooded animal has a constant body temperature, no matter what the external conditions. Birds and mammals (including humans) are warm-blooded. The body temperature of cold-blooded animals varies with the external temperature. Cold-blooded animals include all the invertebrates, as well as fish, amphibians and reptiles. These animals can be active only when the temperatures of their surroundings are relatively high.
- 3 There are 17 species of bat in Britain, and about 900 species in the world as a whole. All the British bats are nocturnal, spending the day sleeping in caves, lofts, hollow trees, barns, church towers, ruins and similar places. On nights when the temperatures are relatively high, bats come out to feed. All the British bats feed on insects and, like all mammals, they produce living young. Contrary to popular belief bats are not blind, although their eyesight is poor. Bats find their way and their food, by making high-pitched squeaks, and listening for the strength and direction of the echoes. There are many myths about bats including the one that they deliberately become entangled in human hair.
- 4 As winter approaches, the male hive bees or drones are turned out by the worker bees. They die as the temperature falls. In the wild the queen and the worker bees would survive by using the store of honey. The beekeeper removes some of the honey from the hive and replaces it with a syrup made from white sugar for use during the winter months. In the warmth of the hive the bees remain active to some extent throughout the winter.
- 5 The name dormouse means 'sleeping mouse', a reference to the fact that this small rodent hibernates in winter.
- 7 Throughout the winter one of the most common British moths – the winter moth – is on the wing; so too are swarms of gnats and mosquitoes.
- 8 Many of the ducks, geese and swans which migrate to Britain for the winter, spend the time on marshes, estuaries and muddy and sandy seashores. There they feed on invertebrate animals, certain kinds of green seaweeds, seeds, wild shoots and roots, and sometimes grain crops. Many of these birds nest and spend the summer inside the Arctic Circle, although the winters there are too severe for these birds to be able to stay and find their food.
- 10 All of our land mammals, except for bats and the hedgehog and dormouse, remain active throughout the winter. Most of them continue to eat the same or similar kinds of food that they eat in summer, although in severe winter conditions, deer for example may be forced to eat tree bark and to raid farm crops.
- 11 a The year is divided up into the four *seasons* we call Spring, Summer, Autumn and Winter.

- b The Earth makes one complete journey round the *sun* each year.
- c We have seasons because, as the Earth spins, it is not upright but *tilted*.
- d The coldest season of the year is *winter*.
- e Many animals get ready for winter by hiding away *food*.
- f In the autumn, swallows and martins *migrate* to the warmer countries of southern Africa.
- g Some animals sleep or *hibernate* during the winter.
- h The trees which lose their leaves in winter are called *deciduous* trees.
- i The trees which do not lose their leaves in winter are called *evergreen* trees.
- j In the spring the *buds* open on deciduous trees.
- k The *scars* on a twig show where the leaves fell off in the autumn.
- l Many of the birds which migrate south in the autumn feed on *insects*.

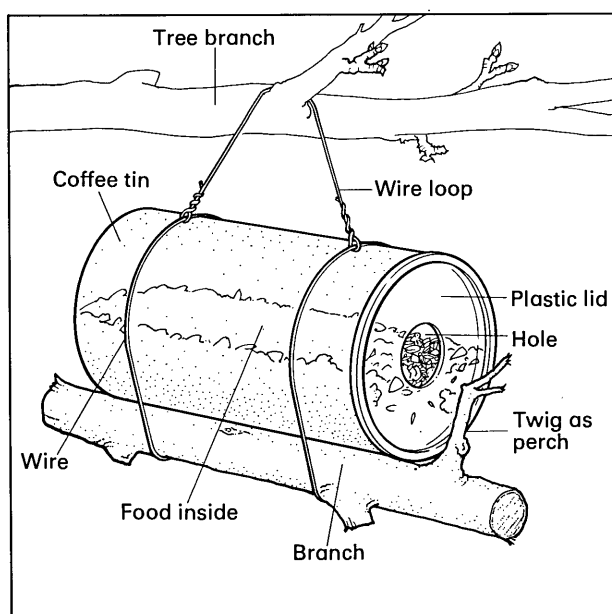
Going further

In both town and country schools, birds provide a good subject for practical study throughout the year.

- 1 **Bird feeders** The children can make bird feeders, like those shown on page 81 of Course Book 1, and in the illustrations below, using scrap materials.

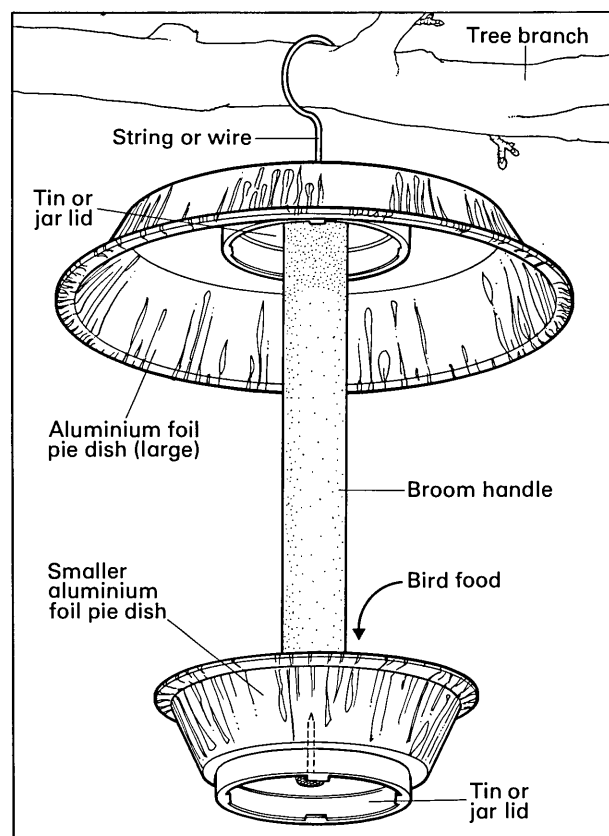
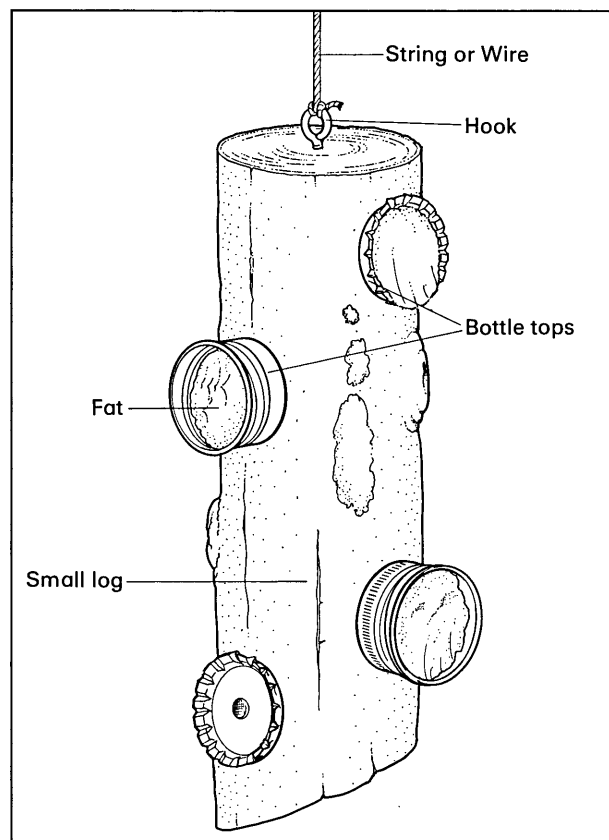
Use the bird feeders only during the autumn and winter months. Remove them at, say, the beginning of April, when there may be young birds about for whom some of these foods could be dangerous.

The children should be encouraged to record what kinds of birds come to the feeders, and how they get the food out of the feeders. Examples of aggressive behaviour by the birds at the feeders should be looked for and recorded.



Another suggestion

- 2 **Nesting materials** Sometimes birds have difficulty in finding sufficient suitable nesting materials during the spring and summer. The birds can be helped if the



children make a collection of clean dry hay, knitting wool cut into very short pieces, dog and cat combings, carpet fluff and any other soft material. Put these into a

large net bag, such as one of the bags in which onions or Brussels sprouts are sent to greengrocers shops. In the spring, hang the bag from a branch of a tree, out of reach of cats. Put one or two sticks through the bag as perches.

Ask the children to record what kinds of birds collect the nesting material. The children should be actively discouraged from interfering with the birds' nests, though.

Interdisciplinary activities

Art and craft

- Pictures of the changing seasons.
- Mobiles of snowflakes cut from tin foil.
- Collages of snow scenes using white tissue paper.
- Silhouettes of bird shapes and of trees in winter.

English

- The Snow Goose* by Paul Gallico
- Jonathan Livingston, Seagull* by R. Bach.
- Poems about the seasons.
- Oxford Junior English: *Book 2 Food and Farms* by Oliver Gregory (OUP).
- Oxford Junior English: *Book 3 The Coastline* by Oliver Gregory (OUP).

Geography

- Seasonal farming activities.
- The tropics and polar regions.
- A survey of imported fresh foods in local shops.
- Seasonal weather measurements – sunshine, rainfall, wind speeds, visibility.
- Nomadism and migration.
- The Young Geographer Investigates: *The Earth* by Terry Jennings (OUP).

Health and hygiene

- Food preparation and hygiene.
- Seasonal availability of foods.
- Food preservation and decay.

History

- The manor and three-field farming.
- The Irish potato famine.
- Viscount Townshend and the Norfolk Four Course Rotation.
- The domestication of rabbits and pigeons for meat.
- The winter diets of rich and poor through the ages.
- The life of the Polish astronomer Nicolai Copernicus.

Mathematics

- Graphs of temperature and rainfall.
- Scale models showing the distances between various bodies of the solar system.
- Calculations of speed and distance of migratory birds.

Music, drama and PE

- Seasonal sporting activities.
- Christmas carols.
- Beethoven's 'Pastoral Symphony'.
- 'Springtime' by Grieg.
- 'Dances from the Seasons' by Alexander Glazounov.
- 'The Four Seasons' by Vivaldi.
- Nativity plays.

Religious education and social studies

- Birds of the Bible.
- The seasons in the Bible lands.
- The Nativity.
- Plagues of locusts.
- Drought and famine in the Third World.

Unit 11: Science in the kitchen

Aims of the Unit

- To show that matter may be classified as a solid, a liquid or a gas.
- To show that matter can be changed, and that the changes may be chemical changes or physical changes.
- To demonstrate methods of dissolving and separating substances.

Science background

Matter is the name given to the substances of which things are made. There are three main 'states of matter', or forms in which substances can exist, namely solids, liquids and gases.

Solids have a fixed shape and a fixed size, and it is quite easy to pick up a solid such as a stone or a brick. It is not usually easy to change the shape or size of a solid unless a great deal of energy is applied to it. By contrast, gases and liquids have no fixed shape. They adopt the shape of whatever container they are put in. It is impossible to pick up a liquid or a gas in the way in which a solid can be picked up. All substances can exist in all three states but, with the exception of water, it is not normally easy to change a substance from one state to another.

The three different states of matter are explained by the fact that all matter is composed of infinitesimally small particles known as atoms or molecules. The latter are small groups of atoms. In a solid, the atoms or molecules move very little. If a solid is heated to a sufficiently high temperature, the atoms or molecules begin to move freely, and the solid loses its shape as it melts and becomes a liquid. If this liquid is heated still more, the molecules move faster and faster until the liquid boils. Then the molecules are set quite free of each other, and a gas is formed. Cooling has the reverse effect. The molecules slow down and form first a liquid, and then, if the cooling is sufficient, a solid.

The way in which a solid can be changed into a liquid, or a liquid into a gas, is an example of what is known as a *physical change*, one of the two main ways in which substances change. It is relatively easy, for example, to heat water and make the gas water vapour, or to cool the water vapour and produce liquid water. Physical changes do not produce any new materials. The material keeps the same chemical composition.

When substances are mixed together without combining chemically, they keep their own properties. A mixture of salt and sand is yellowish-white in colour; it tastes both salty and gritty, and it is a simple matter to use water to dissolve the salt out of the mixture. When salt is dissolved in water the molecules of salt simply disperse and fit in the spaces between the molecules of water, so that the salt seems to disappear. Air is similarly a mixture of gases, including oxygen, nitrogen, carbon dioxide and water vapour.

Under certain conditions, substances react together to form completely new substances with a different chemical composition. Such changes are known as *chemical changes*. Hydrogen and oxygen can be mixed together, and they remain separate gases. If the mixture is ignited, however, there is an explosive chemical reaction and a completely new substance, water, is formed. It is possible

to obtain hydrogen and oxygen from water, with the help of an electric current, but it is not easy. Common salt or table salt can be made from the soft, yellowy-grey metal sodium and the green gas chlorine. Sodium reacts violently with water, while chlorine is a poisonous gas. If sodium metal is burnt in chlorine gas the particles combine to form a completely new white crystalline substance, salt (or to give it its chemical name, sodium chloride). In small quantities at least, salt is a harmless substance, and has none of the potentially dangerous properties of sodium or chlorine. Burning substances, the rusting of iron and the digestion of food are further examples of chemical changes.

It is possible to explain the properties of all matter in terms of the behaviour of the constituent atoms or molecules.

Books for the children

The Young Scientist Investigates: *Everyday Chemicals* by Terry Jennings (OUP).
Science Workshop by Irene Finch (Longman).

Books for the teacher

Science 5/13: *Change* (Macdonald Educational).
 Science 5/13: *Like and Unlike* (Macdonald Educational).
 Science 5/13: *Early Experiences* (Macdonald Educational).

Materials and organisation

Chemistry, like science generally, is essentially a practical subject. However, a strict level of supervision is necessary to prevent accidents and unauthorised experimentation. As well as the experiments on each of the three double-page spreads in the Course Book, there are other 'desk-bound' activities. It is suggested that the class is divided into groups, and while some carry out the experiments, with the teacher's help, the others are engaged in the activities involving writing, drawing or reference book research, which require a minimum of supervision.

Materials and equipment:-

milk
 clean jars with screw-top lids
 measuring jug
 microscope
 microscope slides and coverslips
 bread
 vegetable oil or lubricating oil
 small bottles
 clean jam-jars
 granulated sugar
 sugar lumps or cubes
 spoons
 saucers
 salt
 flour
 bath salts
 washing soda
 bicarbonate of soda
 baking powder
 sand
 instant coffee
 tea
 hand lenses
 funnels

filter papers or blotting paper
 egg-shells
 vinegar
 cork
 ice-cubes
 washing-up bowls
 washing-up liquid
 drinking straws
 talcum powder or chalk dust
 glycerine
 thin wire
 detergents (washing powders)
 ballpoint pens
 poster paints
 orange squash
 gravy or gravy powder
 pieces of cloth
 soap
 yeast
 bottles with corks to fit
 lemon juice
 paint brushes
 clean metal foil milk bottle tops
 foods such as butter, margarine, lard, cheese,
 chocolate and ice-cream
 aluminium cooking foil
 scissors
 spring clothes pegs
 candles
 dishes containing sand
 string
 yoghurt pots
 thermometers
 sticky labels
 dirty copper coins

Making butter (pages 82–83)

Lesson objectives

- a To demonstrate that it is possible to carry out experiments using the substances and materials to be found in an ordinary kitchen.
- b To show some of the ways in which food substances can be changed.

Setting the scene

Possible starting points include:

- 1 A visit to a dairy or a dairy farm.
- 2 Studying milk with the aid of hand lenses or microscopes.
- 3 A study of the food value of milk.
- 4 Simple cooking, eg. bread, shortbread, toffee, fondants, coffee ice, peppermint creams or instant whip.
- 5 Comparing water, ice and water vapour.
- 6 Observing the changes which take place when a candle burns.

New words

Laboratories – buildings or rooms in which scientists carry out their work.

Class management

It is suggested that, while part of the class is working in small groups to make butter, the remainder carry out the reading or written activities, after which the two parts of the class can change over.

Safety precautions

The children should be advised that the experiments described in this Unit are quite safe, and most of the chemicals are harmless. However, they should be warned never to invent their own experiments with chemicals, and to keep these substances away from younger children.

The milk used to make butter should be fresh, and the jars and lids should be thoroughly washed and dried before use, to avoid any risk of food poisoning.

Answers to questions in the text

Making butter (page 82)

Since the children are bound to ask, the milk in the picture on page 82 has been dyed with a purple dye to make the tiny droplets of fat show up more clearly.

It is the churning or shaking of the milk which makes the tiny fat droplets in the cream of the milk join together and form butter.

Three other products made from milk besides butter and buttermilk are cream, cheese and yoghurt. Cream is separated from the milk in a mechanical separator. The cream, being the lightest part of the milk, is simply skimmed off the surface of the milk and purified.

Cheese is made by allowing milk to go sour by adding a substance called rennet. When this chemical has done its work, the solid part of the milk, the curds, is separated from the liquid part, the whey. Cheese is made from the curds by a process which varies according to the type of cheese being made. In the case of Cheddar cheese, the curds are heated to about 37°C, and then salt is added, after which the cheese is pressed in a mould. The cheese is plunged into water at 60°C for a minute, so that a skin or rind forms on the outside. After being wrapped in cotton cloth, the cheese is stored in a dry, well-ventilated room for between three and nine months.

Yoghurt is made by boiling milk and then cooling it. A culture of special bacteria is added to the milk, and left to stand for 2½ to 3½ hours at 40°C. The bacteria make lactic acid, which causes the milk to clot, forming yoghurt. Pieces of fruit or other flavourings may be added to the yoghurt. This is then stored at 4°C, to slow down the action of the bacteria.

Changing foods (page 83)

The children will have no difficulty in writing their own descriptions as to how the foods listed are changed by heat. More important, they should appreciate that the taste and texture of the food is changed by cooking, as well as its appearance. It is *not* possible to change the cooked food back to its original form.

Now try these

- 3 A mixture of oil and water, when left to stand, will settle out so that the oil is floating on the surface of the water. This is because oil is insoluble in water and also less dense ('lighter') than it.
- 4 Common foods which change colour when they are

cooked include egg white, meat, poultry, liver, kidney, pastries, puddings, bread, potatoes, swedes, tomatoes, apple and strawberries.

A number of other changes take place when food is cooked. The texture of the food changes and it may become more digestible, its taste and odour may improve, and any germs on the food may be killed.

- 5 Butter is a solid at normal room temperature, but if butter is warmed it melts and becomes a liquid. Almost all solids will melt and form a liquid if heated to a sufficiently high temperature. For example, while butter melts at 31°C, iron and steel melt at 1500°C.

Expected results of activities and experiments

Making butter (pages 82–83)

For the butter-making activity, the best results are obtained if the cream is cooled in a refrigerator before the shaking begins. If the cream is warm, butter forms quickly, but it is soft and unpleasant.

Many people consider that home-made butter tastes better if salt is added. However, in view of the modern theories on the connection between salt and heart disease, it is probably inadvisable to encourage the children to consume additional salt.

Extending the learning

- 1 *Make cheese and yoghurt* A simple recipe for making cheese is contained in Science 5/13: *Early Experiences* (Macdonald Educational). If you have, or can borrow, a yoghurt-maker this is another interesting activity for the children to assist with.
- 2 *Heating and cooling substances*
What you need: Some clean metal foil milk bottle tops; a bowl of hot water; some foods such as butter, margarine, lard, cheese, chocolate and ice or ice-cream; a spoon. You will also need to use a refrigerator.
What you do: Float a milk bottle top in the bowl of hot water. Put a small piece of butter in the milk bottle top. Watch to see what happens. Then lift the milk bottle top and butter with a spoon. Leave the milk bottle top and butter in the refrigerator for about half an hour. Look at it again. What has happened?
Do this experiment with each of the other foods in turn. In the case of the ice you may have to use the freezing compartment of the refrigerator. Record what happens in each case.
SAFETY PRECAUTION: Care will be necessary when doing this experiment to avoid scalding. It is suggested that the teacher pours out the hot water.
(Expected results: All of the substances listed will melt when heated, and solidify again when cooled. These are all examples of physical changes.)
- 3 *How do food substances change when they are heated?*
What you need: Some aluminium cooking foil; scissors; spring clothes pegs; a candle; a fruit bowl or soup dish containing sand; some or all of the following foods or cooking substances: sugar, salt, bread, flour, custard powder, baking powder, raisins.
What you do: Cut the aluminium foil into strips about 10 centimetres long and 2.5 centimetres wide. Fold one end of each strip into the shape of a spoon. Clip the other end onto a clothes peg. Stand the candle in the bowl or dish of sand.

Draw a table like this:

Substance	What it looked like before heating	Changes seen while heating	What the substance looked like after heating
Sugar			
Salt			
Bread			
Flour			

Put a small amount of sugar into one of the spoons you have made. Write down in your table what the sugar looks like.

Light the candle. Hold the clothes peg and heat the sugar gently over the lighted candle. What do you see? Keep heating the sugar until nothing happens. Write in your table what the sugar looked like after heating.

Put your spoon on the sand until it cools.

Take a new aluminium foil spoon and do the experiment with the salt. Then try each of the other substances. Use a new aluminium foil spoon each time.

Do all the substances change when heated?

SAFETY PRECAUTION: Strict supervision of this experiment is necessary to avoid accidents.

(Expected results: All of the substances listed, with the possible exception of the salt, will be changed by heating. Whether or not the salt changes, depends upon the temperature of the flame. All the changes produced are permanent, and are therefore examples of chemical changes.)

- 4 **Invisible ink** Squeeze the juice from half a lemon into a saucer. Let the children use a fine paint brush and the lemon juice to write their names or a message on a sheet of paper. Let the paper dry. Can the children see the writing?

Heat the paper for the children by rubbing it with a hot iron. Can they see the writing now?

Let the children experiment to see whether orange juice, onion juice or milk will also act as an invisible ink. (Usually they will.)

Further experiments and activities will be found in *The Young Scientist Investigates: Everyday Chemicals* by Terry Jennings (OUP).

Dissolving (pages 84–85)

Lesson objectives

- To demonstrate that certain substances are soluble in water, others are insoluble.
- To demonstrate that substances which dissolve in water can be recovered again by evaporation of the solution.
- To show that insoluble substances can be separated from water by filtration.

Setting the scene

Since this topic is essentially a practical one, it might be best to introduce the lesson by posing a practical problem,

such as how can we obtain salt from seawater. A bottle of real or 'artificial' seawater could be provided, and the children's suggestions could be tested by the teacher. (The answer is to heat the seawater to evaporate the water away, when the salt will be left.)

Other possible starting points include:

- Make a list of things which are dissolved in water in the home.
- Measure how much sugar or salt will dissolve in a given volume of cold water.
- Make lemonade from lemonade powder, or make jellies as examples of dissolving.

New words

Dissolve – when a substance such as sugar or salt disappears in a liquid such as water, we say it has dissolved.

Evaporate – when water is heated it disappears into the air as water vapour. We say the water has evaporated. Other liquids also evaporate when heated.

Filtering – the process whereby a substance which will not dissolve is separated from a liquid by a piece of filter paper, blotting paper or something else which acts as a kind of strainer.

Solution – when sugar disappears, or dissolves in water, a sugar solution is formed. Many other substances dissolve in liquids to form solutions.

Class management

Since this topic consists mainly of practical activities, it is suggested that a 'circus' of experiments is arranged around the classroom, and that the children, working in pairs, move from one experiment to another until they have completed them all.

Safety precautions

In the experiment on page 84 to get sugar back from sugar solution, the children are encouraged to taste the solution and the residue left on the saucer after the water has evaporated. The children should be warned *never* to taste any other substances used in experiments, unless they have been specifically told that it is safe to do so.

Now try these

- When sand and small pieces of cork are mixed together in water and then allowed to stand, the sand will sink to the bottom of the water, while the pieces of cork will float. The pieces of cork can simply be poured out of the jar or scooped out with a teaspoon. After allowing the water to settle, the clear water can be decanted off, leaving the sand. Alternatively, the sand and water can be poured into a filter paper in a funnel, when the sand will be retained in the filter paper.
- A mixture of salt and sand can be separated by first stirring them into water. The salt will dissolve, while the insoluble sand collects at the bottom of the container. If the liquid is poured into a filter paper in a funnel, the sand will be collected in the filter paper. When the clear liquid is evaporated, either by heating to dryness or by leaving it to evaporate in a clean saucer near a radiator, the salt will be deposited.

- 3 If some pieces of egg-shell are dropped into a jar of water, a few air bubbles may rise to the surface, but otherwise nothing happens. When egg-shell is dropped into vinegar, however, there is a vigorous fizzing reaction, as bubbles of carbon dioxide gas are produced. The egg-shell slowly dissolves.
- 4 If a little bicarbonate of soda is added to vinegar in a jar, the mixture fizzes vigorously as bubbles of carbon dioxide gas are produced. It is this carbon dioxide gas which causes food to 'rise' when bicarbonate of soda or baking powder is added to it before the food is cooked.
- 5 An ice-cube floats on water, but much of it is below the surface. Icebergs are dangerous to shipping because, like the ice-cube, only about one-eighth of them sticks up above the surface of the water. An iceberg may stick up only 5 metres above the surface and be difficult to see, particularly at night or in fog, but there is another 35 metres of jagged ice below the surface which could rip a ship open. In addition, because they chill the moist air around them, icebergs are often obscured by clouds of mist.

Expected results of activities and experiments

Dissolving (page 84)

Stirring does help the sugar to dissolve in the water. Sugar, like most substances, also dissolves faster in warm water than it does in cold water.

Granulated sugar dissolves faster than a sugar lump, because in the former there is a larger surface area of the sugar exposed to the water.

Getting sugar back from sugar solution (page 84)

The water in the saucer evaporates into the air, in the form of the invisible gas water vapour. The solid (or treacly liquid) left in the saucer is sugar.

If the experiment is repeated with salt, the same kind of result will be obtained.

Which substances dissolve in water? (page 85)

Of the substances listed, it will be found that the sugar, salt, bath salts, washing soda, bicarbonate of soda, baking powder and instant coffee will dissolve. They dissolve even more readily if warm water is used instead of cold water. Some of the ingredients of custard powder dissolve quite easily, others less so. Some of the constituents of tea leaves dissolve, while the actual fragments of the leaves remain insoluble. Sand is also insoluble.

(This is a good place to introduce children to the words *soluble* and *insoluble*.)

Looking at some common substances (page 85)

The substances suggested differ in the size of their particles, so that the children should have no difficulty in describing the texture and colour of the substances. Smell is very much a subjective sense. Flour and sand are both insoluble, while the sugar and salt are soluble. It will probably be found that more sugar than salt dissolves, although how much of each dissolves will depend upon the temperature of the water used.

Filtering substances (page 85)

There will be nothing visible in the filter paper through which the sugar solution was poured. The sand will be left in the other filter paper.

A filter paper will separate only substances, like sand and soil, which are insoluble in water. Soluble substances, such as sugar and salt, are not affected.

Extending the learning

- 1 *A necklace of sugar crystals* This is a different way of showing children that the water will evaporate from sugar solution.

Take a clean jam-jar and stand a metal spoon in it. Pour hot water into the jar. The water should be hot enough for the children just to be able to bear their fingers in it. Add sugar to the water, a spoonful at a time, and stir. Keep adding sugar until no more will dissolve. There should be a little sugar left on the bottom of the jar (such a solution is known as a saturated solution).

Rest a pencil across the top of the jar. Hang a length of thin string from the pencil in a loop into the jar. Stand the jar in a warm place for a few days. What do the children notice?

(The string acts as a kind of 'wick', soaking up the sugar solution from the jar. The water evaporates readily from the solution in the string, and glistening crystals of sugar are left on the string. The children could see whether salt or lemonade powder will act in the same way – usually they will. An extension of this activity is to grow crystals of various common soluble substances. Details are given in *The Young Scientist Investigates: Everyday Chemicals* by Terry Jennings (OUP).

- 2 *Freezing salt water*

Why is it that the seas around the shores of Britain rarely freeze?

What you need: An ice-cube tray; a jar of cold tap water; another jar containing either seawater or cold tap water with salt dissolved in it. You will also need to use the freezing compartment of a refrigerator.

What you do: Fill half of the compartments in the ice-cube tray with tap water. Fill the other compartments with sea water or salt solution. Make sure you know which is which.

Carefully put the ice-cube tray in the freezing compartment of the refrigerator.

Look at the ice-cube tray from time to time. Which freezes first, the tap water or the salt solution or seawater? (It will be found that the tap water freezes first. Salt, or any other dissolved substance, lowers the freezing point of water. Whereas pure water freezes at 0°C, the salt in seawater lowers its freezing point to –1.9°C. In addition, the perpetual movement of the water in the sea makes it freeze less readily than still water. The above experiment could be carried out using sugar, bicarbonate of soda, or even lemonade powder. The children could also be asked why salt, or a mixture of salt and sand, is put on icy roads in winter. (The answer is that the salt melts the ice, and the water will not freeze again unless the temperature falls much lower. The sand helps vehicle tyres to grip the road surface.)

Keeping clean (pages 86–87)

Lesson objectives

- a To show that water behaves as if it has a 'skin' on it.
- b To show that soap and detergents not only break the surface 'skin' on water, but also dissolve some substances which water alone will not dissolve.

Setting the scene:

Possible starting points include:

- 1 A display of the packets and wrappings of the various brands of soaps and detergents, and also of the manufacturers' claims about the efficacy of their products.
- 2 Why do we wash ourselves? Queen Elizabeth I is said to have bathed once a month whether she needed it or not!
- 3 Which brand of soap gives the creamiest lather?
- 4 Try to wash an oily rag with just cold water.

New words

Detergent – a general name for cleaning substances, including soap. Nowadays the word is most often used for the powders, liquids or flakes which are made from oil or coal, and which are used for washing clothes, cars, floors, crockery and cutlery.

Class management

Again it is suggested that a 'circus' of experiments is arranged around the classroom. The children can work in pairs or other small groups and move from one experiment to another, until they have completed them all.

Safety precautions

Some people are allergic to certain detergents. If any children in the class are known to have allergic tendencies, eg. to suffer from hay fever, asthma, 'nettle rash', or eczema, they should either not carry out the experiments, or should do so only if wearing rubber gloves.

Answers to questions in the text

Keeping clean (page 86)

The animal which is able to walk on the surface of the water is the pond skater, described on page 28 of Course Book 1. It may be worthwhile to repeat the experiment on the surface 'skin' of water described on page 29 of Course Book 1.

Now try these

- 1 The skin has a large number of pores in it, and it is through these that sweat reaches the surface. About 750 cubic centimetres of sweat is given off each day, more in hot conditions, and this helps to regulate the temperature of the body. Dust and dirt, as well as fragments of worn-out skin, stick to the sweat, and soon clog the pores. If the skin is not washed, the sweat glands will not work properly, germs may grow on the skin causing spots, and the stale sweat will produce unpleasant 'body odour.'
- 2 Strictly speaking the word 'detergent' is a general name for cleaning substances, including soap. Nowadays, 'detergent' is most often used for synthetic cleaners in the form of powders, liquids or flakes which are manufactured from petroleum chemicals or by-products of coal. These are used for washing clothes, cars, floors, dirty crockery and cutlery, and in cosmetics, hair shampoos etc.

Soap is manufactured by boiling a mixture of oils and

fats with the strong alkali, caustic soda, and then adding concentrated salt solution to the mixture. The soap may have perfume added to it before it is turned into household bars, flakes, tablets or other forms of soap.

Both soaps and synthetic detergents act because they reduce the surface tension of water. In effect they break the surface 'skin' of the water, making the water 'wetter'. They also loosen the hold that grease and dirt have on the skin, clothing and other surfaces.

- 3 Clean water forms distinct blobs and droplets when it is dropped onto a variety of non-absorbent surfaces. However, if soap or detergent is added to the water, the surface 'skin' is broken and the water spreads out, wetting the surface completely.
- 4 The exact results of this activity will depend upon the particular kind of cloth being used and the size of the pieces. With most porous materials, a small piece of the cloth placed in a bowl of clean water, will remain floating for a considerable time. A small piece of the same cloth floating in water to which detergent has been added will quickly become wetted and sink.
- 5 In comparing washing-up liquids and washing powders it is important, if the comparison is to be fair, for the same amount of detergent to be used, the same amount of water at the same temperature, and for the same kind and size of pieces of cloth to be washed in the same way.

SAFETY PRECAUTION: Some people have skin which produces allergic reactions to certain detergents. The children should wear rubber gloves when carrying out this activity.

Expected results of activities and experiments

The 'skin' on the surface of water (page 86)

The washing-up liquid or soapy water breaks the surface 'skin' of the water quite violently. Whichever has been used, talcum powder, a ring of matchsticks or a loop of cotton thread, it is pushed to the side of the bowl.

For this experiment to work, the bowl must be perfectly clean and free from any trace of soap or detergent initially.

Blow some soap bubbles (pages 86–87)

Whether washing-up liquid is used, or washing-up liquid plus glycerine, the bubbles are all the same iridescent colours.

In general, the larger the wire loop used, the larger the bubbles. The shape of the wire loop makes no difference. Whether the loop is square, triangular or round, the bubbles are always spherical.

How do detergents help to get rid of stains? (page 87)

It is not possible to predict the exact results of this experiment, since they will depend upon the type of detergent used and the exact nature of the stains. As an extension to this experiment, it is suggested that a 'biological' washing powder is compared with a non-biological one.

Whichever type of detergent is used, it will be found that warm water and detergent wash better than warm water alone. It should be pointed out to the children that when the stains are removed they are being dissolved. In other words, detergent and warm water will dissolve substances which warm water alone cannot dissolve.

Extending the learning

- 1 *Model boats* This is another way of showing what

happens when the surface 'skin' of water is broken.

Cut a boat shape about 3 cm long from thin card or a thin sheet of stiff plastic. Make a small notch at the rear end of the boat. Fix a small piece of soap or a small piece of camphor in this notch, and put the boat on water in a washing-up bowl. The water and the bowl must be perfectly clean with no trace of soap or detergent present. As the camphor or soap breaks the surface 'skin' of the water behind the boat, it pushes the boat forwards.

- 2 *Cleaning dirty coins* The children will probably be familiar with the chemicals which are used to clean brass, silver or other metal ornaments in the home. This is a simple cleaner they can make which dissolves the dirt and chemicals that make copper coins dull.

What you need: 2 jam-jars, plastic beakers or yoghurt pots; vinegar; salt; a plastic spoon; some dirty copper coins.

What you do: Pour some vinegar into one of the containers. The vinegar should be about 1 centimetre deep. Add 1 level teaspoon of salt to the vinegar. Stir the salt and vinegar together.

Put some cold water into the other container.

Put one of the dirty coins in the salt and vinegar. Leave the coin there for a minute or two. Use the spoon to take the coin out of the salt and vinegar. Wash the coin in the container of water.

What colour is the coin now? Will salt and water clean copper coins? Will vinegar on its own clean copper coins? Will the salt and vinegar clean silver-coloured (nickel) coins?

(Expected results: Dirty copper coins become bright and shiny again using this mixture. Salt and water alone will not clean copper coins, nor will vinegar on its own. The salt and vinegar will clean silver-coloured (nickel) coins to some extent, but not as quickly or as effectively as copper coins are cleaned.)

- 3 *What happens when vinegar is added to baking powder?*
What you need: Two small bottles, both the same size, aspirin bottles are ideal; 2 balloons; vinegar; baking powder (or bicarbonate of soda); a teaspoon.
What you do: Put a few drops of vinegar into one bottle. Put a few drops of water in the other. Carefully put a teaspoon of baking powder (or bicarbonate of soda) into each balloon.

Stretch a balloon over the top of each bottle without spilling the powder.

Lift each balloon so that the baking powder falls into the bottle. Let go of the balloons. Watch carefully to see what happens.

Did the vinegar affect the baking powder?

Did the water affect the baking powder?

(Expected results: This experiment has been included to show that some examples of dissolving also involve a vigorous chemical reaction. The vinegar, which is a weak acid, reacts with the baking powder, which is a weak alkali, to produce the gas carbon dioxide. This gas inflates the balloon. There is no action, other than simple dissolving, in the bottle in which water is added to the baking powder. A reaction similar to that between baking powder and vinegar occurs in many fire extinguishers. The children can find out more about acids and alkalis in *The Young Scientist Investigates: Everyday Chemicals* by Terry Jennings (OUP).)

Checking (pages 88–89)

Thinking

- 1 Scientifically speaking the differences between solids, liquids and gases are due to the movements of the particles or molecules of which they are composed, and to the spaces between these molecules. In solids and liquids the molecules are packed closer together. However, at this level it is sufficient for the children to know that solids have a fixed or definite shape while liquids and gases take up the shape of the container in which they are placed. If a solid is heated sufficiently it will turn first into a liquid and then finally into a gas. If a gas is cooled sufficiently it will turn first into a liquid and then into a solid. These are physical changes.

- 2 We can tell that when sugar dissolves in water it has not really gone altogether because we can still taste it.

- 3 Dissolving sugar in water is a physical change. We can get the sugar back again by heating, or evaporating, the sugar solution.

Toasting bread is a chemical change because a new substance is formed. However the children may have noticed that steam comes from the bread and if this is cooled we could obtain the original water from it (a physical change).

Lighting a candle melts some of the wax. Solid wax can be obtained again by cooling (a physical change). At the same time the wick of the candle and some of the wax burn and produce completely new and different substances (a chemical change).

Freezing water to produce ice, is a physical change.

Cutting up a piece of paper and stretching a rubber band are both physical changes.

When iron rusts a completely new and different substance is formed, and so this is a chemical change.

- 4 Some of the gases children might know of include:
oxygen – used in breathing and burning.
carbon dioxide – used by green plants to help make their food and in fire extinguishers and fizzy drinks.
chlorine – used to sterilize drinking water and the water in swimming pools.
coal gas and natural gas – used as fuels.
neon – used in neon lights, illuminated signs etc.
helium – used to fill balloons (hydrogen is also sometimes used for this purpose, but is inflammable).

- 5 Fresh water is obtained from seawater in a few areas of the world, but it is not often done because large amounts of expensive oil, natural gas or other fuels have to be used to evaporate the seawater to produce water vapour. This water vapour is then cooled, to form pure water.

- 6 One way to separate a substance from a liquid in which it has not dissolved, apart from filtering, is decanting. The solid substance is allowed to settle out from the liquid, and then the liquid is carefully poured or decanted off. This could be demonstrated by shaking up some clean sand in a bottle of water and then leaving the mixture to settle for a day or so. The water can then be carefully poured away.

- 7 The chalky 'fur' which collects inside a kettle was originally dissolved in the water. Some of it evaporates out each time a kettle of water is boiled. In some places (usually where the drinking water has passed through chalk or limestone rocks) much 'fur' collects in kettles,

hot water pipes and boilers. These are said to be 'hard water' areas, and the water does not lather easily with soap or detergent. 'Soft' water readily gives a lather with soap or detergent since it doesn't contain the dissolved chalky substances that ultimately cause 'furred' kettles, pipes and boilers.

- 8 Just because water *looks* clean it is not necessarily fit to drink. It may contain thousands of germs too small to be seen without a powerful microscope.
- 9 Some of the other acids the children might have heard of are sulphuric acid (used in car batteries), lemon juice (citric acid), and sour milk which contains lactic acid.
Other common acids include nitric, hydrochloric, carbonic and phosphoric acids. Bacteria in the mouth change sugary foods into lactic acid which causes tooth decay.
- 10 We know that little drops of fat in milk are not dissolved since we can *see* them. If the milk is allowed to stand, the little drops of fat form a layer of cream at the top of the bottle. If we shake the milk long enough and hard enough, the drops of fat join together to form butter.
- 11 Iron melts and becomes a liquid at a temperature of about 1500°C. If this liquid iron is heated to a much higher temperature still, it will eventually become a gas or vapour.
- 12 Rocks inside the Earth (in the layer called the mantle) are so hot that they are liquid. This liquid rock also comes out of volcanoes and forms lava. When lava cools it solidifies into the group of rocks known as igneous rocks (see Course Book 2, pages 74–75).

Doing

- 1 There will not be much difficulty in deciding which of the substances commonly used in kitchens are solids and which are liquids. Far fewer gases are used. However, yeast and baking powder, both solids, are used in cooking to produce the gas carbon dioxide. In addition, all of the aerosols that are commonly used today contain a substance which is sprayed into the air. This substance is dissolved in a volatile liquid (a liquid which vaporises easily). Above the liquid is a propellant gas under pressure. When the button is pressed, the gas forces the carrier liquid out into the air. The liquid rapidly evaporates, leaving a fine mist of droplets of starch, air-freshener, paint or whatever.
- 2 Balloon – a solid containing a gas (air, hydrogen or helium)
Glass of orange squash – a solid containing a liquid (a fizzy orange drink would also contain a gas). The drinking straw is a solid.
Bread and candyfloss – solids filled with gases.
Aquarium – fish and water plants are solids contained in water, a liquid.
Soap bubbles and beachball – both contain gases (air). In the former the air is enclosed by a liquid, in the latter it is enclosed by a solid.
- 3 Margarine is a mixture of oils, fats and pasteurised milk, whey or buttermilk, to which vitamins A and D and various flavourings and colourings have been added. Most of the oils used in margarine come from plant products, such as groundnuts or peanuts, coconuts, palm kernels, sunflowers and soya beans. Animal fats and oils are sometimes used.

- 4 Salt is a mineral often mined from underground deposits in Britain, Germany, Poland and the United States of America and other parts of the world. In some countries with hot climates, including those in the Mediterranean region, salt is obtained by evaporating sea water. The sugar we eat comes from two plants – sugar cane and sugar beet.

The children can read more about these two substances in *The Young Scientist Investigates: Everyday Chemicals* by Terry Jennings (OUP).

- 5
 - a When butter and lard are warmed they *melt*.
 - b When sugar is heated it forms a brown liquid, this is a *chemical* change.
 - c When sugar dissolves in water it forms a *solution*.
 - d When water disappears from a saucer of sugar solution the water is said to have *evaporated*.
 - e Salt lowers the *temperature* at which water freezes.
 - f Soap and detergents will *dissolve* some stains which ordinary water will not.
 - g Water acts as if it had a *skin* on it.
 - h When baking powder and vinegar are added together, a *gas* is made which makes the mixture fizz.
 - i When water is frozen and forms the solid, ice, this is a *physical* change.
 - j Soap and detergents *break* the surface skin on water.

Going further – some other suggestions

- 1 *Growing yeast* Yeast is a substance used in making bread and certain cakes. It is yeast which makes bread light, with all the little holes in it. Yeast is interesting because it is not a chemical substance, but a tiny plant, a kind of fungus.

The children can see something of the way yeast grows and behaves if they half fill a plastic bottle with tepid water. Add a level teaspoon of yeast and a heaped teaspoon of sugar. Shake the mixture up.

A cork should be lightly pushed in the bottle. Do not use a screw-cap. Stand the bottle in a bowl of warm water. Look at the bottle from time to time over the next hour or so. What happens to the mixture in the bottle? What happens to the cork? Ask the children to smell the liquid in the bottle. What do they notice?

If a microscope is available, put a drop of the yeast liquid on to a slide. Focus carefully and the tiny yeast cells should be visible. If the children watch they may be able to see the cells dividing up as they grow and multiply.

(As the yeast cells grow, they carry out a chemical change on the sugar, which produces the gas carbon dioxide. The liquid in the bottle will fizz, and the cork may be forced off the bottle. One of the waste products as yeast cells grow, is alcohol, and the children may be able to smell this.)

- 2 *An experiment with yeast*
What you need: Two small bottles, both the same size (such as clean tablet bottles); two balloons; yeast (dried or fresh); sugar; water; labels.
What you do: Add a level teaspoon of sugar to a little water in one of the bottles and add a pinch of yeast. In the other bottle put just water and a pinch of yeast.
Stretch the neck of a balloon and fix it over the top of one of the bottles. Make sure there is no air in the

balloon. Do the same with the other bottle. Label the bottles and leave both in a warm place.

What happens to the yeast inside the bottles? What happens in the bottle without sugar? What happens to the balloons?

Do the experiment again and make other fair comparisons. You might, for example, put yeast, sugar and water in both bottles. But put one bottle in a warm place and the other in a refrigerator.

The gas which the yeast makes is called carbon dioxide. There is carbon dioxide in the air we breathe out. Did you do the experiment with baking powder and vinegar? Carbon dioxide gas was being made there, too.

Can you see now how baking powder and yeast are able to make bread and cakes spongy and light?

Do you think the way yeast changes sugar is a physical change or a chemical change?
(Expected results: In both bottles the yeast breaks down in the water to form a greyish mixture. Quite soon the liquid in the bottle with the added sugar starts to fizz, as carbon dioxide gas is produced. The balloon becomes slightly inflated as it fills with the gas. Nothing happens to the liquid without the sugar, or to the balloon. This shows that yeast needs sugar if it is to produce carbon dioxide.

If the experiment is repeated, with yeast, sugar and water in both bottles, but one bottle is placed in a warm place and the other is placed in a refrigerator, carbon dioxide will be produced only in the bottle kept in a warm place. This shows that yeast will only grow in warm conditions.

It is the carbon dioxide given off by both baking powder and yeast which makes bread and cakes spongy and light.

Since yeast changes sugar into two new substances, carbon dioxide and alcohol, it is a chemical change which takes place.)

Further experiments and activities are contained in The Young Scientist Investigates: *Everyday Chemicals* by Terry Jennings (OUP).

Interdisciplinary activities

Art and Craft

Modelling with clay, plasticine and plaster of Paris.
Mixing paints.
Making and using dyes.
Changes through cooking.

English

Common expressions involving sugar and salt.
Science fiction stories.
See Oxford Junior English: *2 Food and Farms* by Oliver Gregory (OUP).

Geography

Sugar cane production in the West Indies, Australia, Latin America and the southern USA.
Sugar beet farming in East Anglia.
The maple sugar industry of Canada.
Tea, coffee and cocoa farming.
Salt mining and the uses of salt.
The formation of caves, potholes, stalactites and stalagmites.

Dairy farming and the dairy industry.

Health and hygiene

Soap and elementary hygiene.

Sugar and tooth decay.

Clean water and pollution.

Sweating and salt.

Salt and diet.

Sugar and energy foods.

Antiseptics and disinfectants.

History

'Salt money' in Roman times and the modern word 'salary'.

Sugar and the slave trade.

The alchemists.

Medicines through the ages.

Early methods of making butter and cheese.

A visit to the kitchens of an historic house.

Mathematics

Containers and volume.

Graphs of cooling.

Value for money of household commodities in different sized containers.

Boiling points, freezing points, and cooking temperatures.

Music, drama and PE

'I'm for ever blowing bubbles'. (song)

Songs using the words 'sugar' or 'sweet'.

Hygiene in swimming pools.

Energy-giving diets for athletes.

Religious education and social studies

Cooking in Nazareth (see A Primary Religious Education Course: *1 Nazareth* by Richard Hughes (OUP).

Unit 12: Life cycles

Aims of the Unit

- To show that a life cycle is the different stages, in order, that a plant or animal goes through during its lifetime.
- To show that life cycles may differ in the number of stages and the length of each stage.
- To show that the life cycle of a species is essential if that species is to continue to exist and avoid extinction.

Science background

All living things change during the course of their lifetime. They grow larger, mature, produce offspring, and eventually die. Some individuals may die as a result of accidents, disease, starvation, cold, heat, lack of water, or the actions of predators. They may die before they have reproduced themselves. But as long as other individuals of the same species have reproduced themselves, the species continues its existence. If a species fails to reproduce itself sufficiently to maintain or increase its numbers, usually because of a drastic change in its surroundings, then the species will decline in numbers, and may eventually become extinct.

The life cycle of most animals begins with an egg, that of most plants begins with a seed. However, some plants are able to reproduce themselves vegetatively or asexually, that is they produce identical copies of themselves, missing out the seed stage. In many animals the egg grows directly into a smaller version of the adult animal. In others the egg may hatch into an intermediate stage, often called a larva

or a nymph, whose prime function is to feed and grow. The tadpole which hatches from a frog's egg is an example of a larva, so is the maggot which hatches from the egg of a housefly or the caterpillar which hatches from a butterfly's egg. There may be other stages before the adult or mature animal is formed. The main characteristic of the mature animal, or plant, is that it is able to reproduce itself. Reproduction often means the end of the lifespan of the animal or plant for, having reproduced themselves, many animals and plants die.

The life cycles of many plants and animals are synchronized to the seasons of the parts of the world where they live. In Britain and other temperate regions of the world, many plants and animals complete their life cycles during the warmer, longer days of spring and summer when there are ideal growing conditions and an abundance of food is available.

Plants reproduce sexually with the aid of female cells called ovules or egg-cells, located in the carpels or ovaries of the flower, and with male cells contained in the pollen grains. These unite during fertilization to produce a cell, or zygote, which grows into the seed. The flowers of most plants contain both male and female sex cells, although cross-fertilization is still the rule. In animals the male sex cells, the sperms, and the female sex cells, the eggs or ova, are usually produced in separate male and female individuals although there are exceptions, as for example in the case of slugs, snails and earthworms. Sexual reproduction is important because it produces variation in the offspring. Each offspring has some characteristics of both parents and, as we saw in Unit 1, this variation is important in evolution.

The subject of life cycles is extended in Course Book 2 to examine the sexual reproduction of animals where a higher level of parental care of the young is exercised.

Books for the children

The Young Scientist Investigates series: *Flowers, Seeds and Seedlings*, *Trees*, *Small Garden Animals* and *Pond Life* by Terry Jennings (OUP).

How Creatures Multiply by Jill Bailey (Purnell).

The Stickleback by Margaret Lane (Methuen/Walker).

The Frog by Margaret Lane (Methuen/Walker).

The Life of a Butterfly by Jan Ethelberg (Black).

Honeybees by John B. Free (Black).

The Garden Spider by Jan Ethelberg (Black).

The Easy Way to Wild Flower Recognition by John Kilbracken (Kingfisher).

Books for the teacher

Science 5/13: *Trees* (Macdonald Educational).

Science 5/13: *Minibeasts* (Macdonald Educational).

Science 5/13: Using the Environment: *2 Investigations Part 2* (Macdonald Educational).

Science 5/13: Using the Environment: *3 Tackling Problems Part 1* (Macdonald Educational).

Materials and organisation

Children are always interested in the details of reproduction, and they will welcome information on the life cycles of the animals and plants dealt with in this Unit.

The life cycles of as many plants and animals as possible should be studied practically, and if it is not possible to

keep small animals in the classroom permanently, some could perhaps be borrowed for the duration of the teaching of the Unit. The value of secondhand sources of information, including films and television programmes, should also not be underestimated.

Materials and equipment:-

pictures of young animals and plants
large flowers of cultivated plants eg. single daffodils or tulips, or common wildflowers such as buttercups
flowers of wild grasses
hand lenses
jar or sandwich box of moist soil
cotton wool, moss or paper towels
adult slugs
eggs of pond snails
egg cushion of a spider
jam-jars
aquaria, fish tanks or large bowls
washed gravel
water weed
tadpoles, frog spawn or toad spawn
sticklebacks
guppies
aquarium heater and aerator

Making copies (pages 90–91)

Lesson objectives

- a To explain why living things need to reproduce themselves.
- b To explain what a life cycle is.
- c To show how sexual reproduction occurs in plants.

Setting the scene

Possible starting points include:

- 1 A collection of pictures of young animals displayed on the Science Table.
- 2 A collection of *common* wild flowers or garden flowers displayed on the Science Table.
- 3 Bringing a pet animal which has had babies into the classroom, and asking the class why animals need to reproduce themselves in this way.
- 4 Planting seeds (refer back to Unit 2 of Course Book 1).
- 5 Counting the number of seeds produced in the seed-heads or fruits of some garden weeds or cultivated plants.

New words

Reproduce – when animals or plants make copies of themselves, they are said to reproduce themselves.

Extinct – when the last plant or animal of a species dies, the species is said to have become extinct.

Life cycle – all the stages in the life of one plant or animal.

Sexual reproduction – reproduction which involves different male and female parts.

Sepal – the small leaves on the outside of a flower which protected it while it was a bud.

Petal – the part of a flower which is often brightly coloured.

Stamen – the part of a flower which makes the yellow dust-like pollen. Stamens are the male parts of a flower.

Carpel – the part of a flower which grows into a fruit and in which the seeds develop. Carpels are the female parts of a flower.

Pollen – the yellow dust-like particles which are made in the stamens of a flower. Pollen contains the male cells of a flower.

Fertilised – when a pollen grain and the egg-cell of a flower join together, the egg-cell is said to have been fertilised. The fertilised egg-cell can then grow into a seed. The eggs of animals also have to be fertilised before they will grow into a young animal.

Class management

All the work on this topic can be carried out by the children working at their own desks.

Safety precautions

If any of the children suffer from hay-fever, caution will have to be exercised before large numbers of flowering plants, and particularly grasses, are brought into the classroom.

Answers to questions in the text

Making copies (page 90)

The piglets are more or less small copies of their mother. The only major difference is that in the piglets, as in all young mammals, the head is quite large in proportion to the size of the rest of the body. Children may notice that the adult female pig has more hair and that the teats are well developed.

How seeds are formed (pages 90–91)

When insects carry pollen from the stamens of one flower to the carpels of another, they do so accidentally. The insects are only concerned with obtaining pollen or nectar for food. Flowers which rely on insects to carry their pollen have evolved brightly coloured petals, sweet scents or nectar to attract the insects to them, in the hope that the insects will transfer some of the pollen to another flower of the same kind.

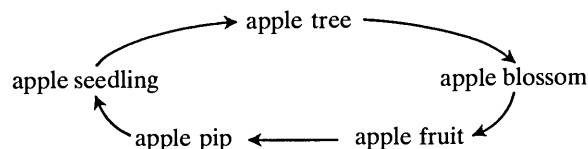
The flowers of grasses all have long stems, so that they sway in the wind. Grass flowers are all rather dull and green in colour, because they have no petals. These would get in the way when the wind carried pollen from one grass flower to another.

When you walk in long grass in summer, the yellow dust which often covers your shoes is pollen from the grass flowers you have brushed past. Sometimes in early summer, there is a yellow dusting on puddles near pine trees and other conifers. These trees are also wind-pollinated, and vast quantities of their pollen are scattered far and wide in the hope that some reaches another tree of the same kind.

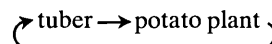
It should be emphasised to the children that the pollen grains, which have to travel to another plant, contain the male cells. The egg-cells in the carpels stay where they are on the parent plant, and there are far fewer of them. Huge numbers of small dry pollen grains are produced by those plants whose pollen is carried by the wind, because most of it either gets lost or is carried to the wrong kind of plant where it is wasted. The pollen grains of insect-pollinated flowers are relatively large, fewer in number, and often the grains are slightly sticky so that they become attached to the hairy body of an insect.

Now try these

- 1 The correct order of the stages in the life cycle of an apple tree is:



- 2 Most flowers of the same species do have the same number of sepals, petals, stamens and carpels. However, if there is a large number of stamens and carpels the numbers may vary slightly. Thus a meadow buttercup has five petals and between 25 and 30 stamens and carpels. Flowers of different species generally have different numbers of parts.
- 3 Foxgloves produce vast numbers of tiny seeds. If all the seeds of a single plant germinated and grew to maturity, within three to four years their progeny would cover the whole of England, Scotland and Wales. However, many of the seeds fall on unsuitable ground; not all of those which do fall on fertile soil germinate; many of the seedlings are eaten by slugs and other small animals, while some of the adult plants are eaten by rabbits and other herbivores.
- 4 The life cycle of a potato plant grown from tubers would be:



- 5 In the world today it is estimated that about 280 mammal and 350 bird species are threatened with extinction, together with about 20,000 plant species and a huge but unknown number of invertebrate species. Some animals and plants are in danger because of hunting or collecting, some because of the use of chemical pesticides, but the largest single cause of extinction today is loss of habitat – the destruction of the animal's or plant's natural home.

To counter this loss or threatened loss, nature reserves and natural parks are being set up. In addition there are captive breeding programmes in zoos, wildlife parks and botanical gardens, with the hope that some of the offspring of threatened species can be returned to the wild. Some threatened species are given legal protection.

It would be instructive for the children to find out more about the work of such voluntary bodies as the World Wildlife Fund, Friends of the Earth, Royal Society for the Protection of Birds, the Wildfowl Trust, the Royal Society for Nature Conservation, and the local county naturalists trust.

Extending the learning

- 1 Try to count how many seeds there are on a garden weed. Wait until a weed such as a dandelion or groundsel plant has produced seeds. Pick off all the seed heads. Put them in a paper bag. Close the bag and shake it thoroughly. Tip out the seeds and count them.
How many seeds would need to grow to replace the parent plants? What is likely to happen to all the other seeds and seedlings?
(Assuming the plant was cross-pollinated, only two

seeds would need to grow to replace the parents. Most of the seeds are likely to be eaten by birds and insects, or to fall on concrete, tarmac or other places where they will not grow. Many of the seedlings will be eaten by herbivores or die from plant diseases.)

- 2 In the spring, find a large single daffodil or tulip flower which has begun to fade.

Draw the flower. Remove the sepals and petals. Then study the parts of the flower which are left with a hand lens.

Draw a stamen. Whereabouts in it is the pollen to be found? Cut across the carpels of the flower. Can you see the egg-cells? How many are there? How are they arranged? Draw them.

(The pollen grains are found in the swollen upper parts of the stamens. The number of egg-cells varies from flower to flower, but they are arranged in three separate chambers of the carpel in both tulips and daffodils.)

- 3 Collect a little of the pollen from different kinds of flowers. Study the pollen grains with a hand lens or a microscope. Draw some of the pollen grains. Are the pollen grains from different kinds of flowers different? (Yes, they are.)
- 4 Make a table to compare the numbers of sepals, petals, stamens and carpels in some common flowers. Choose only simple flowers for this. Avoid daisies, dandelions and other similar composite flowers.
- 5 *Study the life history of a garden weed*
Groundsel is a good plant to choose; a dandelion or a shepherd's purse plant will also do.
What you need: A groundsel plant bearing seed heads; some small pots containing moist soil or compost (yoghurt pots or margarine tubs will do).
What you do: Carefully open one of the seed heads of the plant. How many seeds are there in each seed head? How do you think the seeds are normally scattered? Draw one of the seeds.
Plant some of the seeds in pots of moist soil or compost. Keep the pots watered. Make notes and drawings of the growth of the seedlings. Carefully transplant your little groundsel plants to other pots if they are overcrowded.

How long does it take for the groundsel plants to form flowers from the time the seeds were planted? What do the groundsel flowers look like? How many flowering heads does each plant have? Draw one of them. Also draw the whole adult groundsel plant.

Allow some of the groundsel seedlings to remain overcrowded. Do they grow as well as those you thinned out? Does each plant produce more flowers or less than those which were thinned out?
(Expected results: The seeds of groundsel and dandelion plants are normally scattered by the wind. Those of shepherd's purse are shot out away from the parent plant when the tiny seed capsules burst open.)

Under favourable conditions it is only a few weeks from the time groundsel seeds are planted until flowers are formed. This short life cycle accounts for the success of these plants as garden weeds – they reproduce quickly and efficiently.

The number of flowering heads on a groundsel plant varies, but normally when plants are overcrowded they will grow small or be rather straggly, and they will produce fewer flowering heads than those plants which are growing under more open conditions.)

Further activities and experiments concerned with flowering plants are contained in *The Young Scientist Investigates: Flowers* by Terry Jennings (OUP).

Animal copies (pages 92–93)

Lesson objectives

- a To compare the process of sexual reproduction in plants and animals.
- b To investigate the life cycles of some invertebrate animals.

Setting the scene

Possible starting points include:

- 1 A visit to a zoo or wildlife park, paying special attention to any young animals present.
- 2 A display of pictures on the Science Table showing adult animals with their young.
- 3 An aquarium or large bowl containing a breeding population of water snails.
- 4 Invertebrate animals brought to school by the children.
- 5 A search for invertebrate animals in the school grounds.
- 6 A visit to one of the new butterfly houses and farms, such as the London Butterfly House, at Syon Park, West London.

New words

Sperms – the tiny cells produced by male animals which take part in sexual reproduction.

Class management

All of the work on this topic can be carried out by the children working at their desks. However, if a search for invertebrate animals for use in the lesson is made, this will involve work outdoors, ideally in pairs or small groups.

Safety precautions

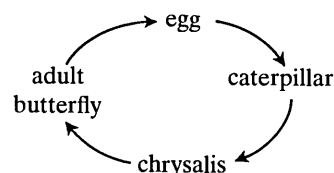
None.

Answers to questions in the text

Butterfly life cycles (page 92)

Cabbage white butterflies also lay their eggs on the undersides of the leaves of nasturtium plants. These plants are colourful and easy to grow from seed if teachers in urban schools wish to attract a breeding population of cabbage white butterflies.

The life cycle diagram of a cabbage white butterfly would look like this:



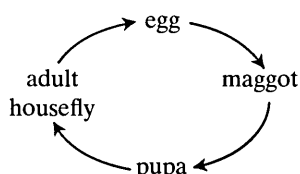
The only harmful stage in the life cycle of the cabbage

white butterfly is the caterpillar. The chrysalis is a resting stage, while the adult butterfly feeds harmlessly on the nectar of flowers. The caterpillar is the feeding stage, eating large quantities of plant material.

Some kinds of butterflies are becoming rare, and the main reasons are the destruction of woodland and hedgerows, the ploughing of downland and heathland, and the widespread use of chemical pesticides. These mean that many of the food plants on which the butterflies lay their eggs have been destroyed. Indirectly then, the reason why some kinds of butterflies are becoming rare is because they are not making enough copies of themselves.

Housefly life cycles (page 93)

The life cycle diagram of a housefly is:



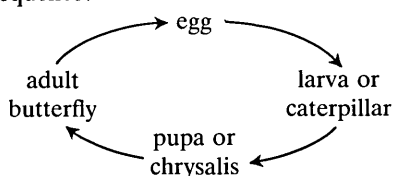
Houseflies lay their eggs in manure, dirty dustbins, uncovered meat and in other warm, moist places. The adult flies feed on the kinds of food on which the eggs were laid, and also bread, sugar, cakes and any other human foods they can gain access to. Flies are harmful to humans because they spread germs from dirty places to human food, causing many cases of food poisoning, diarrhoea, sickness and other illnesses. The enemies of houseflies include birds, spiders, bats, frogs, toads and other insect-eating animals. Many flies are killed by cold weather.

Some insects which care for their eggs and young are ants, bees, wasps and earwigs. These same insects also build nests.

Some of the insects which have only two or three stages in their life history include aphids (greenfly), dragonflies, damselflies, cockroaches, earwigs, stick insects and grasshoppers.

Now try these

- House flies reproduce rapidly because they lay large numbers of eggs (often 100 or more at a time) and, under favourable conditions, these can develop into adult flies in a short space of time, often less than two weeks. The things people do which encourage flies to spread, are to leave food and dustbins uncovered where flies can reach them and lay their eggs. The numbers of houseflies can be controlled by spraying the ceilings and walls of houses with liquid insecticides, by hanging up strips of paper or special 'wicks' impregnated with insecticides, by keeping refuse in covered bins, and by storing food in fly-proof containers.
- The life cycle of all butterflies (and moths) follows this general sequence:



- Spiders reproduce themselves by laying eggs. These

develop into tiny spiders which are miniature copies of the adults. There is no larval stage.

- The eggs of insects hatch only in certain warm, dry conditions. Large numbers of them fail to hatch when the weather is cold or wet. Bacterial and fungal diseases destroy many eggs, larvae and pupae. In addition, insect eggs, and even more so the larvae, pupae and adults, form food for lots of predators amongst the invertebrates, fish, amphibians, reptiles, birds and mammals.

Expected results of activities and experiments

Slugs' eggs (page 93)

There are 24 species of slug in Britain and although identifying the species is not always easy, there is usually no problem in deciding whether or not two slugs are members of the same species.

Slugs' eggs are pearly-white in colour, and it is normally quite easy to see the young slug developing inside each egg if a hand lens is used. The eggs of most species of slug hatch about two to three weeks after laying. The young slugs are miniature versions of the adults, although often they are a very pale colour.

Slugs, young and old, can be fed on lettuce, cabbage leaf, chopped raw carrot, raw potato, celery, dandelion, stinging nettle, dead-nettle, and most kinds of fresh or decaying leaves.

Extending the learning

- Breeding bluebottle flies* It is quite easy to breed bluebottle flies or blowflies, and also houseflies, indeed sometimes it is too easy.

In the spring, summer or early autumn, put a small piece of raw meat in a jam-jar. Sellotape a plastic funnel into the top of the jar. A suitable funnel can also be made by cutting off the top of a washing-up liquid bottle, removing the stopper, and inverting the rest of the top of the bottle into the jar. Leave the jar outside in a warm sunny place for a few hours.

Before long a fly will get into the jar but will find it difficult to get out again. After two or three hours, the surface of the meat should be examined carefully for signs of any small white fly eggs.

Leave the jar outside and watch to see when the eggs turn into maggots. When do the maggots turn into pupae? When do adult flies come from the pupae? Encourage the children to keep records and dates.

It is also easy to rear blowflies from the maggots sold as bait for use by anglers, if a few maggots, and some of the food they are sold in, are kept in a jar in a warm place. Cover the jar with muslin or a piece of a pair of tights.

- How quickly do greenflies breed?*

Most greenflies (or aphids as they are sometimes called) do not lay eggs, but produce minute living babies. Do this experiment in summer.

What you need: A leafy shoot from a rose bush; a small paintbrush; a large greenfly; a jar with a piece of fine material for a stopper; a rubber band; a small tablet bottle; some cotton wool.

What you do: Carefully wash the shoot of the rose bush to make sure there are no greenflies on it. Shake the water off the piece of rose bush and then put it into the

little tablet bottle which should be almost filled with water. Plug the gap around the top of the bottle and the rose shoot with cotton wool. Stand the bottle and rose shoot in the jar.

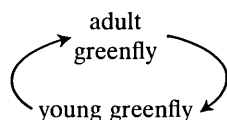
With the paint brush, gently lift the greenfly on to one of the leaves of the rose shoot. Cover the jar.

Look at the shoot after one day, and then again after two days. How many greenflies are there each day? Can you see a greenfly being born? You will need a hand lens to see this.

Draw the life cycle of a greenfly. How is it different from the life cycle of a housefly or butterfly? Why do you think greenfly are sometimes pests of garden plants?

(Expected results: Young greenfly are born at the rate of two or more a day. These young ones in their turn quickly begin to reproduce in the same way in warm, dry conditions.

During most of the summer, the life cycle of a greenfly is simply this:



A small proportion of the greenfly produced have wings, and are able to infect new plants.

During the autumn, separate male and female greenfly appear. These mate and lay fertilised eggs among the bud scales of rose bushes, daisy plants, sycamore trees, and the many other plants on which aphids feed. In the spring, these eggs hatch, and the young all start to reproduce without fertilisation having occurred. Both life histories are different from those of a housefly or a butterfly because they miss out the larval stage (the maggot or caterpillar) as well as the resting stage (the pupa or chrysalis).

Greenfly are pests of garden plants because they suck the juices out of plant leaves, causing them to wilt and die. Since greenfly breed so rapidly, a plant can quite quickly be killed.

- 3 *Rear butterflies and moths* Simple details are given in *The Young Scientist Investigates: Small Garden Animals* by Terry Jennings (OUP).

It is also possible to buy the eggs of British and exotic foreign butterflies and moths. Some of these are quite easy to rear. One source of these eggs, and rearing instructions, is:

The Butterfly Farm (Christchurch), 14 Grove Road East, Christchurch, Dorset BH23 2DQ.

Griffin & George, Gerrard Biological Centre, Worthing Road, East Preston, West Sussex BN16 1AS, produce an inexpensive Butterfly Rearing Kit, with which cabbage white butterflies can be reared at any time of the year.

More copies (pages 94–95)

Lesson objectives

- To examine the reproduction of some animals which lay their eggs in water.
- To show that there is a relationship between the

number of eggs or young produced by an animal and the hazards faced by the offspring.

Setting the scene

Possible starting points include:

- Keeping a small amount of frog spawn or a few tadpoles in the classroom.
- An aquarium containing small fish (sticklebacks, or the tropical fish guppies are ideal).
- A study of the fishing industry in geography, and particularly the causes of the decline in fish stocks.
- A study of courtship in animals.

New words

Shoal – the name given to a large group of fish swimming in company.

Class management

All of the work on this topic can be carried out by the children at their own desks.

Safety precautions

None.

Answers to questions in the text

More copies (page 94)

Many animals, including cod, live in large groups presumably because there is safety in numbers, with many eyes and ears to be alert for predators. When the breeding season comes, there is also no shortage of possible mates. This could be a problem for animals that lived solitary lives scattered in the huge expanses of the oceans and seas, and also for those animals, such as deer and antelope, which live on vast open grassy plains.

Sticklebacks (page 94)

The female cod would not need to lay as many eggs if she laid them in a nest like the female stickleback does, since she, or the male, could guard them, rather than leaving the eggs to their own devices.

Some of the animals in which the males are a brighter colour than the female are: most ducks, pheasants, most kinds of finches, including sparrows, chaffinches and goldfinches, blackbirds, peacocks, many kinds of apes and monkeys, and many butterflies, newts and some lizards. In addition, in a number of species the male has some characteristic or feature which makes him seem larger or more conspicuous, eg. the antlers of male deer or the mane of a male lion.

Some of the animals where males and females are similar in appearance are robins, thrushes, pigeons, rabbits, dogs, cats, horses, frogs and toads.

Frogs (pages 94–95)

In cod and many other water animals, the female simply pours her eggs into the water, and the male similarly pours out his sperms. Many of the eggs are never fertilised because the waves and currents wash the sperms and eggs away from each other. By clinging on to the female's back and producing his sperms at the precise moment the female lays her eggs, the male frog increases the chances of all or most of the eggs being fertilised. The next step

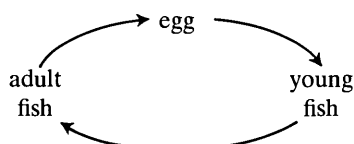
forward in this process, in evolutionary terms, is for the male to have a penis with which he places his sperms inside the female's body, thus ensuring the eggs are fertilised before they encounter the hazards of the outside world.

Having enough babies (page 95)

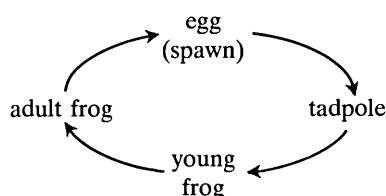
For animals that look after their young, in general, having fewer young at a time means they can be given better care and protection. It also means that there is more food to go round.

Now try these

- 1 Life cycle diagrams for cod and stickleback follow the same basic pattern:



- 2 Frogs are becoming rarer because of collection of the spawn and adults (the latter mainly for use in laboratories), because of the use of chemical pesticides which poison ponds and ditches and contaminate the invertebrate foods of frogs, but mainly because of the destruction of farm ponds. The biggest single way in which people could increase the number of frogs would be to construct new ponds in gardens, parks and other places where the water is safe from pollution, and where the frogs could breed in safety.
- 3 The life cycle of a frog (or toad) follows the general pattern:



- 4 The approximate or average numbers of eggs and young produced by a few kinds of animals are:
- | | | |
|-------------------------|-----------------|--|
| Ling | 28 million eggs | (no parental care) |
| Cod | 10 million eggs | (no parental care) |
| Herring | 500,000 eggs | (no parental care) |
| Queen wasp | 20–25,000 eggs | (no parental care by the queen but there is by the worker wasps) |
| Atlantic salmon | 14,000 eggs | (no parental care) |
| Frog | 5,000 eggs | (no parental care) |
| Cabbage white butterfly | 200 eggs | (no parental care) |
| Partridge | 12–18 eggs | (parental care) |
| Rabbit | 8–10 young | (parental care) |
| Robin | 3–6 eggs | (parental care) |
| Wood pigeon | 2 eggs | (parental care) |
| Golden eagle | 2 eggs | (parental care) |
| Kangaroo | 1 young | (parental care) |
| Human | 1 young | (parental care) |

- 5 Roughly half of the British species of birds live in large flocks during part of the year. Some birds which nest in large groups include penguins, rooks, gulls, terns and gannets. Mammals which live in large groups include

seals, wolves, elephants, lions, most kinds of deer and antelope, sheep, cattle, horses and rabbits. Amongst the invertebrates there are barnacles, mussels, corals, termites, ants, bees and wasps.

One of the main advantages of living in a large group is that there is safety in numbers, with many eyes and ears to look out for danger. At the same time, a large group of animals is very conspicuous, and there may be competition between the members for food, space, nesting sites and mates.

Extending the learning

- 1 *Frog spawn* It is instructive to keep a small amount of frog or toad spawn in the classroom in spring. Put a layer of clean gravel in the tank, aquarium or bowl, and plant some water weed in it. You will need some water from a pond, river or stream. Rainwater can be used, but do not use tap water unless it has been allowed to stand for several days to allow any chlorine in it to disperse.

About a dozen eggs is sufficient. Encourage the children to look at the eggs every day using a hand lens. Ask them to touch the spawn gently. What does it feel like? Can the children see the little black dots, the parts of the eggs which will grow into tadpoles?

Let the children draw the spawn every day, putting the date against each picture. When the tadpoles have hatched, they can also draw a picture of them. What do the newly-hatched tadpoles do? How soon is it before the feathery gills on the sides of the tadpoles' heads are visible? Watch the tadpoles feeding.

Does the tadpole grow its front legs or its back legs first? Or do all four legs grow together? How many days does it take the tadpoles to turn into frogs?

At first the young tadpoles feed on plant material. Later they eat animal food. Some water fleas could be introduced into the water at an early stage, and hopefully these will breed. Alternatively a small piece of raw meat can be put in the water, suspended on a piece of thread, and removed from the tank after about an hour, whether or not the tadpoles have fed. Let the tadpoles or young frogs go free in a suitable pond when you have finished with them.

(Frog spawn normally hatches between 10 days and 3 weeks after fertilisation. At first, the young tadpoles cling to the empty eggs, feeding on these. The feathery gills are usually clearly visible about a week after the tadpoles hatch. The tadpoles grow their back legs first, after about 2 months. By about a month later the front legs have appeared, and the tail begins to shorten. Frogs take about 3 years to reach their full adult size.)

- 2 Set up an aquarium in the early spring with a male and female stickleback. The children will be able to observe the courtship and breeding behaviour of these fish.
- 3 If an aquarium heater and aerator can be obtained, a tropical fish tank can be set up in the classroom, so that the children can study the breeding behaviour of the inhabitants at any time of the year. Guppies are easy fish to keep, and prolific breeders which do not lay eggs but produce living young. Details of how to set up a coldwater aquarium for sticklebacks and a tropical aquarium for guppies and other exotic fish are contained in *Animals in Schools* by J. P. Volrath, published by The Universities Federation for Animal Welfare.

Interdisciplinary activities

Art and craft

- Drawings and paintings of baby animals.
- Mobiles of fish.
- Still life drawings of flowers and invertebrate animals.
- Flower arrangements.

English

- Science fiction stories about prehistoric animals.
- The Wind in the Willows* by Kenneth Grahame.
- Salar the Salmon* by Henry Williamson.
- Tarka the Otter* by Henry Williamson.
- Swallows and Amazons* by Arthur Ransome.

Geography

- Life cycles of farm and forestry crops.
- Life cycles of domestic livestock.
- Locusts and their control.
- The fishing industry.

Health and hygiene

- Sex education and birth education.
- Mosquitoes and malaria.
- Houseflies and disease.

History

- Prehistoric animals and extinction.
- Cave paintings.
- The fate of the passenger pigeon, dodo and North American bison

Mathematics

- Measuring growth rates.
- Graphs of population increase.
- Percentage survival rates.

Music, drama and PE

- 'A frog he would a wooing go' (song)
- 'The owl and the pussy cat' (poem/song)
- Nativity plays.

Religious education and social studies

- The birth of Christ.
- Plagues of locusts.
- 'Five loaves and two fishes'.
- Noah's Ark.
- St. Francis of Assisi.

Course Book 2

Theme: Living Things

Unit 1: Senses and Sense Organs

Aims of the Unit

- a To demonstrate that it is with the senses that we, and other animals, learn what is happening around us and inside our bodies.
- b To show how the senses are adapted to the kind of life an animal leads.
- c To demonstrate the limitations of our own senses.

Science background

Even the simplest living thing must adjust to its surroundings and avoid danger, find food and recognise its own kind. It is the function of our senses to make us aware of changes in our surroundings and also of the changes which take place within our own bodies.

All over our body we have sense cells which respond to stimuli. A stimulus is a change in light, pressure, temperature, chemical concentration or some other factor which produces a reaction in an animal (or plant). Structures which respond to the stimuli are called receptors, and they pass on nervous impulses or messages to which the body responds. Some of these receptors are scattered throughout the skin, while others are concentrated in special sense organs such as the eyes and ears. Sight, hearing, balance, smell and taste are called the special senses because they are located in particular groups of sensory cells.

In humans and other primates, the eyes are set at the front of the head, with each eye giving a slightly different view of the same object. These views are turned into stereoscopic or three-dimensional images, to enable us to judge distances accurately. Stereoscopic vision is most highly advanced in hunting and tree-dwelling animals. In herbivores, such as deer, antelope, rabbits and hares, the eyes are set on the sides of the head, to give a much wider but less detailed field of view.

In each eye, the nerve endings which detect light are grouped together at the back of the eye on the retina. There are two types of nerve endings. Rods are affected by light intensity, while cones can detect colour. Humans, along with apes and monkeys, are among the minority of mammals which are able to see different colours.

Our ears help us to perceive and locate the direction of

sounds. Nerve endings in the inner ear detect sound waves coming from vibrations. The ear drum vibrates in sympathy with these vibrations, which are then transmitted to the inner ear by three tiny bones. In the inner ear, sensory nerve endings respond to the vibrations, sending nervous impulses to the brain. There these impulses are interpreted as sounds.

Semicircular canals, curved tubes in the inner ear, give us our sense of balance. These tubes are filled with fluid which detects turning movements of the head. When the head moves the fluid stimulates tiny nerve endings in the semicircular canals, which in turn send nervous impulses to the brain. As a result of these messages, the brain makes the body move in a way that helps to keep it balanced.

Smell and taste are perceived by receptors which respond to certain chemical stimuli. Taste buds are found in special areas on the tongue. When food touches the taste buds, they send nerve impulses to the brain, which are identified as different tastes. People can distinguish four tastes: bitter at the back of the tongue, sour at the sides, and salt and sweet at the front. Taste is only possible if the substance can dissolve in water, although only a small amount is required. Taste is often at least partly due to smell; some tastes are lost if the nose is blocked by catarrh.

Smells are detected by two groups of sensory hairs occupying a small area at the top of the nasal cavity. Molecules of strong-smelling substances dissolve in the mucus in the nasal cavity and stimulate the hairs, which send impulses to the brain by way of special nerves. Humans have a poor sense of smell compared with most other mammals.

The sense of touch is a combination of five sensations: contact, pressure, heat, cold and pain. The receptor cells to touch are present all over the skin, although the number of sensory cells varies from place to place. For instance, there are far more touch cells on the lips and finger tips than on the backs of the hands.

Books for the children

The Young Scientist Investigates: *The Human Body, Sounds, Light and Colour, Food* by Terry Jennings (OUP)
Starting Science: *Book 2 Finding Out* by John Paull (Heinemann)

Books for the teacher

Science 5/13: *Ourselves* (Macdonald Educational)
All About Me Schools Council Health Education Project (Nelson)
Teaching Primary Science: *Musical Instruments* (Macdonald Educational)

Materials and organisation

This subject is of vital importance to our lives, and it is also extremely important that young scientists develop their senses to the full. The attraction of this subject from the teaching point of view, is that it lends itself to a large number of simple observations and experiments, requiring the minimum of equipment. It also has important links with other areas of the curriculum.

Materials and equipment:-

pencils
pictures of the ears of as many different animals as possible
pictures of the eyes of as many different animals as possible
coins
pins
tape measures
thin card
string
rulers
small mirrors
sugar lumps, salt, toasted bread, plain chocolate
clean yoghurt pots
substances with a strong smell, such as cheese, onion, orange peel, celery, vinegar, chocolate, pickle
rubber bands
muslin, cheesecloth, or old tights
thin wire
wine gums or fruit pastilles
pieces of chopped apple and onion
balloons
sheets of thin paper
clean margarine tubs or large cream pots
magazines
Sellotape or Blu-tack
scarves for blindfolds
cotton wool
a ticking clock or watch
matchsticks
thin string
a range of small unbreakable objects such as pencil erasers, plastic spoons, matchboxes, combs, coins, ping-pong balls etc.
hand lenses

The senses (pages 2–3)

Lesson objectives

- a To explain what our senses are and why they are important.
- b To examine the eyes of humans and other animals.

Setting the scene

Possible starting points include:

- 1 A visit by the school doctor or nurse to test the

children's eyesight.

- 2 A visit to a zoo, wildlife park, museum or livestock farm where the eyes of different animals could be compared.
- 3 A film, television programme or talk about guide dogs for the blind.
- 4 A survey of eye colour amongst the members of the class.

New words

Senses – the different ways we have of knowing about what is happening inside our bodies and around us, through touch, taste, sight, hearing and smell.

Pupil – the small black opening in the centre of the eye through which light enters the eye.

Iris – the coloured part around the pupil of the eye which controls the amount of light entering the eye.

Class management

All of the work on this topic can be carried out by the children sitting at their own desks.

Safety precautions

In the activity to discover why we have two eyes (page 3), short pieces of thin dowel rod are better than pencils. If pencils are used, they should be blunt, and the pointed ends should be clasped in the children's hands.

Answers to questions in the text

Eyes and seeing (page 2)

The pupil is, in fact, a hole which allows light to enter the eye. It is dark because the inside of the eye is a dark colour. The iris, the coloured part of the eye, controls the size of the pupil, which in turn controls how much light enters the eye. In dim light the pupils open wide, in bright light the pupils close up so that only a tiny opening is left.

Animals' eyes (page 3)

Herbivores such as rabbits, hares, deer and antelope have their eyes on the sides of their heads so that they can see all round, in their constant watch for enemies. Although they have all-round vision, they do not see as much detail as those animals, including humans, which have eyes at the front of their heads.

Vertebrates which are brightly coloured include apes and monkeys, birds, fishes, newts, and some snakes and lizards. Brightly coloured invertebrate animals include butterflies, moths, dragonflies and some beetles, including ladybirds. Many sea creatures are brightly coloured, including anemones, jellyfish, sea slugs and some of the marine worms.

Now try these

- 2 Most people can see to the sides of them to some extent, although nowhere near as much as those animals can which have eyes on the sides of their heads. However, some people have only 'tunnel vision'. For them, seeing is literally like looking through a tunnel, for they can see nothing with the sides of their eyes, but only what is directly in front of them.
- 3 In the population as a whole, there are usually more

dark-eyed people (mainly brown eyes) than there are those with blue eyes. Intermediate shades such as greenish-grey and hazel do also exist, however.

- Houseflies, butterflies and other adult insects have compound eyes, made up of numerous minute separate eyes. There may be up to 28,000 of these in a dragonfly, and as few as nine in some kinds of ant. Each minute eye has its own separate lens, so that insects see objects as a mosaic of overlapping images, rather like a badly-tuned television picture. Most spiders have eight simple eyes, arranged around the top of the head, so that they can see in all directions at once.

The compound eyes of houseflies and the simple eyes of most spiders are clearly visible with a hand lens.

Expected results of activities and experiments

Why do we have two eyes? (page 3)

The pencils should be held at arm's length. The children will find that it is easy to make the two ends of the pencils touch each other when they have both eyes open, but very difficult when they have one eye closed. We need two eyes to be able to judge distances accurately.

Extending the learning

- How do eyes react to the light?* The children should work in pairs for this activity. One of the children could look towards a bright light (NOT the sun), and the other could see what happens to his pupils (they narrow). The same child could then look into a dark corner, when his partner will notice that the pupils open wide. Alternatively, one child could blindfold the other for one minute. The blindfold is then removed and the child's eyes are examined. (The pupils will be wide open when the blindfold is removed, but quickly close up in the bright light of the room.)
- Which eye do we use the most?* A pencil should be held upright at arm's length and lined up with the edge of a door or window frame, using both eyes to do this. The right eye is then closed, and then opened again. The left eye is then closed, and then opened again. With most people, the pencil seems to jump to one side when one of the eyes is closed. If the pencil jumps most when the right eye is closed, then it is the left eye that was used the most to line up the pencil. If the pencil jumps most when the left eye is closed, then the right eye was used most to line up the pencil. The children could carry out a survey to see how many people have right eyes that are dominant, and how many have left eyes that are dominant. They could also see whether right-eyed people are right-handed, and whether left-eyed people are left-handed (usually they are).
- Optical illusions* Make work cards so that children can see some examples of optical illusions. Two examples are given on page 27 of *The Young Scientist Investigates: Light and Colour* by Terry Jennings (OUP).
- How good is your eyesight?*
What you need: A magazine; a tape measure; Sellotape or Blu-tack. Work in small groups for this experiment.
What you do: Fix a page of the magazine to a wall with Sellotape or Blu-tack. Try to read it from a distance of two or three metres. Get closer and closer until you can just read the small print. Ask one of your friends to

check that you are reading the print correctly. Measure how close you have to be before you can read the small print clearly.

How close do you have to be to read the small print with your right eye closed?

How close do you have to be with your left eye closed?

Ask one of your friends to try. Does your friend have to be nearer or further away than you were? Test other people.

Test someone who wears spectacles. Do the test with his spectacles on first. Then ask your friend to take his spectacles off. Give his eyes time to get used to being without the spectacles. Then do the test again. Is the result much different from before?

(Expected results: If the child who normally wears spectacles is short-sighted, he will be able to read small print quite easily. It is long-sighted persons who have difficulty in seeing near objects. Children with defects of vision should not in any way be made to feel inferior, they may well have other qualities or abilities that more than compensate for their eyesight. This is another example of the individual differences the children studied in Course Book 1.)

Hearing (Pages 4–5)

Lesson objectives

- To show how sounds are caused and how they are detected by the ears.
- To compare the ears and the hearing of different animals.
- To discover how sounds travel best.

Setting the scene

Possible starting points include:

- A visit to a zoo, wildlife park, museum or livestock farm to compare the ears of different animals.
- A consideration of noise as a form of pollution.
- A study of the part that sounds play in our everyday lives – warning sounds, communication, sounds for pleasure, noise, etc.
- A class survey of 'sounds I like' and 'sounds I dislike'.
- A discussion of the problems faced by the deaf and the hard of hearing.

New words

Vibrate – when something moves rapidly to and fro it is said to vibrate.

Echo – an echo is a sound which bounces off or is reflected from an object.

Class management

All the work on this topic can be carried out by the children at their desks, and the two activities can be carried out by the whole class at once.

Safety precautions

The children should be warned of the dangers of putting foreign bodies in their ears.

Answers to questions in the text

Animals' ears (page 4)

Some of the other animals with large outer ears include foxes, wolves, rabbits, hares, bats, lions, tigers, racoons, horses, zebras and elephants. In some animals from hot climates, including elephants, rabbits and hares, the ears have the extra function of acting as a radiator, through which excess heat from the animal's body is lost.

Now try these

- 1 It is easy to tell the direction from which a sound is coming if both ears are used, but very difficult with only one ear.
- 3 The tone of voice is an important conveyor of mood.
- 4 With the cardboard ears fixed securely in place, the children should be able to hear better, and also be able to tell more accurately from which direction sounds are coming.
- 5 When a ruler is laid on a table so that most of its length is over the edge, and the end of it is flicked, the ruler will be seen to vibrate. The vibrating ruler produces sounds, the loudness of which vary according to the distance the end of the ruler moves to and fro. The pitch of the sound can be made to change by varying the length of the ruler which projects over the edge of the table.

Expected results of activities and experiments

Bigger ears (page 5)

By cupping their hands behind their ears, with the palms facing forwards, the children will be able to hear the sounds better that come from in front of them. If they cup their hands in front of their ears, with the palms facing behind them, the children will be able to hear the sounds better that are coming from behind them.

How do sounds travel best? (page 5)

The children will be able to hear the sounds better with their ear pressed against the top of the desk than they can with the sounds travelling through the air to reach them. The difference is even more marked if the children close one ear with a finger while pressing the other ear against the desk. The difference is because sounds travel better through a solid object than they do through air and other gases. The North American Indians used to make use of this effect. By pressing their ears to the ground, they could detect the approach of animals or their enemies from a great distance. Sounds also travel through water better than they do through the air. This accounts for the fact that a swimmer under water can hear distant sounds very clearly.

If the experiment is repeated using cold water pipes or iron railings, similar results are obtained although, of course, the distances the sounds travel are much greater.

Extending the learning

- 1 *Recognising things by the sounds they make* Let the children work in pairs and collect five small unbreakable objects, such as a pencil eraser, a plastic spoon, a ballpoint pen, a comb and a matchbox. Then one child of each pair should be blindfolded while the other drops the objects on to the table one by one. The

blindfolded child has to try to recognise the objects by the sounds they make. Then the two change places to see who can recognise the most objects.

- 2 *Make a model telephone* The children will need two clean yoghurt pots or cream pots, two matchsticks and some thin string. A small hole is made in the bottom of each pot, and one end of the string is threaded through one of the holes and tied onto a matchstick. The other end of the string is similarly treated. Two children take the yoghurt pots and pull the string tight. While one child speaks into a yoghurt pot, the other places the second yoghurt pot to his or her ear and listens for the sounds that travel along the string.

- 3 *How good is your hearing?*

What you need: some cotton wool; a ticking clock or watch; a ruler or tape measure. Work with a partner in a quiet room.

What you do: Carefully plug your right ear with cotton wool. Ask your friend to bring a ticking clock or watch nearer and nearer to your left ear until you can just hear it. Measure the distance of the clock or watch from your left ear. Do the test three times and find the average distance.

Now test your right ear. Do you get the same result?

Change places with your friend and see if the distances are the same for him.

A number of other activities and experiments concerned with sounds, vibrations and hearing are given in *The Young Scientist Investigates: Sounds* by Terry Jennings (OUP).

Smell and taste (pages 6–7)

Lesson objectives

- a To consider the well-developed senses of smell and taste of some animals.
- b To examine the senses of taste and smell in humans.
- c To examine the sense of touch in humans and to look at how other animals use this sense.

Setting the scene

Possible starting points include:

- 1 A cooking lesson.
- 2 Making perfume from rose petals or other garden flowers.
- 3 Make a table listing substances and objects with a pleasant smell, an unpleasant smell, or no smell at all.
- 4 A survey of which foods the children like best and which they like least. Discuss the reasons for their preferences.
- 5 Put a large number of small items in an opaque plastic bag and see how many of them the children can identify by touch alone.

New words

None.

Class management

The class will need to work in small groups to carry out the experiments and activities. Since the materials required

for it are simple, it is suggested that several groups of children should work on the experiment to test the sensitivity of the skin to touch, while a smaller number work on the experiments on tasting and the sense of smell, where a greater level of supervision and teacher help may be required.

Safety precautions

The children should wash their hands thoroughly before carrying out the tasting experiment, and the food containers need to be very clean. The children should be warned not to devise their own experiments on the senses of smell and taste, unless an adult gives approval first.

Care must also be exercised in the experiment on the sensitivity of the skin to touch, to ensure that the pieces of wire used are not sharp, and that they are not used anywhere near the subject's eyes.

Now try these

- 3 If the point of a pencil is touched lightly against the skin, it will be found that some areas are more sensitive than others. The skin of the upper arm and backs of the hands is relatively insensitive to touch, while the face and palms of the hands, and particularly the fingertips, are very sensitive.

A bristle is more effective than a pencil point for testing the sense of touch.

A discussion of the sense of touch in humans could lead to a consideration of Braille, used in books for the blind.

- 4 It is fairly easy to identify the flavours of wine gums or fruit pastilles, even though the eyes are closed, but it is very difficult if the nose is held.
- 5 There are a variety of ways in which animals mark their territories using scents. Deer and antelope, for example, have glands on their faces, near to their eyes, into which they poke the ends of twigs. The strong-smelling substance left on the twigs serves as a notice of ownership. Dogs and foxes use their urine and dung to mark their territories, while rabbits use their urine, droppings, and a scent gland under the chin which is rubbed on plants and stones.

Expected results of activities and experiments

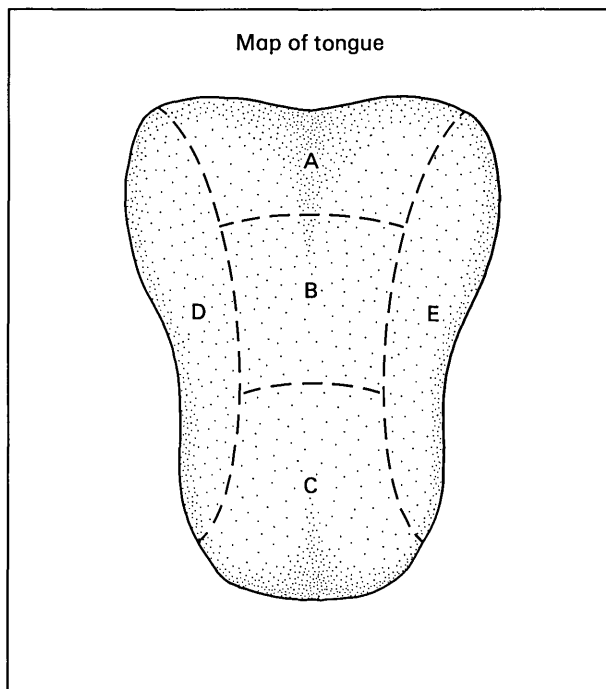
Tasting food (page 6)

There is a degree of subjectivity in the results of this experiment, but most children will find that they can taste the bitter chocolate best with the back of their tongue, and the salt, sugar and toast at the front of their tongue.

This experiment could be extended to include some vinegar or lemon juice diluted with water, which can be applied to different areas of the tongue with a cotton bud or with a short length of drinking straw. The children will find they can taste these sour substances best with the sides of their tongue.

The recording of the results of tasting experiments may be simplified if the children are given a simple map of the tongue, like that shown below. They can then say for each substance tested, whether each of the areas of the tongue

marked on the map was very sensitive to it, slightly sensitive or insensitive.



Testing your friend's sense of smell (page 7)

The substances suggested all have quite characteristic smells. The ones the children may find difficulty with are cheese (depending upon the variety used), chocolate and possibly the pickle.

How sensitive is your skin to touch? (page 7)

The children will probably find that the finger tips and lips are most sensitive (although care is necessary in testing the latter). The backs of the hands, upper arms and legs are relatively insensitive to touch.

Extending the learning

- 1 *Classifying objects by touch* Collect about a dozen common objects such as a plastic spoon, a pencil eraser, a nail file, a piece of tree bark, a pebble, a tissue, a sheet of writing paper, a piece of blackboard chalk, and so on. Ask the children to prepare a table with the following headings: Rough, Smooth, Hard, Soft, Warm, Cold, Thick, Thin. Ask them to feel each of the objects in turn, and to write its name in the appropriate column. Of course, each object will appear in more than one column, and the children could then go on to write a sentence about each of the objects they have examined. They might, for example, describe a pencil eraser as being 'smooth, soft, warm and thick.'
- 2 *Studying the skin* Ask the children to study their skin using a hand lens. They should describe what they see when they look carefully at the tips of their fingers, the palms of their hands, and the backs of their hands. The children may notice hairs, pores, spots, cuts, scars, lines, wrinkles, blood vessels, and so on. They could return to the study of fingerprints begun in Unit 1 of Course Book 1. While they are studying their skin with a hand lens, the children could also examine the taste buds on the tongue.

Checking (pages 8–9)

Thinking

- 1 The sense organs of smell quickly become tired, and so people entering a room may notice a smell which those in the room have become used to.
- 2 Our outer ears have the same basic structure and function as those of a dog, but a dog can ‘prick’ its ears, raising up the outer ears, to detect quiet sounds, which we cannot do. Apes, monkeys and chimpanzees have the same type of ears as ours.
- 3 A cat uses its whiskers, which are sensitive to touch, to find out whether or not it can get through a narrow opening.
- 4 A seal has large eyes on the front of its head. They enable it to judge distances accurately when chasing its prey – fish – underwater. The seal has no outer ears to hinder it as it swims underwater. Its whiskers would be particularly useful when it is hunting in murky water.
- 5 Earthworms are sensitive to vibrations. When a blackbird or gull runs up and down on the lawn, earthworms come up to the surface and are eaten. Stamping on the ground or rocking a wooden post in the ground so that vibrations are produced, also often induces earthworms to come up to the surface.
- 6 The senses most important a) when riding a bicycle are seeing, hearing and balance; b) crossing a busy road at a pelican crossing are seeing and hearing; c) finding the light switch in a darkened room is the sense of touch; d) checking soup requires the senses of taste and smell (and possibly also the sense of touch to test the texture of the soup); e) tuning a violin uses the sense of hearing.
- 7 We humans do seem to have a sense of direction, but it is better developed in some people than others. Mammals and birds which migrate huge distances seem to have the best developed sense of direction. Homing pigeons also have an excellent sense of direction.

Doing

- 1 If the children cannot look at the eyes of living animals, perhaps they could collect as many pictures of animals’ eyes as they can find. They could sort the pictures into those of animals which are hunters, or carnivores, and those which are hunted (often the plant-eaters, or herbivores).

A cat’s eyes are similar in shape to our own although, like those of birds and most other mammals, they have a third eyelid (called the nictitating membrane), which can sweep sideways across the surface of the eye to keep it clean. The cat’s pupils widen in dim light and narrow in bright light, as ours do, although the cat’s pupils are vertical slits not circles.

Of the other animals listed, a dog and a bird need to see particularly well, so do many fishes and some insects such as dragonflies, which are predators.

- a Our senses help us to *survive*.
- b We see because *light* enters our eyes.
- c The dark part in the centre of the eye is called the *pupil*.
- d The *iris* is the coloured part of the eye.

- e Animals which catch and eat other animals often have their eyes at the *front* of the head.
- f Having two eyes helps us to judge *distances* better.
- g The part of the ear we see is called the *outer* ear.
- h An *echo* is formed when sound waves bounce back off something.
- i You *smell* with special patches of cells inside your nose.
- j The tiny red bumps on the tongue are called *taste buds*.
- k The whiskers on a cat’s face are sensitive to *touch*.

Going further

Why do you sometimes lose your sense of smell when you have a cold?

SAFETY PRECAUTION: It is essential that the pieces of food used in this experiment are prepared under hygienic conditions and that the children wash their hands thoroughly. It is also necessary to ensure that only the test items are tasted.

(Expected results: The children should learn that the senses of taste and smell are intimately linked. It is very difficult to taste the difference between foods when you cannot smell them.)

Some other suggestions

Is your sense of temperature always right?

What you need: Three margarine tubs or large cream pots; hot water; cold water.

What you do: Put the three containers in a row. Fill the first one with hot water. The water should be just hot enough for you to bear your fingers in it.

Half fill the second container with hot water, and then add cold water until the container is full.

Fill the third container with cold water.

Sit for one minute with two fingers of one hand in the hot water and two fingers of the other hand in cold water. Then put all four fingers in the container of warm water. What does it feel like?

Can you always trust your senses of heat and cold?

SAFETY PRECAUTIONS: It is suggested that the teacher pours out the hot water to ensure that the children do not scald themselves.

(Expected results: The children will find that, in the warm water, the fingers which had previously been in the hot water now feel cold, while the fingers which had been in the cold water now feel hot.)

Interdisciplinary activities

Art and craft

- Colour mixing experiments.
- Perspective.
- Finger painting.
- Making banners and posters.

English

- Creative writing describing sights and sounds.
- Communication and the media.
- Letter-writing.
- Lists of words which describe smells and tastes.
- Sign language
- Oxford Junior English: *5 Our Language* by Oliver Gregory (OUP).

Geography

- Compasses and direction.
- Maps and map-reading.
- Air pressure, temperature and humidity.
- Thunder and lightning.
- Flags of the world.

Health and hygiene

- The care of the eyes and ears.
- Eyesight and spectacles.
- Deafness.
- Guide dogs for the blind and hearing dogs for the deaf.
- The dangers of smoking and air pollution.
- Solvent abuse.
- Noise.
- Protecting the ears from damage caused by loud noises.
- The care of the hands.

History

- The lives of Louis Braille, John Milton and Helen Keller.
- Cave paintings.
- The history of the postal service.
- Watch-towers, beacons and other danger signals.

Mathematics

- Thermometers and the measurement of temperature.
- Codes and ciphers.
- Estimating weights and checking the accuracy of the estimates.

Music, drama and PE

- Percussion instruments and home-made instruments.
- Sound effects.
- Mime and gesture.
- Vibrations and musical instruments.
- Tuning forks.
- Loudness, pitch, tone quality and resonance.

Religious education and social studies

- Jesus curing the blind man.
- The Tower of Babel.
- The Dead Sea scrolls.
- Problems faced by the blind and deaf.
- Charities which assist the blind and deaf.

Unit 2: Grasses and Lawns

Aims of the Unit

- To show the importance of grasses and cereals to our everyday life.
- To examine the adaptations to their way of life of some grassland weeds.
- To demonstrate ways of estimating large numbers when there are too many individuals to count.

Science background

The grass family is vital to humans because it includes not only lawn and pasture grasses, but also cereals and a number of other economically important plants. There are over 10,000 species in the world as a whole, ranging in size from dwarf mountain and desert grasses, to South American species more than 3 metres high.

Of the cereals, wheat has been cultivated for more than 10,000 years, while rice, barley, oats, maize (the 'corn' of the United States) and millet are all widely cultivated.

Two other Asian grasses are very important. Sugar cane, from which much of the world's sugar is extracted, is a giant grass 3 to 6 metres tall. It is now grown mainly in the New World, where it was introduced by Columbus. Today it is the main crop of the West Indies and Brazil. Bamboo, another giant grass, is used for making houses, furniture, mats, screens, containers, fishing rods, knives and a whole catalogue of other items. The young bamboo shoots are often used as a food. Marsh grasses include reeds, sedges and rushes, all of which can be used for thatching, matting and making baskets.

All grasses have long narrow leaves, and often the stems are hollow with solid joints called nodes. Grass flowers are usually green and inconspicuous. They are pollinated by the wind, rather than by insects. The grasses which grow, or are sown, on lawns and pastures generally have short or creeping stems, which are left undamaged by cutting or chewing. This is because, unlike all other plants, grasses have their growing buds at the base of their leaves, rather than at the tip of the leading shoot. When the leaves are mown or bitten off by a grazing animal, grasses can re-grow from the base of the plant. Pasture grasses, either fresh, dried in the form of hay, or preserved as silage, are the main food for sheep, cattle, horses and other domesticated herbivores. Wild grasses are also food for many herbivores.

Grasses have the added important function of helping to prevent soil erosion on hills and slopes. They are able to do this because their roots are fibrous, which means that they are all about the same length and thickness, so that they can hold loose soil together. Grasses are also pioneer species, being amongst the first plants able to grow on any new ground or freshly disturbed soil. This characteristic also makes them effective weeds of garden and farmland.

In the case of cereals, it is the seeds (grains) which are used as food. A cereal grain consists of a small embryo (the 'germ') that will grow into a seedling, and a supply of food (endosperm) to nourish it. The food is mainly starch, although the grain also contains other foods such as proteins and vitamins. In recent years, plant-breeders have succeeded in producing high-protein varieties of the common cereals.

Wheat, the oldest and most widely cultivated cereal, is grown in most non-tropical areas of the world. Its grains are ground (milled) to make flour, from which bread, cakes and many other foods can be made.

Rice is the staple food of over half of the world's population, particularly in southern and eastern Asia. It is mostly grown as a swamp crop, and the seed is planted either directly in the flooded paddy fields, or in well-fertilized waterlogged nursery beds, from which the seedlings are later transplanted into the fields.

Barley is a cereal grass which is widely grown for animal and human food, and to make beer and whisky.

Rye is coarser than wheat, and is grown only in soils which are too poor for wheat, such as parts of eastern Europe and Russia. It is used to make black bread, and also for cattle food. Oats, which can be grown in moist climates with short summers, is used to make oatmeal for porridge and cakes and as an animal food.

Maize (or corn) is a large cereal plant which originated in the Americas. It is widely used for animal food, but some is used for human consumption in, for example, cornflakes, while the young seed heads provide sweet corn. Another edible grain, mainly grown in the tropics, is millet, also known as sorghum.

Books for the children

The Young Scientist Investigates series: *Food, Flowers, Seeds and Seedlings* by Terry Jennings (OUP).
The Young Geographer Investigates: *Grasslands* by Terry Jennings (OUP).
A Concise Guide in Colour: *Grasses* by J. Sikula (Hamlyn).

Books for the teacher

Teaching Primary Science: *Seeds and Seedlings* (Macdonald Educational).
Science 5/13: Using the Environment: 3 *Tackling Problems Part 2* (Macdonald Educational).

Materials and organisation

Like the previous Unit, this topic lends itself to simple experimentation and observation. It also ties in with the subject of the reproduction of plants, and with seed germination, dealt with in Course Book 1. There is an abundance of grasses in both town and country and, in addition, cereal grains and the seeds of lawn and pasture grasses are inexpensive to buy and easy to grow indoors at any time of year.

The work on estimating can also be carried out equally effectively in city and country schools.

Teachers may be able to obtain helpful films, booklets, posters and other aids from The Flour Advisory Bureau, 21 Arlington Street, London SW1A 1RN.

The Association of Agriculture, 78 Buckingham Gate, London SW1E 6PE, may also be able to provide teaching aids and information, and help with farm visits.

Materials and equipment:-

flowers of wild grasses
newspaper or blotting paper
grass seeds
radish, mustard or cress seeds
samples of cereal seeds
maps of the British Isles
washing-up liquid
watering cans
buckets
wooden frames 1 metre square (or hoops would do)
dried peas
egg-cups
jam-jars
plant pots or yoghurt pots
seed compost or garden soil
sticky labels
dandelion flowers and dandelion 'clocks'
large flat stones
smaller rounded stones (from a beach or stream?)
cotton wool
saucers, egg-cups, small paste jars or clean egg-shells
sand, ashes, felt, blotting paper, newspaper, cloth, sawdust, cardboard, orange peel, sponge and pieces of broken brick
seeds of ornamental grasses
bird seed
grass plants with roots
hand lenses
wooden frames, 20 cm × 20 cm
earthworms
rulers

scissors
clocks or watches with a second hand
small trays or sandwich boxes
black paper
samples of self-raising, plain, wholemeal and brown or wheatmeal flours

Grasses (pages 10–11)

Lesson objectives

- a To show that grasses are common and widely distributed flowering plants.
- b To demonstrate the structure of grass flowers.
- c To show the economic importance of grasses and their value in preventing soil erosion.

Setting the scene

Possible starting points include:

- 1 A survey of the most abundant weeds in the garden.
- 2 Cooking with flour.
- 3 Weaving or model-making with dried grasses.
- 4 Writing or illustrating food chains which begin with grass plants.

New words

Hay – dried grass which is used as a foodstuff or bedding material for farm animals.

Class management

It is possible to find some grasses in flower at almost any time of the year, and so this work can be carried out at any season. All of the work, apart from the actual collecting of the grass flowers, can be done by the children at their desks.

Safety precautions

Care should be exercised in summer about bringing large quantities of grass flowers into the classroom if any of the children suffer from hay fever.

Answers to questions in the text

Grasses (page 10)

Grass flowers are different from most flowers in being green in colour and lacking petals. Grass flowers do produce seeds.

Grasses in the country (page 11)

In Britain some of the animals which eat grass include cows, sheep, horses, goats, deer, rabbits, hares, field voles, water voles and grasshoppers.

Hay is grass which is cut in May or June, when it has grown to its tallest, and is then allowed to dry in the sun. Hay is used to feed farm animals in the winter when, because of the cold conditions, the grass in fields and pastures does not grow. Hay is also used as warm bedding for some farm animals.

Another way in which grass is preserved for use in the winter, is as silage. For this the grass is cut while still fresh and juicy and is pressed down hard in a container called a

silage. In the absence of air, bacteria form an acid which preserves the proteins in the grass. Silage is a more nutritious food for farm animals than hay.

Now try these

- 1 If all types of grass began to be killed by a disease, there would be a severe shortage of food for cows, sheep, horses and other domestic livestock. This would lead to a shortage of meat and other animal products. As well as an absence of cereal foods, there would be widespread soil erosion. A worldwide famine amongst the human population would soon result.
- 2 It is not possible to predict how many grass seeds will grow. It depends upon the age and species of the grass seed. Normally, however, grass seeds have a very high germination rate.
- 3 Like all seedlings, those of grasses have a root and a shoot, the latter turning green when it is exposed to light. However, the shoot of a grass seedling produces only one seed leaf (technically known as a cotyledon), whereas most seedlings have two seed leaves.
- 4 Grass-eating animals (herbivores) have sharp front teeth for biting off the grass. They have no canine teeth, while their back teeth (the molars and premolars) are flat-topped or grooved, and are used for grinding the grass into small pieces. By contrast, meat-eating animals (carnivores) have sharp teeth for gripping, killing and tearing their prey. The larger meat-eating animals such as the lion, dog, or cheetah have long fang-like canine teeth for stabbing or tearing their prey.

Expected results of activities and experiments

Looking at grass flowers (page 10)

The pollen-bearing parts of the stamens (the anthers) of grasses are hinged, so that they sway in the wind. The pollen grains are very small and yellow but can be seen clearly with a hand lens. The carpels are in the centre of the flower, and in most grass flowers the top of each carpel has three feathery tufts which catch any pollen grains blown there by the wind.

Extending the learning

- 1 *What conditions do grass seeds need to germinate?* Sow grass seeds on cotton wool contained in saucers, egg-cups, small paste jars or clean eggshells. Leave the cotton wool in one of the containers dry. Keep the cotton wool in the others moist. Place the container with the dry cotton wool, and one of those with moist cotton wool, on a sunny windowsill. Place another in a warm dark cupboard. Put a fourth container in a refrigerator. Examine the seeds every day.
(Expected results: The seeds on the dry cotton wool, and those on the moist cotton wool which were put in the refrigerator, will fail to germinate. The seeds on moist cotton wool in a dark cupboard will grow, but the seedlings will be tall and straggly, and pale yellow or white in colour. The seeds on the moist cotton wool kept on the sunny windowsill will grow into healthy green seedlings. We therefore conclude that grass seeds, like all seeds, need water and warmth if they are to germinate. If the seedlings are to develop the green

substance chlorophyll, with which plants make their food, light is also needed.)

- 2 *Where will grass seeds grow?* Try to grow grass seeds on different moist surfaces. As well as soil or compost, the children could also try moist sand, ashes, felt, blotting paper, newspaper, cloth, sawdust, cardboard, orange peel, a piece of sponge, and pieces of broken brick. How many of the grass seeds grow (it may be helpful to express the results as percentages of the number of seeds sown)? On which of these materials does the grass seed grow best?
(It is not possible to predict the exact results of this experiment, but it will be found that grass seeds will grow on almost any surface, which accounts for their success as colonists of new ground and also as weeds.)
- 3 *Ornamental grasses* Some seed merchants and garden centres sell packets of seeds of ornamental grasses. These are the seeds of grasses from all over the world.
Sow some of these seeds in the open garden in summer, or in pots of moist compost indoors. Let the children watch the grass plants grow. The flowers are well worth studying and drawing, and they also look attractive cut and put in vases with other flowers. They can be dried and used as decorations in winter.
Some of the seed mixtures sold as food for canaries, budgerigars and other tame birds also contain the seeds of interesting grasses. Sow a little of this bird seed and see what grows from it.
- 4 Dig up some grass plants of different kinds and let the children draw them. The children may notice that all grasses have similar fibrous root systems.

Cereals (pages 12–13)

Lesson objectives

- a To show the widespread importance of cereals as human food.
- b To study the structure and growth of cereal seeds.
- c To study the adaptations of grassland weeds to their surroundings.

Setting the scene

Possible starting points include:

- 1 Cooking with flour.
- 2 Making collages with different cereal grains.
- 3 Experiments on the germination of cereal grains.
- 4 A collection of breakfast cereals or cereal packets displayed on the Science Table.

New words

Cereals – the name given to certain members of the grass family which are grown for food, such as wheat, oats, barley, rice, rye, maize and millet.

Adapt – the way in which living things, or parts of living things, adjust to the surroundings in which they live or the jobs they have to do.

Class management

All of the work on this topic can be carried out by the

children at their desks. However, if the class can be taken outside to find, dig up and examine some lawn or playing field weeds, this would make the study of these plants more meaningful.

Safety precautions

To eliminate the possibility of obtaining cereal seeds which have been 'dressed' with poisonous chemicals, it is safest to buy them from a health food shop.

It is very difficult to cut cereal seeds in half unless they have previously been soaked in water for several hours. The children should be provided with a piece of wood on which to do the cutting, and should always cut *downwards*.

Answers to questions in the text

Grassland weeds (page 13)

Both the dandelion plant growing on the roadside verge and that growing on the lawn must be growing successfully since both are flowering. One of the tests of the success of an organism is that it is able to reproduce itself.

Different kinds of roots (page 13)

The dandelion plant has a long tapering root, from which other roots grow. This type of root is called a tap-root. By contrast the grass plant has a number of shorter roots which are all about the same length and thickness. Roots of this kind are called fibrous roots.

In hot dry weather, it is the surface of a lawn which loses water first. The shallow-rooted grasses start to die. However, plants such as the dandelion, which have long tap roots, are able to obtain water from deeper down in the soil, and so can stay fresh and green much longer.

Now try these

- 2 The main areas in the British Isles where barley and wheat are grown are southern, central and eastern England and the eastern half of Ireland. If oats are included, the cereal-growing area extends to much of mainland Britain, except for the higher mountains. In the world as a whole, the main cereal-growing regions are the prairies and plains of Canada and the United States, the grain belt of Australia, the pampas of Argentina and the Ukraine region of the Soviet Union.
- 3 Cornflakes are made from maize. About half of the world's total crop of maize is grown on the fertile soils of the mid-western states of North America, where there is plenty of sunshine together with frequent summer rains and warm nights. Most of this crop is fed to farm animals. In Italy, parts of eastern Europe, India, China, Egypt, South Africa, Central America and Brazil, many people live mainly on maize. In North America the cultivation of maize is highly mechanised, but in many of the other countries mentioned above, sowing and harvesting are done largely by hand.
Rice is the chief food for about half the world population, including the enormous numbers of people who live in China, Japan, India and Malaysia. One variety of rice can be grown on dry sloping fields, like wheat, oats and barley. This is called hill or upland rice. However, most rice, called lowland rice, is grown on the flat areas in the flood-plains of rivers and lakes. This lowland rice needs hot weather and a great deal of moisture, and most of it is still cultivated and harvested by hand. The rice grains are soaked in water and then

sown in special seed-beds of mud. Meanwhile the rice fields are flooded by rain or water from rivers or streams, forming the so-called 'paddy fields'. The rice seedlings are planted out in the flooded fields, and when the rice is ripe the fields are drained so that harvesting can begin.

- 4 In the early days, the Romans milled with 'quern stones'. The cereal grains were put on a large, smooth flat stone and crushed with a smaller stone. Later the Romans used two large conical stones, one fitting inside the other. The upper stone was rotated by means of a handle fitted into its side, whilst the lower one remained stationary. The grains were poured between the two grinding surfaces as the handle was turned. It is possible that it was the Romans who first used the power of falling water to drive large circular stones to grind grains into flour. The Romans also produced various grades of flour, by sieving out different sized particles from the coarse cereal flour. In the Middle Ages, flour was made in Britain using large circular stones that were turned by either windmills or watermills. (See A Primary Religious Education Course, *Nazareth* by Richard Hughes [OUP] or *Pompeii* by Peter Connolly [Macdonald Education].)
- 5 A small amount of flour is still 'stone ground' today, but most is made in large factory-like buildings where the wheat is first weighed, cleaned and dried, after which it goes through more than 40 other processes, including crushing between metal rollers, and removing the skins of the wheat – the bran – to produce flour.
The white flour produced in the way described briefly above is *plain flour*. *Self-raising flour* is simply plain white flour to which chemical raising agents have been added. It is used widely to produce cakes and pastries. *Wholemeal flour* is made from the whole cleaned wheat grains, including the bran. *Brown* or *wheatmeal flour* has had some of the coarsest bran removed from it. Both wholemeal and wheatmeal flours are a brown speckly colour, because of the presence of bran.

Information on the different kinds of flour and modern milling processes can be obtained from the Flour Advisory Bureau, at the address on page 105.

Expected results of activities and experiments

A hand lens or a low-power binocular or stereoscopic microscope will enable the children to see the internal structure of cereal seeds more clearly.

Extending the learning

- 1 *Comparing the growth of cereal grains* Soak cereal grains of different kinds overnight. Fit a piece of blotting paper around the inside of a clean jam-jar. Slip one seed of each kind between the blotting paper and the glass. Carefully pour cold water into the jar until it is 3 or 4 cm deep. Stand the jar on a sunny windowsill. Add water to the jar from time to time so that the seeds never dry up. The children can construct a table, like that on page 11 of Course Book 1, and compare the growth of the different kinds of cereal grains.
- 2 *A breakfast cereal survey* Let the children carry out a survey amongst their friends at school to find out which is the favourite breakfast cereal, and which is the least

popular one. Why do the children prefer or dislike these particular cereals? They could make a histogram or block graph of the results of the survey, and also go on to find out which cereal grains the different breakfast cereals are made from.

- 3 The children could grow different cereal grains in clean plant pots or yoghurt pots containing a seed compost or a good garden soil. Each pot should be filled to within a centimetre of the top.

Soak the seeds for about 24 hours in clean cold water, and then sow four or five seeds of one kind in each pot. The seeds should be gently pressed into the compost or soil, and then be covered with a light sprinkling of compost or soil. Place the pots on a sunny windowsill and water them every day. How many of the seeds grow? Measure their rate of growth.

If the cereal seedlings are carefully transplanted to larger pots of moist soil or compost, they should go on growing. With luck the cereals will go on to produce flowers and then seed heads or ears. The children could count how many grains there are in each of the different cereal ears.

Estimating (pages 14–15)

Lesson objectives

To demonstrate the methods of estimating large numbers when there are too many individual items to count.

Setting the scene

Possible starting points include:

- 1 Show the children a jam-jar containing wheat seeds. Ask them to guess how many seeds there are in the jar. Then use the method described on page 14, with an egg-cup or some other small container, to make an estimate.
- 2 Ask the children to suggest ways of finding out the approximate number of words there are on a page of a newspaper, without counting them.

New words

Estimate – a careful guess to judge the approximate number of items.

Class management

All of the work on this topic can be carried out by the children at their desks, but ideally they should be taken out on the playing field for a demonstration of how to estimate the number of earthworms.

Safety precautions

If the washing-up liquid method is used to extract earthworms from the soil, they should be rinsed off in clean cold water as soon as they are caught to remove all traces of the detergent. The worms should be returned to the playing field or a flower bed as quickly as possible.

Answers to questions in the text

Estimating (page 14)

There are approximately 360 daisies in the picture, and

approximately 418 peas in the jar.

How many earthworms are there in a lawn or playing field? (pages 14–15)

Steven and Petra's estimate of the number of earthworms was not a good one because they took only one 1 metre sample. This may or may not have been typical. The more samples taken, over as wide an area of the playing field as possible to account for differences in soil conditions, then the more reliable the estimate will be.

There are approximately 22,000 words in Course Book 2, and approximately 1000 birds in the picture on page 15.

Now try these

- 1 The number of children in the school can be estimated by multiplying the number of children in your class by the number of classes in the school. The accuracy of the estimate will depend on how near the size of your class is to the average for the school. Ideally a larger size sample should be used, eg. in a large school to count the number of children in a year group and to multiply that number by the total number of year groups.
- 2 To obtain a reasonably accurate estimate of the number of words in a large book, count the number of words on several pages chosen at random. Find the average number of words on a page, and multiply this by the total number of printed pages.
- 3 To estimate how much liquid your class drinks in a year, it will first be necessary to find out the average amount of liquid consumed in a day. Ask several children to measure this, and find the average. Multiply this average consumption by the number of children in the class, and then by the number of days in a year.
- 4 Earthworms improve the soil (make it more fertile) by making burrows that help to drain the soil and allow air to reach the plant roots. They add humus to the soil by dragging leaves into their burrows, where they decay. Earthworms also mix the soil up by passing it through their digestive systems and depositing it either on the soil surface as 'worm casts', or underground in the burrows.
- 5 An Opinion Poll is really an estimate of the opinion of the whole population, based on a sample of perhaps 1,000 or so people. Most often the Opinion Poll is concerned with support for the various political parties or some other party-political matter. About 1,000 people of varying ages and backgrounds and of both sexes are asked the same questions, and then the results are calculated as percentages. Consumer researchers carry out similar surveys to find out which brands of margarine, cat food or other commodities people prefer to buy.

The children could take an opinion poll of the favourite brands of sweets, favourite sports personality or pop group, or similar. It would be interesting to analyse the results of such a poll carried out amongst the children, to see whether boys and girls have different opinions, or whether the results differ when two different age groups are sampled.

Expected results of activities and experiments

How many earthworms are there in a lawn or playing field? (pages 14–15)

The actual numbers of earthworms caught will depend

upon the fertility of the soil. Figures of between 25 and 700 per square metre are typical.

Extending the learning

- 1 Use a small wooden frame, say 20 cm × 20 cm to estimate the number of grass leaves on a lawn or playing field.

- 2 *Studying earthworms*

What you need: A large earthworm; a hand lens; a ruler; a pair of scissors; two sheets of paper; a clock or watch with a second hand.

What you do: Look at your earthworm. How many segments (little rings) is it made of? Has it a swelling, known as a 'saddle', along its body? Can you see a mouth, eyes, ears or a nose on your earthworm?

Let your earthworm move on a table. How does it move?

Lay the worm against a ruler. Measure the worm when it is at its longest. Record this length. Then measure the worm when it is at its shortest.

Let the worm crawl over a sheet of paper. Put your ear close to it and listen carefully. What can you hear? What do you think is making the noise?

Dampen the other sheet of paper. Put the worm on it. Mark where its head is. Mark where the worm's head is one minute later. How far has your earthworm travelled in one minute?

(Expected results: The bodies of most earthworms are made up of about 150 segments. The region known as the 'saddle' is where the cocoon is produced when the earthworm lays its eggs. Only adult worms have this structure. The earthworm's mouth is at the front tip of its body, underneath a little lobe, called the prostomium. Earthworms have no eyes, ears or nose, although they do have light-sensitive cells scattered throughout their skin. They are also very sensitive to vibrations.

Earthworms move by alternately becoming shorter and fatter and then longer and thinner, gripping with tiny bristles, of which there are eight on almost every segment. It is these bristles which can be heard scratching on the sheet of paper.)

- 3 *What conditions do earthworms like best?*

What you need: Earthworms; a small tray or sandwich box; blotting paper or paper towels; black paper.

What you do: Cover one half of the bottom of the tray or box with damp blotting paper or paper towels. Cover the other half of the tray with dry blotting paper or paper towels.

Put two or three earthworms in the middle of the tray. Cover the tray over with a sheet of black paper. Look at it again 5 minutes later. Are the earthworms in the dry part of the tray or the damp part?

Do the experiment two or three more times. Do you always get the same result?

Do the experiment again. This time cover the whole of the bottom of the tray with damp paper. Cover half of the top of the tray with black paper. Place the worms in the middle of the tray. Leave them for 5 minutes. Where do the earthworms go, to the dark part or the light part of the tray?

Do this part of the experiment two or three more times. Do you always get the same result?

Which do the earthworms like best: damp or dry

places, light or dark places?

(Expected results: Earthworms prefer dark, damp places.)

Checking (pages 16–17)

Thinking

- 1 Most plants grow from buds at the tips of the shoots. If these buds are removed, the plant either dies or its growth is interrupted. Grasses have their growing points at the *base* of the plant, so that if the top of a grass plant is cut off or eaten, the plant can carry on growing from its undamaged buds.
- 2 The list of weeds is very much a personal thing and is complicated by the fact that many weeds have local names. They are alike in that they all reproduce rapidly, either by seeds or by the plant spreading vegetatively, or both, and they grow successfully in places such as lawns, flower beds and vegetable gardens where they are not wanted.
- 3 The foods which have flour in them include bread, cakes, biscuits, pastries, puddings, pies, spaghetti, macaroni, noodles, semolina and lasagne.
- 4 The combine-harvester got its name because it combines the two tasks of cutting the cereal stems and removing the grains from the ears, or 'threshing' the grain, as it moves along. The earliest cereal harvesting was carried out by hand, using sickles made of flint and then later of iron. The people of the Bible threshed the grain from the straw and chaff by spreading it on the floor and driving oxen over it. Later flails of wood or leather were used to beat or whip the grains from the ears. At the end of the 18th century threshing machines were invented, and the first mechanical reaper appeared in 1826. At first it was horse-drawn and then later pulled by tractors. Combine-harvesters were an American invention, and the first one reached Britain in about 1930.
- 5 It is extremely difficult to tell the difference between wheat, oats and barley if the cereal ears have not yet formed. Once the ears are formed, even though they are not ripe, it is easy to recognise wheat by its tightly packed upright ears. Barley is similar to wheat, but each grain is in a close-fitting shell which has a long spikey awn on it. By contrast, an oat plant does not have its grains in a tightly-packed upright head. Instead they hang individually at the side of the stem in a loose cluster.
- 6 Cereal straw can be used for thatching buildings, for animal food and bedding, for making paper and cardboard and for packing fragile objects such as glass, pottery and wine bottles. In the garden, straw is put under strawberry plants to keep the ripening fruit clean. Stored vegetable crops such as potatoes and turnips may be protected from frost by straw. Straw can also be used for making straw matting, hats, and corn dollies and other decorations.
- 7 The ways in which earthworms are adapted to living in the soil include their ability to burrow, partly by swallowing the soil, partly by pushing the soil particles to the sides of the burrow. Earthworms have a long thin shape, no eyes, ears or legs, and a slimy body to enable them to slide between the soil particles. Bristles along

the side of the body enable an earthworm to grip the sides of its burrows. It is also sensitive to light and vibrations.

- 8 Many of the once common weeds of cereal crops, including the corn marigold shown in the picture, have become rare or even extinct because of the widespread use of chemical weedkillers which kill all the weeds but do not affect the cereal plants.

Doing

- 1 *Grow grains and cereal seeds.*

SAFETY PRECAUTIONS: Beware of buying grass seeds or cereal grains which have been treated with chemical pesticides. In the case of cereal grains, if in doubt buy them from a health shop.

(Expected results: Normally grass seeds germinate within a day or two; cereal grains take a little longer. If you put some of the cereal or grass seedlings in a dark cupboard they will grow tall and straggly and be a yellow colour, whereas those grown in the light are shorter, sturdier and a dark green in colour.)

- 2 It is not possible to tell the time with a dandelion clock. If the parachute of a dandelion seed is moistened, it floats through the air either badly or not at all. The best kind of weather for a dandelion plant to scatter its seeds would be dry windy conditions.
- 3
 - a A plant which is growing where it is not wanted is called a *weed*.
 - b The pollen of grass flowers is scattered by the *wind*.
 - c Unlike most flowers, grass flowers do not have *petals*.
 - d Wheat straw is sometimes used to *thatch* the roofs of buildings.
 - e Food grasses, like wheat, oats and barley, are called *cereals*.
 - f Wheat grains are ground into *flour*.
 - g Dandelions are very successful plants because they can *adapt* to changes in their living conditions.
 - h Sometimes when there are too many things to count, it is quicker and easier to *estimate* the number.
 - i Earthworms prefer to live in *dark* damp places.
 - j Grasses provide food for many animals which are plant-eaters or *herbivores*.

Going further

Making your own flour

SAFETY PRECAUTIONS: Scrub the stones clean and do not use cereal grains which have been 'dressed' with chemical pesticides.

Some other suggestions

- 1 Use equal amounts of self-raising flour, plain flour, wholemeal flour, and brown or wheatmeal flour to make separate samples of dough. Cut the different doughs into biscuit shapes, and bake them. Do a 'taste test' on the results.
- 2 On a visit to a farm or a trip into the country, watch animals feeding in a grassy field. How does each one bite the grass? Roughly how much does each take with

one bite? For how long does each animal eat at any one time?

Some grass-eating animals 'chew the cud'. Ask the children to find out which animals they are and what they do when they chew the cud. (Animals which chew the cud are hoofed animals including sheep, cows, deer, antelopes, giraffes and camels, but not horses and pigs. Animals which chew the cud have a multi-chambered stomach. They bite and swallow their food quickly and then retire somewhere safe to regurgitate the food into their mouths, where it is chewed properly.)

Ask the children to observe what kinds of plants in a grassy field, are not eaten by cows, sheep or horses. Why do the children think the animals do not eat these plants?

(Plants noticed will include those such as buttercups and bracken which are poisonous, and such plants as nettles and thistles which are inedible because they sting or have prickles. This is a further attribute of weed species: they are often inedible to herbivores.)

- 3 Ask the children to find out more about the grasshoppers they may find in grassy places in summer. How many species are there? (29 species of grasshoppers, crickets and their relatives in Britain.) What do they feed on? (Grasses and other plants.) Do they have wings? (Yes, two pairs.) How do they move from place to place? (By rubbing their hind legs across the leathery front wings.) Do grasshoppers lay eggs? (Yes, surrounded by solidified froth in the soil.) What do young grasshoppers look like? (They are called nymphs and are a miniature version of the adults.)
Keep grasshoppers for a short time in a large glass or plastic container with plenty of tussocks of grass. Lightly spray the grass with water each morning. Keep the container well ventilated. After a few days release the grasshoppers from where you collected them.
- 4 *Make some bread* Simple recipes for quick bread and Irish potato bread are given in *The Young Scientist Investigates: Food* by Terry Jennings (OUP).

Interdisciplinary activities

Art and craft

Making corn dollies.

Collages using cereal grains and breakfast cereals.

Drawings of different breeds of cows and other grazing animals.

Model-making or weaving with straw and dried grasses.

Flower-arranging with grasses and cereal plants.

Cooking with flour.

English

Demeter, the corn goddess of the Greeks.

Ceres, the Roman goddess of corn and harvest.

Words and phrases associated with cereals, dough and bread.

Oxford Junior English: *2 Food and Farms* by Oliver Gregory (OUP).

Geography

Cereal farming in Britain, France, the Soviet Union and North America.

Rice farming and irrigation.

Markets and the distribution of cereals.

The Common Market.

The Young Geographer Investigates: *Grasslands* by Terry Jennings (OUP).

Health and hygiene

Grass pollen and hay fever.
Bread and cereals as foods.
Fibre in the diet.

History

The manor and three-field farming.
Sowing, reaping and milling through the ages.
Windmills and watermills.
The Corn Laws.
The Agrarian Revolution.
Enclosures.
Christopher Columbus.

Mathematics

Calculation of percentages.
Percentages of seeds which germinate.
Opinion polls and consumer surveys.
Growth rates.
Temperature and timing.
Calculation of averages.

Music, drama and PE

Songs about ploughing, sowing and harvesting.
Grass for sport and athletics.
Home-made percussion instruments using cereal grains.
Worzel Gummidge by Barbara Euphan Todd.

Religious education and social studies

Hunger in the world today and the 'Green Revolution'.
The Parable of the Sower.
'Our Daily Bread'.
The story of Moses in the bulrushes.
Papyrus and the ancient Egyptians.
Harvest festivals in various religions.

and sills provided by buildings, and they seem unaffected by the never-ending noise and pollution. The buildings provide roosts and nesting sites for many bird species, including the ubiquitous starlings, sparrows and pigeons, together with less common birds such as house martins, kestrels and owls. Towns and cities have the added advantage to wildlife that in winter they are several degrees warmer than the nearby country areas.

The parks, gardens, churchyards and cemeteries in city suburbs are often richer in wildlife than the countryside surrounding the city. In addition, railways, roads and canals reach into the centres of cities from the open country, often acting as corridors along which plants and animals can move unhindered to colonise new areas. The embankments of these lines of communication provide ample plant cover where foxes, badgers, hedgehogs, mice, voles, shrews and rabbits can search for food in relative safety.

As well as feeding the birds in their parks and gardens, town-dwellers throw out huge quantities of food in their dustbins, and produce vast amounts of other waste. Sewage farms and rubbish tips are an important source of food for birds and mammals on the outskirts of towns and cities. Rats, foxes, badgers, hedgehogs and rabbits, as well as common, herring and black-headed gulls, scavenge rubbish tips for food. In addition, the decomposing sewage and refuse acts as a breeding ground for flies. These attract huge flocks of starlings, flycatchers, wagtails, warblers and other insectivorous birds.

The other necessity of a city or large town is vast quantities of fresh water, and the reservoirs that supply this need are a home for a wide variety of fish and other aquatic animals. These in turn are food for herons, grebes and cormorants, together with big flocks of ducks, geese, swans and wading birds.

Even indoors, in town or country, the average householder shares his domain with a large number of animal species, perhaps 50 or more, which take advantage of the warm, dry conditions, and adequate supplies of food to be found there.

Unit 3: Wildlife in the City

Aims of the Unit

- a To demonstrate the wide variety of wildlife to be found in cities.
- b To show how these plants and animals have become adapted to life in this relatively new and hostile environment.

Science background

For the town-dweller, the variety of wildlife near his home is often as great, or even greater, than for the person who lives in the country. Truly urban wildlife exists because of its ability to adapt and live in close proximity to people. Wild plants in towns, for example, have to be able to tolerate the reduced light intensity caused by smoke, dust and exhaust fumes in the air, and the shading effect of tall buildings. They also have to be able to withstand the corrosive effects of acids, produced by atmospheric pollution, on their leaves. It is these acids which also make the soil sour. Yet in spite of these hazards, some plants not only survive but actually thrive in urban environments. A few of the plant success stories in this respect include the flowering shrub buddleia, and the Oxford ragwort, both of which have colonised almost every city's areas of waste ground, as well as the Canadian fleabane, brambles, pellitory-of-the-wall, and many other species.

Birds have similarly adapted to the artificial cliffs, ledges

Books for the children

The Young Scientist Investigates series: *Flowers, Birds and Small Garden Animals* by Terry Jennings (OUP).
The Wild Life in your Home by Terry Jennings (Young Library).
Town and City Wildlife by D. Shipp (Usborne).
Birds in Towns by Francesca Greenoak (Black).

Books for the teacher

Science 5/13 *Minibeasts* (Macdonald Educational).
Science 5/13: *Using the Environment: 4 Ways and Means* (Macdonald Educational).
The Amateur Naturalist by Gerald Durrell (Hamish Hamilton).

Materials and organisation

Most schools have an area of waste or neglected ground within easy reach of them which can, with permission, be used for field studies, if the school grounds themselves are not suitable. In addition, the value of churchyards and public parks and gardens should not be overlooked, as long as permission is first obtained for the kind of work to

be carried out there.

Teachers will find useful *Nature by Design*, an 80-page illustrated pack of ideas and information to help teachers develop a School Nature Area. It is obtainable from the Urban Wildlife Group, 11 Albert Street, Birmingham B4 9UA (price £3.00 including postage and packing).

The Nature Conservancy Council, Dept UN, Northminster House, Peterborough PE1 1UA, will supply details of publications and other materials dealing with urban wildlife.

The Royal Society for the Protection of Birds (RSPB), The Lodge, Sandy, Bedfordshire SG19 2DL, also produces many publications of interest to teachers and children in both town and country schools.

Materials and equipment:-

bird books
jam-jars, smooth-sided tins or clean yoghurt pots
scrap foods as bait for pitfall traps
pieces of wood or old tiles
shallow dishes, such as old saucers or coffee jar lids
blotting paper, paper towels or tissues
'cling-film'
disposable paper plates
poster paints
breadcrumbs
set of scales
portable tape recorder
large shallow dish in which to provide water for the birds
large jars
soil, bark and stones
paintbrushes
plastic spoons
large sheets of black paper
plastic sandwich boxes or large margarine tubs
decaying tree leaves
woodlice
slugs
scrap raw vegetables or vegetable peelings
long narrow boxes, such as plastic bacon boxes
cardboard
scissors
ice-cubes
transparent polythene
corrugated iron, black plastic or large pieces of wood

The waste ground (pages 18–19)

Lesson objectives

- a To explain the origins of some of the plants found on waste ground in cities.
- b To describe some of the animals to be found on waste ground.

Setting the scene

Possible starting points include:

- 1 A survey of the wild plants or animals seen by the children on their way to school.
- 2 A survey of the wild plants or animals to be found in the school grounds.
- 3 A visit, with permission, to a cemetery, churchyard, or public park or garden to examine the wildlife there.

New words

None.

Class management

Outdoor work is essential for this topic. However a search of even the most barren-looking school grounds will reveal some wildlife that can form the basis of this topic.

Safety precautions

The children should be warned that broken glass, jagged metal, projecting nails and other dangers are often present on waste ground. When turning over timber, bricks, corrugated iron and other such materials, the children should ideally wear old gloves. After examination, the objects should be returned to exactly the same position they were in originally, to avoid destroying the homes of large numbers of small animals.

Answers to questions in the text

The waste ground (page 18)

Some of the plants which have berries, such as the elder bushes, brambles and ivy, probably reached the waste ground because birds deposited the seeds there, having eaten the fleshy parts of the berries. Plants such as coltsfoot, rosebay willowherb and Oxford ragwort have seeds which are dispersed by the wind. Other seeds probably arrived at the waste ground in the mud on the shoes of people or the feet of birds, or stuck on the tyres of vehicles. Many seeds also travel in straw and other packaging materials.

Animals in the city (page 19)

Of the animals mentioned in the text, the following rely mainly on plant material for their food and can, therefore, be considered as herbivores: butterflies, bumblebees, moths, elephant hawk moth caterpillars, slugs, woodlice and woodmice. The carnivores are: spiders, kestrels, tawny owls, pied wagtails and house martins. In the country blackbirds, robins, blue tits and starlings eat mainly animal material, but in the town, like house sparrows, pigeons, house mice and rats, they will eat almost anything, plant or animal.

Now try these

- 1 The animals which sometimes or regularly share our homes with us include: ants, spiders, houseflies, blowflies or bluebottles, fruit-flies, moths, wasps, beetles, aphids, earwigs, silverfish, gnats and mosquitoes, house crickets, slugs, house mice, bats, rats, cockroaches and, in winter, lacewings, ladybirds and small tortoiseshell and peacock butterflies. Further information on these animals can be found in *The Wild Life in your Home* by Terry Jennings (Young Library).
- 2 There are four main ways in which fruits or seeds are dispersed from the parent plant:
 - a Wind – including fruit parachutes such as those of dandelions and thistles, winged fruits and seeds such as pine and sycamore, and the scattering of small light seeds such as those of poppy and campion.
 - b Water – fruits and seeds that float, including coconuts and water lilies.
 - c Animals (including birds) – succulent fruits and

seeds including strawberry, raspberry, elderberry and ivy; hooked fruits and seeds, such as those of burdock and goosegrass.

- d Explosive mechanisms – such as gorse, violet and geranium.

3 Briefly, the foods of the birds mentioned on page 19 of Course Book 2 are:

Kestrel – mainly mice, voles and young rats; also frogs, earthworms and insects; sparrows and other small birds in towns.

Tawny owl – mice, voles, shrews, young rats; some birds; at times frogs, slugs, snails, fish, worms and insects.

House sparrow – grain and weed seeds; insects and their larvae; almost entirely bread and table scraps in built-up areas.

Town pigeon – mostly bread and other scraps; also grain, weed seeds and small snails, vegetables and young plants.

Starling – insects and their larvae, earthworms, spiders, slugs, snails; fruits, seeds, roots and berries; table scraps in winter.

Blackbird – insects and their larvae; earthworms; fruits and seeds; table scraps in winter.

Blue tit – insects and their larvae, particularly aphids; some fruits, seeds and grain; table scraps in winter; cream from exposed milk bottles.

Robin – insects and their larvae; fruits and seeds; earthworms; table scraps.

Pied wagtail – flies, beetles, small moths and other small insects.

House martin – almost entirely insects caught on the wing, particularly flies, gnats, mosquitoes and small beetles.

Expected results of activities and experiments

Birds and buildings (page 19)

It is not possible to generalise on the results of this activity. They will depend upon the nature of the school environment, the degree of disturbance, the number of trees present, and whether or not people put out food for the birds.

Extending the learning

- 1 *Make a pitfall trap for small animals* This type of simple trap can teach the children much about small invertebrate animals, many of which are active only at night.

A jam-jar, a smooth-sided tin or a yoghurt pot is needed. Bury the container in a lawn, in a flower bed, under a hedge, on waste ground or somewhere else where it will not be disturbed. The top of the container should be level with the surface of the ground. Bait the trap with small pieces of bread, vegetables, scraps of meat, dog food, and so on.

Put two stones at opposite sides of the top of the trap. Lay a piece of wood or a tile over the top to keep out the rain. Leave the trap for several hours, or overnight.

Encourage the children to keep records of the kinds of animals they are able to trap in different parts of the school grounds or other study sites, and with different baits. Do the numbers and kinds of animals caught

differ according to the weather or the time of the year? (Usually they do.)

It is important that these traps are dug up as soon as they are finished with. Alternatively, if a jar is used, this can be fitted with a lid until the trap is next needed. If these traps are forgotten or left, large numbers of small animals may die.

2 *Investigating seed travellers*

What you need: Some shallow dishes such as old saucers or coffee jar lids; blotting paper, paper towels or tissues; 'cling-film'.

What you do: After you have been for a walk across a park or in the garden or country, carefully scrape the mud from your shoes. Line the saucers or coffee jar lids with several layers of wet blotting paper, paper towels or tissues. Sprinkle the mud from your shoes onto the moist paper and wet the mud. Cover the dishes with 'cling-film'. Keep them in a warm place.

If you have permission, you could also collect some of the mud from inside the mudguards of a bicycle, or from the wheel arches of a car.

Do any seeds germinate from the mud? Can you transplant any of the seedlings into pots of soil or compost to see what kinds of plants they grow into? (Expected results: The mud often does contain seeds, particularly those of grasses and small garden weeds such as speedwell and chickweed.)

Town pigeons (pages 20–21)

Lesson objectives

- a To show how pigeons have adapted to life in cities and have come to depend on people for their food and shelter.
- b To study the behaviour of town pigeons.

Setting the scene

Possible starting points include:

- 1 Drawing or painting town pigeons.
- 2 Putting out food on the bird table during the winter months.
- 3 Discuss with the children where our meat and eggs come from.
- 4 Arrange a visit to a pigeon loft or dovecote, or for the children to be given a talk by a pigeon fancier.

New words

Dovecote – one of the special buildings in which pigeons or doves are reared.

Class management

In most towns and cities, the practical work on this topic can be carried out within the school grounds, or even looking from the classroom window. In the country, where pigeons are much shyer, it may be necessary to study sparrows or starlings instead.

Safety precautions

The droppings of pigeons can carry infections, and the

children should be warned of this. They should wash their hands thoroughly after touching any object a pigeon may have contaminated. Pigeons should not be brought into the classroom under any circumstances, because of this risk to health.

Answers to questions in the text

Town pigeons (pages 20–21)

The connection between the two pictures is that the cliffs in County Kerry, Ireland, are one of the last breeding places in the British Isles of rock doves, the wild ancestors of the town pigeons shown in the lower picture.

The man is sorting letters into pigeon-holes, so-called because they are almost identical to the small compartments inside a dovecote in which pigeons or doves build their nests and rear their young.

Flocks of pigeons (page 21)

There are approximately 140 pigeons in the picture. They are being released from a lorry at the start of a pigeon race.

Which colours do pigeons like best? (page 21)

Since the pigeons ate from the blue plate most (21 times), the results of the experiment suggest that pigeons like blue best.

An alternative experiment would be to place the food in matchbox trays fastened down on a plank of wood with drawing pins. Food is placed in each of the trays, and then the trays are covered over with paper of different colours. The pigeons would have to peck through the paper to reach the food. Another possible experiment would be to make several batches of flour and water dough, and to add different food colourings to them, before cutting them up and feeding known numbers of them to the birds.

These experiments could be carried out on any birds which come into the garden or playground to feed in reasonable numbers. House sparrows, starlings, and in some areas gulls, are the obvious choices.

Some reasons why people might not like to have pigeons in towns and cities are that they foul buildings, pavements and people's clothes with their droppings, attract flies and spread germs. The pigeons may even damage buildings, by eating the crumbling cement to obtain the calcium they need to make their eggs. Some reasons why people might like to have pigeons in their town are that they are attractive-looking creatures, they can help to make people feel less lonely, and they attract tourists.

Now try these

- 1 One of the ways of deterring pigeons from the centres of towns and cities is to stop providing them with table scraps and other food. In addition, if there are few horizontal ledges accessible to pigeons, fewer of these birds will be able to roost or nest there.

Methods of controlling the numbers of pigeons include shooting them, poisoning them (not very selective), destroying their nests and eggs, and using bird-scarers to frighten them.

- 2 In the country, the wild wood pigeons eat mainly cereals and clover, but also wild fruits and seeds, members of the cabbage family, oil-seed rape, peas, and a little animal food. Because they can destroy growing crops, particularly in winter, farmers consider wood pigeons to be pests.

- 3 The feeding habits of pigeons have changed. In their natural homes by the sea, rock doves, the ancestors of town pigeons, eat mostly seeds and grain, peas, potatoes, shellfish and seaweed. Now town pigeons eat mostly bread and other table scraps, grain, weed seeds and small snails.

- 4 There is tremendous variation between individual town pigeons: they may be blue-grey, cinnamon-brown, black or white, or any combination of these colours. In addition, wood pigeons are also common in towns. The children may notice that many town pigeons have lost one or more toes, presumably either in traps or as a result of disease.

- 5 The town pigeon builds a flimsy nest of grass and twigs on a ledge or in a hollow on a building; nesting occurs mainly between March and September. Usually there are two eggs, white in colour. These hatch after 17 to 19 days. The young are fed by both parents, and fly after 35 to 37 days. Each pair usually has two to four broods.

Wood pigeons build a nest which consists of a flat platform of twigs, usually in a tree. Nesting occurs in almost any month, but mainly in August or September. Two white eggs are laid. The young, like those of the town pigeon, are fed by both parents with 'pigeons' milk' – a white liquid produced in a pouch in their throats, called the crop, from partially digested food.

The children could also find out more about the breeding habits of the other British doves and pigeons, including the rock dove, stock dove and collared dove.

Extending the learning

- 1 Carry out a survey to find out why people feed pigeons.
- 2 Use a portable tape-recorder to record the calls of a pigeon. Play back the recording when other pigeons have come to feed. How do they react to the recording?
- 3 Put a dish of water where pigeons and other birds come to feed. Ask the children to watch carefully until they see a pigeon drink, and to record exactly what it does. Also observe how other kinds of birds drink. Do they drink in the same way that pigeons do?

The children could also record instances of pigeons bathing (they will often use their drinking water for this). How do the pigeons get their feathers wet? It would be instructive if the children made a note of the air temperature and the time of day when the pigeons were bathing. Do pigeons have a favourite bath-time? Do they bathe only in fine weather? Exactly how do they preen themselves after bathing?

Suggest that the children look for a pigeon with distinctive colouring. Can they find out how often this particular pigeon bathes?

Investigate the favourite foods of pigeons. One such experiment is described on page 29 of *The Young Scientist Investigates: Birds* by Terry Jennings (OUP). Other activities and experiments which could be carried out on pigeons or other birds are also described in this book.

More town animals (pages 22–23)

Lesson objectives

- a To show how some other bird species have adapted to living in towns and cities.

- b To demonstrate that many small animals have taken advantage of the warmth and shelter provided by human homes.
- c To study the behaviour of slugs.

Setting the scene

Possible starting points include:

- 1 Observations at a bird table.
- 2 A search of the school grounds for small animals.
- 3 Mapping starling roosts in the area around the school in winter.
- 4 A visit to a town park, garden, cemetery or churchyard to survey the wildlife there, if this has not already been done earlier.

New words

Hibernate – animals which sleep through all or a large part of the winter are said to hibernate.

Class management

If all the children carry out the observations on slugs, it may be necessary to begin collecting these some weeks before the actual lesson when they are needed. The slugs should be kept in an old aquarium, or a large jar or sandwich box, containing moist soil or compost, and fed on pieces of carrot root, cabbage, lettuce, dandelion, deadnettle, stinging nettle and other greenstuff.

Safety precautions

The children should wash their hands thoroughly after handling the slugs. It may be better for the children, and for the slugs, if the animals are moved using plastic spoons instead of being handled.

Answers to questions in the text

More town animals (page 22)

Kestrels, gulls and house martins are having to change their habits because there are now more people in the British Isles. There are fewer areas of undisturbed seashore where the gulls can nest, and few lengths of cliff, where gulls, kestrels and house martins can nest free from human disturbance. There are also far fewer large trees where kestrels can nest because of the effects of Dutch elm disease and the spread of modern intensive agriculture.

One of the main reasons why starlings move into cities in the winter to sleep is because the temperature in cities then is several degrees higher than in the surrounding countryside. There are also many ledges on high buildings where these birds can rest in safety.

Another reason why some animals live near people, as the pictures show, is because we put out large quantities of waste food in our dustbins and on our rubbish tips.

Now try these

- 1 Kestrels often hunt near main roads and motorways for the voles and other small animals that live on the grassy verges and embankments. Rooks, crows and magpies sometimes scavenge on the corpses of mammal and bird road accident victims.

- 2 Foxes, and to a lesser extent badgers, have made their homes in towns and cities. Otters are unlikely to take up residence in towns because they require clean, unpolluted water for catching fish and swimming, and because they need complete freedom from disturbance when they breed. Hares need wide open grassy spaces for feeding and breeding, although they do live on some airfields and airports. Wild deer also need a large amount of room and freedom from disturbance, although of course tame deer survive in large town and city parks.
- 3 Most slugs feed on living or decaying plants, and they do some good in clearing away weeds and dead vegetation. However, slugs do much damage in tidy gardens by eating seedlings of many kinds, leaves of such vegetables as cabbages and lettuces, and the underground stems, or tubers, of potatoes.
- 4 The animals which have been brought from other countries and allowed to go wild in Britain include rabbits, pheasants, coypus, grey squirrels, mink, the house mouse, brown rat, black rat, muntjac deer, sika deer and fallow deer. In their original homes, the numbers of these animals were kept in check by their natural enemies. When moved to their new homes, these animals often had nothing to keep their population down, and therefore they became pests.

Expected results of activities and experiments

Studying slugs (page 23)

There are 24 species of slug in Britain. It is fairly easy to tell them apart, although in some species, including the most common one, the netted slug, there is considerable variation in colour within the one species.

If a slug is touched gently with a paintbrush, it will withdraw its feelers and contract its body.

If the underside of a slug's body is examined while it is moving, the contraction and relaxation of the muscles of the base of its body, or 'foot', can be observed as the animal crawls along.

Extending the learning

- 1 *Which foods do slugs like best?* This experiment is described on page 31 of *The Young Scientist Investigates: Small Garden Animals* by Terry Jennings (OUP).
- 2 *Keeping woodlice* Woodlice are common in cities and in the country. Keep some in a plastic sandwich box or a large margarine tub. Line the box with moist blotting paper or paper towels. Put a layer of damp, decaying tree leaves, pieces of bark, moss, and one or two stones in the box. Place four or five woodlice inside. Give them a raw potato with a hole cut through it for food, or carrot, potato or other vegetable peelings. It is a good idea also to place in the box a lump of chalk, mortar or dry plaster of Paris, from which the woodlice can obtain the calcium they need for their external skeletons. Cover the box with polythene or 'cling-film'. Make small holes in this to allow the woodlice to breathe. Keep the container away from bright lights, heaters and radiators. Moisten the blotting paper or paper towels and tree leaves if they begin to dry out. Put fresh food in the cage from time to time. Look out for the tiny young woodlice – they look like

minute grains of rice, and also for adult woodlice that are in the process of casting off their external skeleton and growing a new one.

3 Which conditions do woodlice prefer?

What you need: A long box (a plastic bacon box is ideal); cardboard; Sellotape; scissors; blotting paper or paper towels; a plastic spoon and a small paintbrush; ice-cubes; polythene or 'cling-film'; black paper; 10 woodlice.

What you do: Make a cardboard partition across the middle of the box. Leave a small opening for the woodlice to pass through. Fix the partition in place with Sellotape.

Put damp blotting paper or paper towels in one half of the box, and dry blotting paper or paper towels in the other half.

Carefully put 5 woodlice in each half of the box. Use the plastic spoon and paintbrush to move them. Cover the box with 'cling-film' or polythene so that the woodlice cannot escape.

Look again after 15 minutes. How many woodlice are there in each half of the box? Do woodlice prefer damp places or dry places?

Do the experiment again with damp blotting paper or paper towels in both halves of the box. Put two or three ice-cubes in one half of the box. Leave the other side as it is. Put 5 woodlice in each side of the box and cover it over with polythene or 'cling-film'. Look again after 15 minutes. Do woodlice prefer cold or warmer places?

Do the experiment again with moist blotting paper or paper towels in both sides of the box. Put 5 woodlice in each half of the box. Cover one half of the box with black paper and the other half with clear polythene or 'cling-film'. Look at the woodlice again after 15 minutes. Do they prefer dark or light places?

Try this experiment with millipedes, centipedes or slugs. Do they prefer the same things as woodlice?

At the end of your experiments, let your animals go again where you found them.

(Expected results: Woodlice, like millipedes, centipedes and slugs, prefer warm, dark moist conditions which accounts for the type of places they are found in – under stones, bark, pieces of wood, scrap metal, heaps of dead leaves, and so on.)

Checking (pages 24–25)

Thinking

- 1 In bright sunlight old bottles can act as a magnifying glass or burning glass and start a fire. Both old bottles and drinks cans can act as traps for animals. Small animals sometimes creep inside them, looking for food, and are drowned in the water that often collects in discarded bottles and cans, or the animals may be trapped because they are unable to climb back up the slippery sides. Broken bottles can also cut the larger wild animals, while small animals have been known to trap their heads in the ring-pulls from drinks cans.
- 2 Pigeons and other birds pick up food from the ground with quick pecking movements, so that their attention is focused on the ground (and away from possible dangers) for the least possible time.

Most humans cannot see an object immediately before picking it up with the lips, because the nose gets

in the way. It is probable that many birds are unable to see small objects at the moment they pick them up, because the beak obstructs their vision. However since the eyes of most birds are on the sides of their head, they may have some vision at these close distances.

- 3 A sociable bird is one which seems to like the company of others of its own kind. Starlings are sociable mainly outside the breeding season, so are winter flocks of finches, ducks, geese, swans and wading birds. Other birds nest in large colonies including rooks, gulls, terns, gannets and many other seabirds.
- 4
 - a Pigeons are likely to increase in numbers when buildings are made with lots of ornamental ledges on the outside.
 - b Pigeons are likely to decrease in numbers when people take pigeons' eggs, damage the nests or disturb the birds sitting on them.
 - c Pigeons are likely to decrease in numbers if farmers cut down hedges and put up barbed-wire fences instead. This is because hedges are important nest sites for pigeons.
 - d Pigeons are likely to increase in numbers if people put out food for the birds in cold weather.
 - e Pigeons are likely to decrease in numbers if cats become more popular as pets, since cats are important predators of pigeons.
 - f Pigeons are likely to decrease in numbers if roads become busier with more cars and lorries. The pigeons may be killed by the traffic.
 - g If farmers spray their crops with chemicals which kill insect pests and weeds, then pigeons may eat the contaminated insects and weeds and be poisoned. This will lead to a decrease in the numbers of pigeons.
 - h If grain is spilled on farms during the harvest (when pigeons are still breeding), this will act as food for the pigeons, and they will increase in numbers.

Doing

- 3 A champion racing pigeon can cost several thousands of pounds to buy. In 1978 a Japanese pigeon fancier paid the equivalent of £25,000 for a pigeon.

Racing pigeons are fed mainly on seeds and grains of various kinds.

Young racing pigeons are trained from the age of about one month. Their owner takes them a short distance away from the home loft and then releases them. If the pigeons find their way back, they are taken further away next time, and so on. Eventually the best pigeons can be trusted to return from a long distance, sometimes more than a thousand miles.

In a pigeon race, birds from various places are released at the same time and at the same spot. The first bird to reach its home loft is the winner. Each pigeon carries a ring round one leg with its own number on it. In addition, before a race the pigeon has a special number put on its leg, held in place with a rubber ring. When the pigeon arrives back at the end of the race, the owner removes this numbered tag and puts it in a sealed time-check clock, which stamps the hour and minute of arrival on it. The clock can be opened only by the organisers of the race. The distance between the start of the race and the home loft of each pigeon is measured,

and its speed of travel, in terms of distance per minute, is calculated. The pigeon with the highest speed is the winner.

It is not known for certain how racing pigeons find their way back home. There is some evidence that they navigate using the sun, when this is visible, and when conditions are overcast they may use the Earth's magnetic field.

There are a number of kinds of fancy pigeons including pouters, which have large puffed-out chests; fantails, with broad spreading tails; and tumblers which turn somersaults in the air as they fly.

- 5 Tame cats are most likely to catch and kill mice, voles, shrews, young rats and small birds, particularly newly-fledged young birds. It is probable in towns and cities that cats are the main – sometimes the only predators – of birds and small mammals, and so they are likely to have a big effect on wildlife.
- 6
 - a The first plants to grow on a piece of waste ground are often *mosses* and grasses.
 - b The plants which grow on waste ground are *adapted* to living where there is little soil.
 - c The home of the ancestors of town pigeons was *cliffs* by the sea.
 - d Pigeons were kept by people for *meat*.
 - e The buildings in which pigeons were reared were called *dovecotes*.
 - f One bird of prey (or carnivore) which often feeds and nests in towns and cities is the *kestrel*.
 - g At night in winter, thousands of *starlings* often come into cities to sleep.
 - h Many of the small invertebrate animals on waste ground live under bricks, stones and wood because they prefer moist, *dark* places.
 - i Many invertebrate animals have discovered that the *insides* of buildings provide warmth and shelter.
 - j Some animals in cities live on the waste *food* we throw away in our dustbins.

Going further

- 1 The most likely animals to be found under a piece of corrugated iron, black plastic or a large plank of wood left on the ground are woodlice, slugs, centipedes, millipedes and possibly earthworms. All of these creatures prefer the warm dark, damp conditions under these objects. Spiders may also hide in these places in search of prey.
- 2 The flowering plants growing on a wall may well include wall rocket, stonecrop, wall pennywort, ivy, ivy-leaved toadflax, red valerian, Oxford ragwort and dandelion. There may also be mosses, lichens, the green alga *Pleurococcus*, and ferns.

Generally the flowering plants grow near the top of the wall, and most of the mosses, lichens, algae and ferns in the lower regions. If one side of the wall is permanently shaded, these non-flowering plants may be abundant all the way up the wall on that side.

Old walls made from soft limestone rocks, or old brick walls with soft mortar, usually have the most plants growing on them.

- 3 Bees often seem to specialise in flowers of one species, and while they appear to prefer flowers of certain

colours they do not necessarily restrict themselves to these. Butterflies also seem to show a preference for flowers of one species.

Some other suggestions

- 1 Ask the children to examine an area of the playing field or a piece of waste ground which is used by a lot of people as a short cut. Are the plants growing on these unofficial paths different from the same areas where the ground is not trampled?
(Expected results: Generally there are fewer plants per unit area of trampled ground, and the plants tend to be low-growing ones that can resist kicking and trampling, cf. the dandelions on the lawn described on page 13 of Course Book 2.)
- 2 Encourage the children to make a survey of the animals which live under bricks, pieces of concrete or wood. Ask them to keep records of all the animals they find, but to be sure to return the bricks, concrete or wood back exactly as they found them. Are the kinds of animals found under bricks different from those which live under concrete or wood?
(Expected results: The animals most likely to be found are woodlice, slugs, snails, earthworms, centipedes, millipedes and spiders. It is unlikely that the animals living under bricks will be different from those living under concrete or wood. If there is a difference it is probably due to the smaller size of bricks, and drier conditions under them, than under large pieces of wood or concrete.)
- 3 It would obviously be difficult for children to study homing behaviour in pigeons, but this would be another opportunity to investigate the homing instinct of garden snails. This experiment is described on page 31 of The Young Scientist Investigates: *Small Garden Animals* by Terry Jennings (OUP).

Interdisciplinary activities

Art and craft

Sketching birds.
Still-life drawings of ivy and other wall plants.
Model-making of woodlice and snails.
Embroidery of patterns made by mosses and lichens.
Making and using dyes.

English

The Bad-tempered Ladybird by Eric Carle.
James and the Giant Peach by Roald Dahl.
Charlotte's Web by E. B. White.
The Secret Garden by Frances Hodgson Burnett.
Regional names for woodlice, ladybirds and other common animals.
Kes by B. Hines.
Pigeons and doves in poetry.

Geography

Mapping the routes of pigeon races.
Mapping the school grounds.
The weathering of buildings, statues etc.
The native countries of introduced plant and animal species.

Health and hygiene

Pigeons as health hazards in towns. (Leicester Square in London is particularly filthy.)
The dangers of broken glass, discarded cans etc.
First aid.

History

Dovecotes and rabbit warrens as sources of meat in the Middle Ages.

Homing pigeons in the two World Wars.

London and other cities in the blitz.

The extinction of the American passenger pigeon in the 19th century.

A survey of gravestones in the local churchyard or cemetery.

Industrial archaeology.

Mathematics

Use sports record books to prepare calculations on the speed and distance covered by homing pigeons.

Calculating large areas.

Shape and symmetry.

Music, drama and PE

City homes of great composers.

Concert halls and theatres.

Pigeons and doves in the work of song writers and composers eg. Handel.

Religious education and social studies

The dove of peace.

The dove released by Noah.

Pigeons and doves as sacrifices.

Vandalism in parks and public gardens.

Cruelty to animals – the work of the RSPCA and RSPB.

Unit 4: Reproduction in Birds and Mammals

Aims of the Unit

- a To show that among birds and mammals, the sexes are separate and distinct, with the females producing eggs and the males producing sperms.
- b To show how some birds and mammals, including humans, care for their young.
- c To emphasise the prolonged care and responsibility involved in giving and preserving human life.

Science background

This Unit extends the topic of life cycles, begun in Unit 12 of Course Book 1, to examine the reproduction of birds and mammals.

In birds, the digestive and reproductive tracts open to the outside of the body through one chamber, the cloaca. Fertilization in birds is internal, a process which is essential for animals living on land. External fertilization such as that which occurs in fishes, frogs and toads is impossible here, because the eggs and sperms would dry up when exposed to the air. In birds the sperms pass from the testes of the male into its cloaca, and thence into the cloaca of the female. This internal fertilization requires a behaviour pattern which brings the male and female together at the right time, so that the sperms are released when the eggs are mature. It is the function of courtship to bring the pair together and to stimulate them to mate and remain together as a pair while the young are reared. Like reptiles, birds lay eggs with shells around them. The shell forms around the egg after fertilization has occurred. The egg also contains the supply of food and water necessary

for the embryo to develop. In most species of birds, one or both of the parents incubates the eggs by sitting on them, and then one or both parents continues to feed the young until they are completely independent.

In mammals, including humans, internal fertilization is also the norm. Again there is a process of courtship which synchronises the reproductive systems of the pair. In mammals the male animal has developed a penis which is inserted into the female's reproductive system in order to deposit the sperms. After this internal fertilization, the eggs develop inside the body of the female in a specialised part of her reproductive system, the uterus or womb. The embryos are thus protected by the mother. They are supplied with food and oxygen from the mother's blood through a special organ, the placenta with its attached umbilical or birth cord, which is actually part of the embryo.

In mammals, growth and development of the embryos, unlike those of birds, is independent of the external temperature, and the embryo mammal is protected to a far greater extent from injury or predators. In addition, the female mammal does not have to remain on the nest incubating the eggs, but is free to lead a reasonably normal life until just before the birth of her young. Most young mammals are born at a fairly advanced stage of development, and are fed on milk supplied by the mother until they are able to feed themselves.

Although both birds and mammals employ internal fertilization, an adaptation to life on land, in both cases the embryo develops in water. In birds the embryo develops within its own 'private pond' inside the egg-shell. In mammals, the embryo develops inside a membranous bag of fluid, the amniotic sac, which only bursts shortly before the young mammal is born.

There is often a connection between the amount of parental care and the number of eggs or young produced. Where there is little parental care, as in most invertebrates, fishes and amphibians, there is usually a large number of eggs. Because the parents do not protect the eggs or young, or bring them food, many of the offspring die. The large number of eggs, however, ensures that some offspring will survive to maturity. The parental care shown by birds and mammals gives them a much better chance of survival, and as a result they have smaller numbers of offspring.

Books for the children

The Young Scientist Investigates: *Birds* by Terry Jennings (OUP).

The Young Scientist Investigates: *The Human Body* by Terry Jennings (OUP).

Where did I come from? by P. Mayle (Michael Joseph).

How Babies are made by A. C. and S. Schepp (Time-Life).

How you Began by Lennart Nilsson (Kestrel).

Goose Lays an Egg by Helen Piers (Methuen).

Window into a Nest by G. L. Flanagan and Sean Morris (Kestrel).

Books for the teacher

Sex Education in School and Society by Dorothy Dallas (NFER).

Science 5/13: *Ourselves* (Macdonald Educational).

Materials and organisation

This is a subject which has at times an almost overwhelming interest for children. Although there is obviously a limit to the amount of practical work which is possible, it is suggested that the children should be exposed to a wide range of books, films and television programmes dealing with different aspects of the subject. Ideally opportunity should be taken to keep a breeding pair of small mammals, such as mice or gerbils, in the classroom. The subject, as dealt with in Course Book 2, provides a basis for those who wish to move on to a more formal and detailed consideration of human reproduction and sex education with their classes.

Materials and equipment:-

- a breeding pair of mice, gerbils or some other small mammal
- hens' eggs (hard-boiled)
- hens' eggs (uncooked)
- squares of cloth
- pieces of stiff card
- clean egg-shells
- scissors
- scales
- books
- dried grass and leaves, or thin strips of paper
- clay or plasticine
- a collection of pictures of different mammals
- microscopes
- microscope slides and cover-slips
- an onion
- a tomato
- yeast
- fresh green leaves, eg. from a cabbage
- Canadian pondweed leaves
- green water from a pond, puddle, or a flower vase
- squared paper
- pictures of items needed for a new baby
- pictures of the nests and eggs of birds
- pictures of baby animals
- pictures of male and female animals of the same species

Chickens (pages 26–27)

Lesson objectives

- a To study the reproduction of birds.
- b To examine the structure of a bird's egg.

Setting the scene

Possible starting points include:

- 1 Putting up a bird nesting box in the school grounds.
- 2 Examining the structure of a hen's egg (possibly by cutting slices through a hard-boiled egg).
- 3 Revise the life cycles of fish and frogs dealt with in Course Book 1.

New words

Hen – the name given to a female chicken, or the female of most other bird species.

Cockerel – the name given to a male chicken.

Class management

All of the work on this topic can be carried out by the children at their own desks.

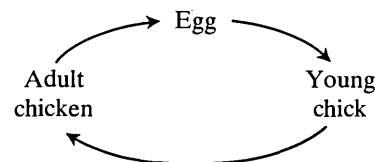
Safety precautions

If the egg-shell experiment is carried out, the egg-shells should be first washed in warm soapy water.

Answers to questions in the text

Chickens (page 26)

The life cycle of a chicken is:



Robins (page 27)

Some of the other young birds which can run around soon after they have hatched include the young of ducks, geese, game-birds such as pheasants, partridges and grouse, wading birds, moorhens, coots, gulls and terns. In general, these are birds which nest on the ground or on or near water. Almost all the other birds, including all the common garden birds, produce young which are born blind, naked and helpless.

Now try these

- 1 The actual factor which brings birds into breeding condition in the spring and early summer is the increasing length of the days. The result of this is that the young birds hatch when most insect and plant foods are available, since these too grow rapidly and reproduce in the warmer weather of spring and summer.
- 2 Traditionally, hard-boiled coloured eggs, the symbols of new life, were given as presents at Easter. Today, however, Easter eggs are usually made of chocolate. It is easier to decorate hard-boiled eggs with felt-tipped pens or painting sticks than to use crayons or paints.
- 3 The birds which lay 'camouflaged' eggs are those which nest on the ground, including gulls, terns, oystercatchers, pheasants, partridges and skylarks. Usually the nest consists simply of a hollow in the ground with little or no nesting material.
- 5 The largest egg in the world is produced by the largest bird, the ostrich of Africa and Arabia. A typical ostrich's egg is 15 to 20 cm long, and weighs 1.65 to 1.75 kg. It is equal in size and weight to about two dozen hens' eggs.

Often several ostriches lay their eggs in a shallow hollow in the sand. There may be as many as 15 white eggs in a clutch. The hen birds take turns to look after the eggs in daytime, and the cock bird takes charge at night. Often the eggs are not incubated in the daytime, but are kept warm by the hot sun. However, the hen birds still stand guard over them. It takes 42 to 48 days for the eggs to hatch.

The largest egg of a British bird is that of the mute swan.

Expected results of activities and experiments

Looking at a hen's egg (page 26)

The actual part of a fertilized hen's egg which develops into a chick is a tiny sphere, the fertilized egg-cell, on the surface of the yolk. The vast majority of hens' eggs sold for human consumption have not been fertilized and so lack this structure. The yolk of the egg provides the developing chick with food (fats and protein), while the egg-white provides it with water and additional food (protein).

How strong is an egg-shell? (pages 26–27)

If the egg-shells are cut evenly, it will be found that they can withstand a considerable weight. It is unlikely that there will be any significant difference between the strengths of white and brown egg-shells.

Extending the learning

- 1 *Making a collection of birds' nests* This activity can be carried out only during the autumn and winter. Details are given on page 27 of *The Young Scientist Investigates: Birds* by Terry Jennings (OUP).
- 2 *Make egg-men* Fill some clean egg-shells with moist cotton wool. Sprinkle some cress seeds on the top of the cotton wool. Paint or draw faces on the egg-shells, so that when the cress grows the 'egg-men' appear to be growing hair.
- 3 *Why are eggs egg-shaped?* Remember that birds' eggs must fit neatly together in a nest so that the female bird can incubate them. They must be easy to turn over several times a day, so that the growing baby bird does not stick to the inside of the shell. If the eggs are laid on a cliff ledge, they must not roll off.
What you need: Some clay or plasticine.
What you do: Make model eggs which are different shapes. Make them spheres, cubes, cylinders, pyramids and other shapes including, of course, egg-shapes. Try fitting them together in a clay or plasticine nest.

Which shape takes up the least room? Which shape is the easiest to turn over (remember that birds do this with their beak only)? Some cliff-nesting birds do not build a nest, but simply lay their eggs on a narrow ledge. Which shapes are the hardest to roll off a table, shelf or some other artificial cliff ledge on to the floor?

What is the best shape for an egg?

(Expected results: Cubes and some other shapes can be packed together into a small space, but they are difficult to turn over with the aid of only a beak (try it with the point of a pencil!). Spheres are easy to turn, but they roll too easily. The only satisfactory shape for an egg is, of course, ovoid or egg-shaped.)

Mammals (pages 28–29)

Lesson objectives

- a To describe the features of a mammal.
- b To examine the reproduction of non-human mammals.

Setting the scene

Possible starting points include:

- 1 Keeping a breeding pair of mice, gerbils or some other kind of small mammal in the classroom.
- 2 A visit to a zoo, wildlife park or livestock farm, paying

particular attention to any young mammals present.

- 3 Bringing a litter of puppies, kittens or young rabbits into the classroom to give the children an opportunity to compare young mammals with their parents.

New words

Mammals – a group of animals with backbones (vertebrates) which have hair or fur on their bodies, and which produce living young that are fed on milk produced in special glands in the female's body.

Class management

All of the work on this topic can be carried out by the children at their own desks although, as mentioned above, a visit to examine baby mammals is highly desirable, if it is not possible to bring some into the classroom.

Safety precautions

None.

Answers to questions in the text

Mammals (page 28)

Altogether in the world there are more than 4,000 species of mammal. They include, as well as humans, all the various apes, monkeys and lemurs, moles, shrews, hedgehogs, bats, rats, mice, rabbits, hares, guinea pigs, porcupines, beavers, lions, tigers, bears, hyenas, domestic cats, dogs, wolves, foxes, otters, stoats, weasels, seals, sea-lions, walruses, whales, porpoises, dolphins, horses, zebras, rhinoceroses, cattle, camels, deer, giraffes, antelopes, pigs, hippopotamuses, elephants, kangaroos and opossums. The odd-ones-out amongst the mammals are the spiny anteater and duck-billed platypus, both of which lay eggs, although they still feed their young on milk.

Baby mammals (page 29)

Some of the baby mammals which run around soon after birth include the young of sheep, cattle, horses, zebras, camels, deer, giraffes, antelopes and elephants. These are all herbivores, and most of them live on grassy plains where there is little cover from their enemies, and where the only defence is to run.

Some of the mammals which are born blind and helpless include the young of rats, mice, gerbils, hamsters, moles, shrews, hedgehogs and kangaroos. Some other mammals are born blind, although they have hair or fur right from birth. They include puppies and kittens and the young of lions, cheetahs, leopards and all the other big cats. In general, those mammals which are born blind and helpless are born in caves, burrows or underground chambers or, in the case of kangaroos, the young develop inside the mother's pouch.

The newly-born kangaroo is about the size of a child's little finger. It is naked, blind and apart from well-developed front legs, it has only a partly-formed body. The mother anticipates the birth of her infant by licking the inside of her pouch and also by licking smooth a path through her fur from her vagina to the pouch. When it is born, the shapeless little animal climbs up its mother's fur unaided and clambers into her pouch. There it grasps a nipple in its mouth, and remains in the pouch for about six months, feeding on milk, until it is sufficiently grown to

run about on its own.

The mammals, in decreasing order of size, are: elephant, camel, giraffe, horse, human, kangaroo, sheep, dog, rabbit, rat, mouse. In general, the larger the animal, the longer the young takes to develop inside its mother's body (the gestation period). The exception is the kangaroo, which is born at an early stage of development, but continues its growth inside its mother's pouch. Whales are another exception. The gestation period for the blue whale, the largest mammal that has ever lived, is just under a year. This short period of development may be because the young whale is totally aquatic and is therefore supported and protected by water after birth, as it was while growing inside its mother's womb.

Now try these

- 1 Young mammals differ from their parents not only in size and weight but also in the relative proportions of their bodies. Generally the head of a young mammal takes up a much larger proportion of its total length than it does in the adult. The limbs of the young mammal are also less sturdy, its senses and muscles less well developed, while its knowledge of its surroundings is slight. The young mammal's hair or fur may also differ in colour and texture from that of the adult. It should be remembered that some young mammals, eg. rabbits, rats, mice, gerbils and hamsters, are born blind, deaf and naked.
- 3 A kangaroo's pregnancy lasts only about 38 days. During this time the fertilized egg is developing inside the mother's womb. Shortly before birth, the mother cleans her pouch by licking, and also licks a pathway through her fur between the opening of the vagina and her pouch. When the baby kangaroo leaves the womb it is only about 2 cm long. It is blind and naked but has well developed claws which it uses to climb up the mother's body into her pouch. Inside the pouch the baby kangaroo fixes itself to a nipple and feeds on milk. It stays there, in its mother's pouch for about 6 months. During its third month the young kangaroo begins to go out and look for food, returning to the pouch when it is tired or frightened.
- 4 There is considerable variation in the number of young produced by mammals. The following are average or typical figures:-

House mouse	4 to 8
Fox	4 or 5
Pig	6 to 12
Elephant	1
Whale	1
Sheep	1 or 2
Cow	1
Human	1
Rabbit	3 to 7
Lion	1 to 6

Extending the learning

- 1 All living things are made up of cells. The children can see some examples of cells with the aid of a microscope. Good samples to look at include a piece of onion membrane (the very thin 'skin' you find between two layers of an onion), a very thin piece of tomato skin, and a drop of yeast suspension (yeast shaken up with

water and left for an hour or two). The children could also examine cheek cells (scrape the inside of the cheek with the little finger, having washed the hands thoroughly first). Other possible subjects include a very thin layer peeled off the underside of a cabbage leaf, a leaf of the water plant Canadian pondweed, and some of the green water from a pond, puddle or a vase in which flowers have been kept.

- 2 Weigh a baby mammal, such as a mouse or gerbil once its eyes are opened, and at regular, say daily, intervals to show how it grows.
- 3 Carry out a survey of the children's pets. Plot the results on a graph made on squared paper. On the horizontal axis of the graph write in the names of the different kinds of pets. On the vertical axis write in the numbers of each kind of pet. Which is the most popular kind of pet?

Human life cycles (pages 30–31)

Lesson objectives

- a To describe the growth of the human baby after fertilization.
- b To describe the lengthy process of the growth and development of humans from infancy to maturity.

Setting the scene

Possible starting points include:

- 1 Collecting pictures of human babies, and making a display of them on the Science Table.
- 2 The birth of a baby to a famous person.
- 3 For a teacher or some other friend of the school to bring a young baby into the classroom, for the children to see and to observe its stage of development.

New words

Breasts – the milk-producing organs of a woman.

Class management

All of the work on this topic can be carried out by the children at their own desks.

Safety precautions

None.

Answers to questions in the text

Human life cycles (page 30)

The mark which shows where a child was joined by the umbilical or birth cord to the inside of the mother's body is the so-called 'belly button' or navel.

How big were you as a baby? (pages 30–31)

New-born babies usually weigh between 2 and 4 kg and are about 50 cm long.

Growing up (page 31)

The pictures show that the biggest spurts in growth occurs between birth and one year and between the ages of ten and fifteen.

Now try these

- 1 It is largely a matter of opinion when a human child becomes independent of its parents. At the age of two to three years, most infants no longer depend totally on their mothers for food and hygiene. Some people might consider that the age of independence for humans lies somewhere between the ages of sixteen (the end of compulsory schooling), and eighteen (the legal age of adulthood). With other animals the approximate ages of adulthood are:

Mouse	4 to 6 weeks
Dog	8 weeks
Elephant	12 years
Zebra	18 to 24 months
Lamb	10 to 12 weeks

- 2 The main items needed for a new baby are:

Clothes

Stretch suits or nightgowns
Cardigans
Vests
Shawls
Hats
Mittens

Toilet items

Nappies – disposable or towelling
Nappy pins
Disposable nappy-liners or gauze squares
Buckets
Sanitizing solution
Baby bath
Small bowl
Baby soap
Talcum powder
Cotton wool balls
Cream
Soft towels
Baby hairbrush
Baby wipes
Plastic pants
Bibs

Feeding

Bottles and teats
Bottle sterilizer
Breast pads
Large jug
Dried baby milk
Bottle warmer

Bedding

Sheets for crib or carrycot
Sheets for pram
Cellular blankets for cot or pram
Top quilt or cover for cot or pram
Under-blankets or flannelette sheets
Waterproof sheeting

Larger equipment

Crib or carrycot
Pram, baby buggy or transporter for carrycot
Firm mattress

- 3 In the first few days of his life, a baby feeds when he is hungry. He may want five feeds in one hour and then nothing more for four hours. Eventually most babies settle down to five feeds a day.
- 4 Milk from the mother's breast is specially suited to the baby's needs. When a mother is unable to breast feed

her child, the baby is then fed with a modified form of cow's milk, usually prepared from a powder, which matches the mother's milk fairly closely. The milk has to be manufactured and prepared under hygienic conditions, and the bottle and teat sterilized before use with a special disinfectant solution to destroy any germs. The milk has to be warmed so that it is given to the baby at approximately body temperature.

- 5 The main difference between the baby and the grown-up in the picture is the different proportions of the head to the rest of the body. In the baby the head makes up approximately one quarter of the total length. In the adult the head forms about one-eighth of the total height.

Extending the learning

- 1 Collect pictures of all the items needed for a new baby. Make a display of these on the Science Table. Try to find out the cost of the individual items, and the total cost.
- 2 Ask the children to draw up a table consisting of two columns headed 'Men' and 'Women'. Let the children list as many differences as they can between the two sexes. They can then repeat this exercise by comparing boys and girls.
- 3 Ask the children to find out all they can about the work of the Save the Children Fund. Make a display or exhibition of the work of this charity.

Checking (pages 32–33)

Thinking

- 1 A 'species' is one of the different kinds of plants and animals. Confusion may arise with domesticated animals and cultivated plants where, within one species, there are a number of different breeds or varieties. With dogs, for example, spaniels, alsatians, boxers and corgis, are all different breeds within the species dog.
- 2 Milk is sometimes called the 'complete food' because it contains, besides water, substances which give us energy, keep us warm, help us to grow and repair damaged parts of the body, and which enable us to stay healthy (ie. carbohydrates, fats, proteins, vitamins and mineral salts). We could guess that milk is a good food, certainly for young children, because it is the only food received by babies and other young mammals.
- 3 Most birds lay few eggs because the eggs are quite large, and if many were laid the bird's body would not cover them whilst the eggs were being incubated.
- 4 The nest and eggs shown are those of an oystercatcher, a common bird of the seashore. The colouring of the eggs and the absence of large amounts of nesting material, ensure that the nest and eggs are camouflaged by the sand and stones on the seashore.

It is almost certain that the bird does not know she is protecting her eggs by building a nest like this, since all oystercatchers have the same type of nest and eggs, even during their first breeding season when they have never previously seen an oystercatcher

building its nest and laying its eggs. This is an example of instinctive behaviour.

- 5 Animals reproduce when they have reached the adult stage of development, while plants usually reproduce when they have grown to their maximum size.
- 6 Many children do not realise that a cow gives milk only after she has given birth to a calf. Even then, if the farmer stopped milking a cow, her milk supply would soon dry up. When the cow's milk supply does dry up, she is again mated. Her calf is quickly weaned onto artificial milk or solid foods, so that the cow can again supply milk to the dairy.
- 7 As well as the difference in size between the bones of the hand of a child and those of the hand of an adult, the children will notice that the individual finger bones of the child do not appear to touch. This is because the ends of the bones are made of cartilage, a soft, gristly substance which is able to grow and lengthen the bones. Eventually the cartilage hardens into bone. Cartilage does not show up in X-rays, whereas hard bone does.

The children can feel examples of cartilage if they hold the lobes of their outer ears or the tips of their noses.
- 8 A baby's head has to be handled very carefully since the individual bones are soft, with gaps between them called fontanelles. These allow for considerable moulding of the head to occur while the baby is being born, without the head becoming crushed by the muscles of the womb. Gradually the gaps between the bones close up, and the bones harden.
- 9 The eggs of a mammal can be much smaller than those of a bird, because the mammal's eggs are protected inside the mother's body. The developing mammalian embryo receives all its food, water and oxygen from the mother's blood, and her blood system also disposes of the embryo's waste products. By contrast, a bird's egg has to contain enough food and water for the embryo to develop, and there have to be spaces inside the egg-shell where waste products can be stored.
- 10 Children look a bit like their mothers and a bit like their fathers, because they started their existence as a bit from their mother's body (an egg-cell) and a bit from their father's body (a sperm cell).
- 11 If a human baby is born head first, then the shoulders, arms and legs automatically and quite easily follow the head out of the birth canal. If one of the baby's feet is born first, then one or both legs, could get tangled up inside the mother's body or become wrapped around the birth cord. The same thing could happen if the baby is born bottom first. These problems could be demonstrated by pulling a doll with movable arms and legs through a narrow opening.
- 12 A bird's egg has to be fertilized while it is still inside the female's body, because the shell is formed around the egg as it is laid. Sperm from the male would not be able to pass through the hard egg-shell.
- 13 A female bird turns her eggs several times every day so that the young bird (the embryo) does not stick to the shell.
- 14 An examination of the proportions of the head to the rest of the body in a baby and an adult shows that the trunk and limbs grow quite quickly, while the head grows much more slowly.

- 15 A human egg doesn't need a shell because it is protected throughout its existence inside the mother's body.
- 16 Both a human egg and a hen's egg are kept warm while they develop by the heat of their mother's body (occasionally in the case of other birds, also by the heat of the father's body). In humans the egg is carried everywhere the mother goes, and is kept warm the whole time. Periodically the hen has to leave her eggs to seek food and water. At these times the eggs may cool down and the development of the embryos is slowed.
- 17 A pregnant woman has to take care about the food she eats because she is eating for her baby as well as for herself. She should try to eat foods which will enable the baby to grow healthily, while at the same time maintaining her own health and fitness.

If a pregnant woman smokes or drinks alcohol, these harmful substances will pass from her blood into the baby's blood and may damage the growing baby.
- 18 The possible disadvantages of having a baby animal develop inside the mother's body include the fact that the mother has to take the developing baby with her wherever she goes. The pregnant mother's speed will be reduced, and she will not be able to escape so easily from her enemies.
- 19 A human baby developing inside its mother's body is rather like a spaceman inside a spaceship, because they are both protected inside a warm container and receive their supplies of food, water and oxygen from the container and release their waste products into it. The differences include the fact that as the baby grows, so does its container. If the supplies of food, water or oxygen to the baby begin to run low, the mother can easily obtain more. This is not so easy in the case of the spaceman in his spacecraft.

Doing

- 3 It is not possible to generalise about the comparisons the children will make between pictures of adult and baby animals. However the head of a baby animal is always larger in proportion to the rest of the body than it is in an adult, and the limbs are usually either shorter or more spindly. Many young mammals are born blind, deaf and naked.
- 4
 - a Birds reproduce by laying eggs which have *shells* around them.
 - b Young chickens hatch from eggs that were *fertilized* inside the hen's body.
 - c During mating, *sperm* cells pass from the cockerel into the hen's body.
 - d Young robins are born *blind*, naked and helpless.
 - e An egg shell has to be thin enough to allow *air* in for the baby bird to breathe.
 - f Animals with hair or fur on their bodies are called *mammals*.
 - g A female mammal produces tiny *eggs* inside her body.
 - h After a baby mammal has been born its mother feeds it on *milk*.
 - i Our bodies are made of millions of *cells*.
 - j The developing baby floats in a water-filled *bag*.

- k Food and oxygen pass to a developing baby from its mother through a special *tube*.
- l When it is ready to be born, the mother's *muscles* push the baby to the outside.

Going further – some other suggestions

- 1 If you can keep a pair of small mammals such as mice, gerbils or rats in your classroom, the children will be able to study their breeding behaviour. The children can keep a diary of events and try to find answers to the following questions: How many young are born at once, and how are they born? How many young are born altogether? When do the young first leave the nest? How often do they feed on their mother's milk? When do they first eat solid food?

Strict supervision of the children will be necessary to ensure that the mother is not disturbed or frightened while she has very small young, otherwise she may kill them or desert them.

- 2 Ask the children to find out how twins, triplets, quadruplets and other human multiple births occur. Why are some twins identical, whereas others are not? How many sets of twins are there in your school? What proportion or percentage is this of the total number of children? (There are two ways in which multiple births are produced. Sometimes, the egg splits after fertilization into two or more pieces, each of which develops into a child. These children are all of the same sex and identical in almost every other way. Alternatively two or more eggs may be produced and fertilized at the same time. The children which result may or may not be of the same sex and they may or may not have characteristics in common.)
- 3 The children might be asked to collect sets of pictures showing male and female animals of the same species. These could be arranged on a wallchart and the children asked to examine, and write about, the ways in which males and females of the same species are alike or how they are different.

Interdisciplinary activities

Art and craft

- Decorating hard-boiled eggs.
- Cooking with milk and eggs.
- Collages and paper sculptures of chickens and other birds.

Drawing young mammals and birds.

English

- The Water Babies* by Charles Kingsley.
- King Solomon's Ring* by Konrad Lorenz.
- The Jungle Book* by Rudyard Kipling.
- The Snow Goose* by Paul Gallico.
- Oxford Junior English: *2 Food and Farms* by Oliver Gregory (OUP).

Geography

- Poultry farming in Britain.
- Dairy farming and the dairy industry.
- Find out about the countries of origin of some common pet animals.

Health and hygiene

- Sex education.
- The value of milk and eggs as food.
- Hygiene and the reproductive system.

History

- The family in Roman times and in the Middle Ages.
- Children in factories in the 19th century.
- The Welfare State.

Mathematics

- Measuring changes in growth and growth rates.
- Relative costs of baby foods per gramme.
- Statistics: charts and graphs.
- Histograms and pie charts.

Music, drama and PE

- The Carnival of the Animals* by Saint-Saens.
- Mime and gesture.
- Nativity plays.

Religious education and social studies

- Parental care in different human societies.
- The birth of Jesus.

Theme: Structures, Forces and Energy

Unit 5: Materials

Aims of the Unit

- a To classify materials and compare the properties of metals and non-metals.
- b To examine the properties and uses of some common metals.
- c To examine the properties and uses of some common plastics.

Science background

An element is a substance that cannot be split into a simpler substance by ordinary chemical means. If an electric current is passed through water, for example, the two elements oxygen and hydrogen are produced. No amount of chemical treatment will split oxygen or hydrogen into simpler substances. They are elements.

There are just over 100 elements, from which all the different chemical compounds are formed. More than 70 of these elements are metals. Of the rest, about 20 are definitely non-metals, while some of the remainder are intermediate between these two categories. Most metals are solids at ordinary temperatures. The exception is mercury, which is a liquid, and is commonly used in thermometers. When polished or freshly cut, metals are bright and shiny and they reflect light. Most metals are good conductors of heat and electricity. They can be shaped by rolling or hammering them while hot and some metals can be pulled out into wires. A common method of shaping metals is by casting, the metal being melted and poured into a mould of the required shape.

There are two groups of metals: pure metals (elements) and alloys. Iron, copper, gold and aluminium are pure metals. Alloys are combinations of metals which produce a metal which is in some way better than the original components. Bronze for example, is an alloy made by mixing molten copper and tin, while brass is similarly made from molten copper and zinc. Solder is an alloy of lead and tin. Steel is made by heating molten iron with carbon. Since carbon is a non-metal, steel is not really an alloy, although it behaves like one.

Most metals are found in the Earth's crust as *ores*, which are rocks in which the metal is chemically combined with other substances. There are two main methods of obtaining a metal from its ore. The most usual method is

by smelting, in which the ore is heated in a furnace, usually with coke, charcoal or some other form of carbon.

Sometimes the metal is obtained from its ore by a process known as electrolysis, literally 'splitting with electricity'. The only metals found in the Earth in a pure state are gold, platinum and small quantities of silver and copper.

The other group of substances included in this Unit are the plastics. Chemically they are very complicated compounds consisting of thread-like molecules, technically called polymers, composed of many thousands of atoms. They all contain the non-metal elements carbon and hydrogen, and sometimes oxygen and other non-metals as well. Most are made from chemicals obtained from oil, although a few come from coal.

Strictly speaking a plastic substance is one that can readily have its shape changed. Not all synthetic polymers are plastic in this sense, but since the word plastic is in common use as in 'plastic bag', 'plastic spoon' or 'plastic ruler', the term is also used here.

There are three main groups of plastics. Thermoplastics are those which can be softened by heat, and this makes them easy to shape. If they are reheated they become soft once more. Examples of thermoplastics are polythene, used in plastic bottles and for plastic bags, perspex, PVC, polystyrene, and such synthetic fibres as Acrilan, polyester (Terylene) and nylon.

Thermosets can be moulded when first made, but cannot be remoulded if they are heated again. They are much more rigid than thermoplastics and are good at withstanding heat and acting as insulators. Examples of thermosets are Formica, used in table tops and kitchen surfaces, melamine used in electrical plugs and sockets, picnic crockery and telephones, and the polyester resins used in fibreglass for some cars, boats and furniture.

Elastomers are materials that stretch and then return to their original shape. Rubber is an example of a natural elastomer. Synthetic elastomers are used in certain kinds of swimwear, stretch clothes and divers' wet suits.

Books for the children

The Young Scientist Investigates: *Materials* by Terry Jennings (OUP).

Man and Materials: *Plastics* (Macmillan Education).

Metalcraft for Beginners by T. Potter (Usborne).

World Resources Series: *Copper* and *Gold and Silver* (Wayland).

Science Workshop by Irene Finch (Longman).

Books for the teacher

Science 5/13: *Metals Background Information* (Macdonald Educational).

Science 5/13: *Metals* (Macdonald Educational).

Science 5/13: *Children and Plastics* (Macdonald Educational).

Materials and organisation

Both the different kinds of metals and the different kinds of plastics can be difficult to identify. It is a good idea for the teacher to build up a collection of samples of known, and labelled, plastics and metals for reference. These can be displayed on the Science Table.

A number of commercial organisations are often willing to supply teachers with booklets, posters, films and other aids in the teaching of plastics and metals.

Griffin and George Ltd,
Ealing Road,
Wembley,
Middlesex HA0 1HJ. (Plastics and metals).

BP Educational Service,
P.O. Box 5,
Wetherby,
W. Yorkshire LS23 7EH. (Plastics).

The Plastics Institute,
11 Hobart Place,
London SW1N 0HL.

Trylon Ltd,
Thrift Street,
Wollaston,
Northants. NN9 7QJ. (Plastics).

ICI Ltd,
Plastics Division,
Bessemer Road,
Welwyn Garden City, Herts. (Plastics).

Shell Chemicals Ltd,
Shell Centre,
London SE1. (Plastics).

British Steel Corporation,
Information Office,
12 Addiscombe Road,
Croydon, Surrey. (Iron and steel).

Gold Information Office,
30 St. George Street,
London W1.

Copper Development Association,
Orchard House,
Mutton Lane,
Potters Bar, Herts.

Aluminium Federation,
Broadway House,
Calthorpe Road,
Five Ways,
Edgbaston,
Birmingham.

Materials and equipment:-

magnets
clean, shiny nails
gloss paint
jam-jars
oil or vaseline
pieces of rusty iron
pieces of rust-free iron
brass screws
samples of metals of different kinds
emery cloth
piece of wood
small steel pins
powerpack batteries
paper clips
lampholders with bulbs
short lengths of plastic-covered wire
drawing pins
small blocks of wood
small screwdrivers
keys
pencil erasers
pencils
thick rubber bands
string
strips cut from a plastic bottle
plastic spoons
cardboard
rubber hot-water bottles
pieces of wood (about 15 cm × 15 cm)
tin lids
plastic plates
china plates
pieces of wool and cotton materials
2p coins
tablespoons
pieces of plastic of different kinds
washing-up bowls
plastic drinking straws
paper bags and plastic bags
clean washing-up liquid bottles
scissors
waste wrapping materials
apple cores and orange peel
stones or wooden pegs
steel knitting needles
house bricks
candles
candle wax
saucers or candle-holders

Metals (pages 34–35)

Lesson objectives

- a To examine the properties of metals.
- b To study the preparation and properties of iron and steel.

Setting the scene

Possible starting points include:

- 1 A display on the Science Table of objects made from iron and steel, or from metals generally.

- 2 Carry out a survey of the objects made from metal which are in use in the classroom.
- 3 A display of metal mechanical toys.
- 4 A collection of pictures of metallic objects displayed on the Science Table.
- 5 A display of metal packaging on the Science Table.

New words

Ores – rocks with a lot of metal in them.

Furnace – a large oven giving very great heat.

Class management

All of the work on this topic can be carried out by the children at their desks, but a certain amount of movement around the school will be necessary if the children are to find out which things around the school are attracted by a magnet, unless this is done as a homework activity.

Safety precautions

The children should be warned of the danger of cuts from sharp pieces of metal, and also of the dangers from lead. Although this metal is useful in making comparisons, the children should be warned that lead is poisonous, and they should handle it as little as possible, and to wash their hands after touching the metal or, better still, wear gloves when handling it. Incidentally the 'lead' in pencils is not lead at all, but the completely harmless substance graphite.

Answers to questions in the text

Metals (page 34)

Some of the more common or better-known metals include:

Iron and steel – used for ships, railways, cars, bridges, the framework of tall buildings, bicycles, cutlery, pins and needles, 'tin cans', nails, screws, nuts and bolts and many other everyday objects.

Copper – used for wires and cables, water pipes, the roofs of some churches and other buildings, parts of boilers and radiators, some saucepans, coins, some bracelets, and some paints.

Aluminium – used for many saucepans, kettles and teapots, railway carriages, buses, coaches, aircraft and some cars, milk-bottle tops, 'silver foil' around chocolate and cigarettes, toothpaste tubes, and the mirrors for large telescopes.

Lead – used for some church roofs, joining the pieces of coloured glass in church windows, protecting some electric cables, the sinkers on fishing tackle and in the boots of divers, printers' type, some bullets and the shot in cartridges, car batteries, and certain paints.

Zinc – used for galvanising iron or steel articles such as buckets, dustbins and wire netting to stop them rusting, and making brass (with copper).

Tin – used mainly for coating steel plate when making airtight food cans (the so-called 'tin cans') to stop them rusting.

Gold – used for jewellery and ornaments, some coins, fountain pen nibs, in dentistry, some electrical contacts and wires, gold leaf on the covers of books and manuscripts, and for coating the windscreens of jet aircraft

and spacecraft.

Silver – used for jewellery and ornaments (sometimes the latter are made of another metal which is plated with silver), cutlery (often silver plated), mirrors, photographic films and chemicals, some coins, some electrical contacts. *Platinum* used for rings and jewellery, electrical contacts and crucibles (melting pots) in laboratories. As a catalyst it helps to bring about some industrial chemical reactions, eg. making sulphuric acid, although the platinum itself is not used up.

Some other metals and alloys include bronze, brass, pewter, chromium, titanium, magnesium, sodium, potassium, nickel, calcium, tungsten and uranium.

In the picture the things which are made of metals are the 10p coin, the iron nails, the cap of the glass bottle, the spoon, the scissors, the point of the ballpoint pen and the saucepan. The things which are made of non-metals are the china cup, the ruler and pencil, the bottle, the reel of cotton, the body of the ballpoint pen, and the plastic-coated handles of the saucepan and scissors.

Iron and steel (pages 34–35)

The large objects made of iron or steel in the picture are warehouse, cranes, ship, fuel tank and railway wagons.

Now try these

- 1 Bronze is an alloy of copper and tin. Copper is sometimes found in the ground as a lump of pure metal. At first our distant ancestors probably beat out copper metal to make knives and axes. Later it was noticed that the copper was easier to beat out if it was first heated. Eventually it was discovered that if copper was heated sufficiently it melted, and could then be poured into a mould shaped like a particular object. However copper by itself has a poor cutting edge and eventually someone found that by adding tin (to make what we now call bronze,) they could make a much harder metal that still melted at a low temperature. In a sense, therefore, the Bronze Age was preceded by a 'Copper Age'.
- 2 After the Bronze Age came the Iron Age. Iron ore, from which iron is made, is much more widely available. Iron is harder and tougher than bronze and produces much sharper knives and axes and can be used to produce a wide range of other implements. It melts at a higher temperature than copper and came into use when it was discovered how to increase the temperature of 'furnaces'.
- 3 Tarnishing is a film of colour formed on the surface of a metal. Silver and copper tarnish very rapidly, gold not at all. Tarnishing is brought about by a chemical reaction between the air, particularly moist or polluted air, and the metal.
Rusting is a reddish-brown coating which forms on the surface of unprotected iron and steel. It is caused by a chemical reaction which occurs when the metal is in contact with both the oxygen of the air and with moisture.
- 4 Rusty iron is reddish-brown in colour and pieces flake off the surface. The rusty iron is lighter in weight and weaker than a piece of fresh iron of the same measurements.
- 5 Modern car bodies are usually made of sheet steel pressed into the required shape. Steel is strong and relatively inexpensive, and car bodies can be mass-

produced from it easily. A few car bodies are made of aluminium, fibreglass or plastics. These materials are strong, light and they do not rust.

Most aircraft are made from alloys between aluminium and other metals. These alloys are strong and light and they do not corrode. Stainless steel or the metal titanium are used where great strength or heat resistance are required. Glass fibre is often used for light aircraft, microlites and gliders.

Expected results of activities and experiments

Why is iron often painted? (page 35)

The nail which has been painted does not rust, but a coating of brown rust quickly forms on the untreated nail.

In the same way, a nail coated with oil or vaseline does not rust, whereas the untreated one does.

Extending the learning

- 1 Bury a clean shiny nail and a brass screw in the garden. Mark the spot. Dig the nail and screw up again after two or three months. What has happened to them? (The nail will be badly rusted, and probably the metal will be crumbly and weak. The brass screw may have a coating of tarnish, but otherwise it will be unharmed.)
- 2 *Shiny metals* Collect samples of different kinds of metals. Clean them with emery cloth and then shine them with metal polish. Does the colour of the metal change? Ask the children to write down what each metal looked like before it had been cleaned and what it looks like after.

Many metals go dull when they are left in the air, especially if the air is damp. We say the metals tarnish.

Put some samples of metal that have been polished on a piece of wood outside the classroom. Examine them every day for a month or so. What happens to each of the metals?

Ask the children to find out whereabouts in the home, school, garage or road they can see metals which are shiny and which do not tarnish easily. Ask them to find out what these metals are called.

(Copper and alloys of copper such as coins, bronze and brass, tarnish particularly readily, as a greenish coating forms on them. This green tarnish, or patina, can be seen on roofs and church spires which are made of copper.)

The two main metals used on cars and bicycles which do not rust or tarnish easily are stainless steel and chromium. In the case of the latter, the object is usually made of steel and then coated with a thin layer of chromium to protect it.)

- 3 *Magnets* Let the children investigate the strength of magnets. How many nails or small pins will each magnet pick up? (Care is needed here, because some pins which appear to be made of steel are in fact made of brass, coated with tin. These are not attracted to a magnet.) Count and weigh the nails or pins picked up by different magnets.

Ask the children to try and magnetise a large nail by stroking it with one end of a bar magnet. The nail should be stroked in the same direction all the time. Test the nail to see whether it will pick up steel pins. Does the strongest magnet produce the strongest new magnet? (Yes it does.)

Other experiments and activities concerned with magnets are contained in *The Young Scientist Investigates: Electricity and Magnetism* by Terry Jennings (OUP).

Some more metals (pages 36–37)

Lesson objectives

- a To examine some common uses of aluminium and copper.
- b To show the importance of the metal gold in jewellery and in industry.

Setting the scene

Possible starting points include:

- 1 A collection on the Science Table of examples of packaging made from aluminium.
- 2 A display of pictures showing the uses of gold.
- 3 A comparison of the weights of equal-sized pieces of aluminium, iron or steel, and lead or copper.

New words

Aluminium – a light, silvery white metal, much used for packaging and the bodies of aircraft, coaches, buses and railway carriages.

Copper – a common metal of a reddish-brown colour, much used in water pipes, boilers, coins, radiators and hot-water tanks.

Class management

All of the work on this topic can be carried out by the children at their desks.

Safety precautions

Again, the children should be warned that pieces of aluminium and copper may have sharp edges that can cut the skin deeply.

Answers to questions in the text

Copper (page 36)

Penny coins made of pure copper were minted until 1860. Since that date our 'copper coins' have been minted from bronze, an alloy of copper and tin which does not rust or corrode. However, since 1947 British 'silver' coins have also been made of an alloy of copper, this time with the metal nickel, called cupronickel.

Gold (pages 36–37)

Gold never rusts, tarnishes or loses its shiny appearance. Silver quickly tarnishes, turning brown or black in the air, particularly if the air is polluted.

Now try these

- 1 Most coins are no longer made of gold and silver because the value of these metals has increased so enormously. The £1 coin is made from nickel-brass. The 50p, 20p, 10p and 5p coins are minted in cupronickel, while the 2p and 1p coins are minted from

bronze. The only gold coins now minted are gold sovereigns, krugerrands and similar coins, sold as investments because of their gold value. The only silver coins now minted in Britain are the Maundy Money, the sets of silver coins distributed by the Queen to poor people in a special service on Maundy Thursday, the day before Good Friday. From time to time special proof sets of silver coins are issued, usually to commemorate some special event, such as the Queen's Silver Jubilee.

- 4 Not only is gold found as an actual metal in veins in rock, it also occurs in the form of grains in certain kinds of sand or gravel. This kind of gold is usually found in the bed of a river, or where a river has flowed in the past. Such gold, called alluvial or place gold, can be obtained by separating away the lighter sand and gravel with water. It can be done with a frying pan, which is filled about one-third full with the sand and then topped up with water. The mixture is swirled and tilted so that the lighter sand is washed over the edge while the heavier grains of gold collect at the bottom. There are certain sands and gravels bearing small quantities of gold in the mountains of North Wales and in the Highlands of Scotland.
- 5 If a thin piece of metal is bent backwards and forwards several times it will be noticed that the metal begins to break up into crystal-like structures at the point of the bending. This shows the onset of 'metal-fatigue', which is a particular problem in the parts of aircraft and other metallic structures subjected to constant stresses and strains, since without warning the affected metal may suddenly break.

Some other suggestions

- 1 Which materials are conductors of electricity and which are insulators?

What you need: A battery; two paper-clips; a

lampholder with a bulb; three pieces of plastic-covered wire with the plastic stripped from the ends; two drawing pins; a small block of wood; a screwdriver; a key; a rubber; a pencil; a thick rubber band; a piece of string; a strip cut from a plastic bottle; a plastic spoon; a piece of cardboard.

What you do: Push the two drawing pins into the block of wood. The pins should be about 3 centimetres apart. Join up the two drawing pins to the battery and lampholder, using the pieces of wire, as shown in the picture.

See that all the connections are tight. If you now lay the blade of the screwdriver across the two drawing pins, the bulb should light.

Now lay the handle of the screwdriver across the two drawing pins. Does the bulb light now? Now try other materials.

Materials which let electricity pass through them and make the bulb light are called *conductors*.

Materials which do not let electricity through them, so that the bulb does not light, are called *insulators*.

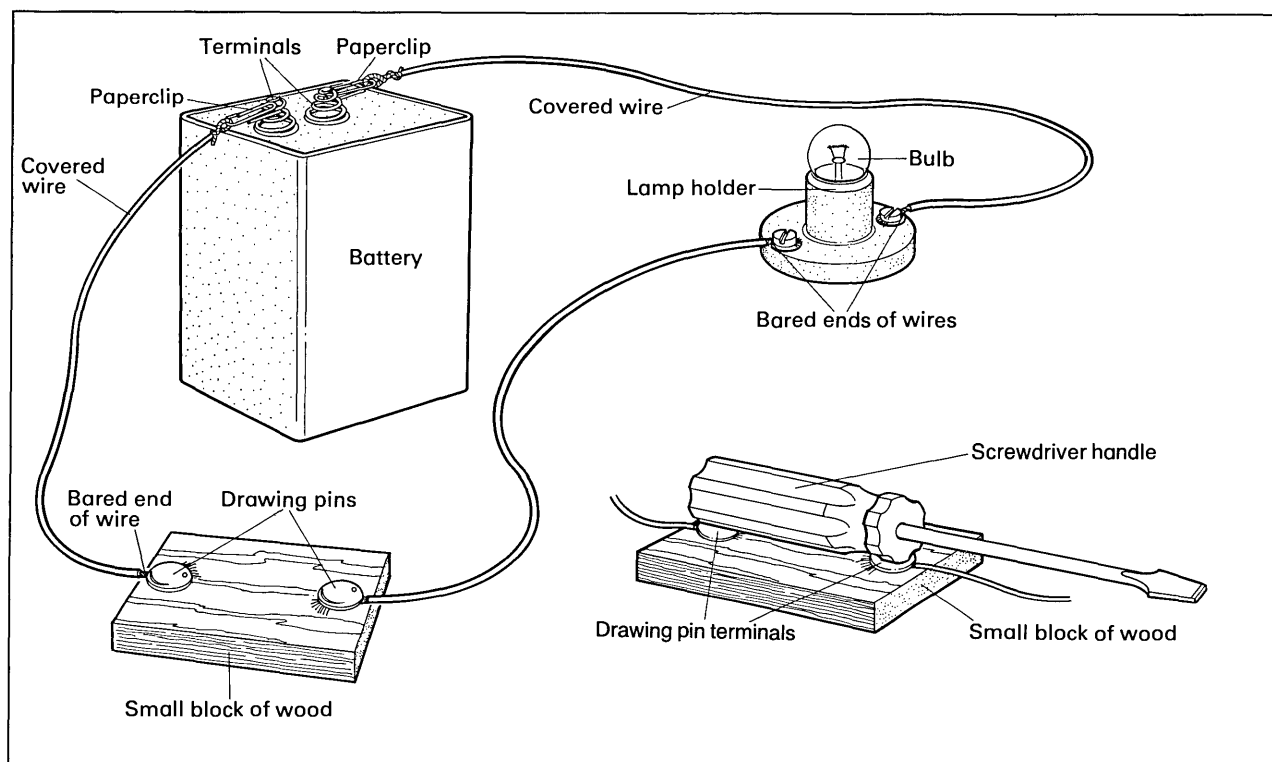
Make two lists, one of materials which are conductors of electricity, and the other of materials which are insulators. What do you notice about the materials in each column?

It may be found easier to leave this apparatus more or less permanently set up and fixed onto a board which can be passed from desk to desk. The ends of the wires should be bare of their insulating plastic cover, and all connections should be tight.

(Expected results: The materials which do not cause the bulb to light, that is which are all insulators, will be found to be the non-metals such as wood, glass, rubber, plastic etc. The metal objects are conductors of electricity.)

- 2 Which materials does heat pass through?

What you need: A rubber hot-water bottle; a piece of wood; a tin lid; a plastic plate; a china plate; some



cardboard and paper; pieces of woollen and cotton materials; a 2p coin; a tablespoon.

What you do: Ask your teacher to fill the hot-water bottle with hot (NOT BOILING) water. Lay the hot-water bottle on your desk. Quickly touch the outside of the bottle. Is it hot?

Lay the piece of wood on top of the bottle. Leave it there for a few minutes. Put your hand on top of the piece of wood. Does it feel hot? Does it feel warm?

Next lay the tin lid on top of the hot water bottle. Leave it for a few minutes. Now put your hand on the lid. Is it hotter or colder than the wood was?

Now try the experiment with other materials. Make lists of those materials which let heat through quickly and those which let heat through slowly or not at all.

Materials which feel warm and which let heat through slowly are called heat insulators. Materials which feel cold to the touch and which let heat through quickly are called heat conductors.

Which of the materials you used are heat conductors and which are heat insulators?

(Expected results: The heat conductors are metal objects such as the tin lid, coin and tablespoon. The heat insulators are the non-metal objects such as wood, plastic, cardboard and paper. However, it will be found that not all metals are equally good heat conductors, and not all non-metals are equally good heat insulators.)

Plastics (pages 38–39)

Lesson objectives

- a To show some of the properties and uses of the different kinds of plastics.
- b To introduce the concept of the recycling of valuable materials.

Setting the scene

Possible starting points include:

- 1 Comparing plastic plates and crockery plates.
- 2 A general collection of plastic objects.
- 3 A display of plastic containers and packaging.

New words

Plastics – a group of substances which, during some stage of their manufacture, can be shaped or moulded into any form. Plastics are made from chemicals which come from oil.

Transparent – something we can see through clearly is said to be transparent.

Opaque – something which will not let light through and which we cannot see through is said to be opaque.

Class management

All of the work on this topic can be carried out by the children at their desks.

Safety precautions

Some plastics are inflammable and should not be brought near to a naked flame, others will break producing sharp splinters or jagged edges.

Answers to questions in the text

Plastics (page 38)

The handles of saucepans and kettles are often made of plastics, because these materials are poor conductors of heat, or heat insulators. Heat can travel rapidly up the metal handle of a saucepan or kettle, and burn anyone who touches it. If, however, the handle has a plastic coating, heat does not pass through this easily, and the handle stays cool to the touch.

Plastics are often used in electrical products because, as well as being poor conductors of heat, they are also poor conductors of electricity, or electrical insulators.

Plastic components of cars are lighter in weight and cheaper to produce than metal ones. The bodies of a few kinds of cars are made of plastic materials, but for mass-produced cars it is not possible to produce large, strong plastic panels at an economic price.

Transparent plastic greenhouses have the advantage over those made of glass in that the plastic is virtually unbreakable, whereas glass shatters easily. Transparent plastics have the disadvantages that they scratch easily and, after a few years, the plastic begins to lose its transparency. Plastic greenhouses are also very light in weight, and might blow away in exposed situations.

Old metals (page 39)

People collect scrap metals, so that these materials can be sorted, melted down and made into new products, a process known as recycling.

At present people do not collect scrap plastics because it is cheaper and easier to make new plastics from oil. However, as oil becomes scarcer and more expensive in the years to come, people will probably be forced to recycle plastics.

Litter of all kinds is unsightly, but plastic litter is worst of all because it takes many, sometimes hundreds of years, for it to decay away. By contrast paper, apple cores, orange peel and other *biodegradable* types of litter decay away quite rapidly.

Now try these

- 1 The simplest way to test the strength of a plastic drinking straw is to make a small S-shaped hook from bent wire (a paper-clip would do). Lay the drinking straw across a narrow gap between two desks or chairs. The ends of the straw should overlap equally on the desks or chairs. Hang the hook in the centre of the drinking straw and suspend paper-clips or other small weights from it until the straw buckles or breaks.
In comparing the strengths of one, two and three straws, keep the desks or chairs in exactly the same position and, when drawing conclusions, remember to allow for the weight of the hook.
- 2 A fair test to compare the strengths of a paper bag and a plastic bag would require the two bags to be of exactly the same size. One test would be to suspend each bag in turn from a bulldog clip hanging on a hook, and to add weights to the bag until it broke or tore.

Expected results of activities and experiments

Comparing plastics and metals (page 39)

It is not possible to predict the results of this experiment, they would depend upon exactly which materials are chosen. However, it will be found that, in general, plastics

feel warm to the touch, whereas metals feel cold. Most metals will not float, unless the pieces tested are very large and thin, whereas most pieces of plastic will float. One kind of plastic which floats particularly well is expanded polystyrene, as used in ceiling tiles, and if possible a piece of this should be included amongst the materials under test. Plastics are not affected by a magnet whereas pieces of iron or steel will be attracted to a magnet.

Extending the learning

- 1 Compare the strengths of different kinds of plastic sheeting cut from polythene bags, plastic carrier bags and plastic wrapping materials. Cut strips all the same size, about 30 cm long and 3 cm wide of each of the materials. The two ends of the strip under test should each be wrapped around a pencil and held in bulldog clips. One bulldog clip is hung from a hook or nail in a shelf, while a clean yoghurt pot is tied, with thin string, to the other bulldog clip.

Weights are placed in the yoghurt pot, one at a time, until the strip finally breaks. The other strips are treated similarly.

- 2 Use washing-up liquid bottles and yoghurt pots to make musical shakers. The method for doing this is described on page 26 of *The Young Scientist Investigates: Sounds* by Terry Jennings (OUP).

- 3 *What happens to litter?*

What you need: Some waste wrapping materials, such as a sweet wrapper, newspaper, tissue paper, writing paper, cardboard, and a plastic bag. You could also include an apple core, some orange peel, a tin lid and a piece cut from a plastic bottle. You also need some stones or wooden pegs.

What you do: Cut the pieces of wrapping materials so that they are all the same size. Fix them to the soil in a garden or flower bed with stones or wooden pegs. Carefully draw a plan of the position of each of the materials, so that you can find them and identify them later. Peg down the apple core and piece of orange peel as well, and lay the tin lid and piece of plastic bottle on the soil.

After a month, look carefully at each of the materials. How have they changed? Leave them for another month and then look at the materials again. Which kinds of litter take the longest to rot away? (Expected results: The paper, cardboard, apple core and orange peel will decay away quite rapidly. The tin lid will also begin to rust away quite quickly. However, as mentioned previously, plastic materials are very slow to decay.)

Checking (pages 40–41)

Thinking

- 1 In theory at least, recycling old iron and steel should mean fewer big holes in the ground because less iron ore, coke and limestone will be needed. This will mean that there should be fewer iron ore and limestone quarries and fewer coal-mines.
- 2 Some of the ways in which shiny metals are used to reflect light or heat include:
 - a In torches and car headlamps to reflect the light forwards.

- b Behind electric radiant fires to reflect the heat into the room.
- c Aluminium cooking foil is used to reflect heat.
- d Ornaments of brass, silver or silver plated metal, as well as gold, silver and platinum jewellery are attractive because they reflect light.
- e Some solar panels are curved and shiny so that they reflect the sun's heat onto tubes containing water which is thus heated.

- 3 On a hot day, the telephone wires expand or get longer, and so they sag between the poles. On a cold day the wires contract or get shorter so that they are stretched tightly between the poles. More examples of expansion are met with on page 48 of Course Book 2.

- 4 Plastic bottles are better than glass ones because they are unbreakable. Glass bottles are better than plastic bottles because they do not scratch or stain so easily, and so remain transparent, and they can also be sterilized and reused many times.

Doing

- 1 The aluminium foil, milk bottle tops and metal tabs from drinks cans are melted down so that the metals can be used again.

- 2 Other ways of classifying materials include:

- a those which float and those which sink;
- b those which are attracted to a magnet and those which are not;
- c natural materials and man-made or manufactured materials;
- d metals and non-metals;
- f rough and smooth materials;
- g warm and cold materials.

Each child could also make up a set of materials and ask the rest of the class to find the odd one out which he has added to his set.

- 4 Gold, silver and platinum are the three precious metals. They are precious because of their attractive appearance and their scarcity.

The uses of gold include jewellery, coins, ornaments, in dentistry, and for some electrical contacts and wires, and in scientific instruments. In addition, gold leaf is used in sign-writing and for coating the windscreens of aircraft.

Silver is used, amongst other things, for jewellery, coins, ornaments, cutlery, mirrors and the contacts in some electrical switches.

Platinum is used for some rings and jewellery, in the contact points in some electrical circuits, for making very accurate weights and measures (those used as standards), and widely in industrial chemistry where it acts as a catalyst (it can bring about changes in chemical substances without being changed itself).

- 6
 - a Some metals are light but some are *heavy*.
 - b Some metals can be *bent* into any shape.
 - c Some metals can be *hammered* into thin sheets.
 - d Those materials which are not metals are called *non-metals*.
 - e Rocks which have a lot of metal in them are called *ores*.
 - f Iron is a hard and strong metal, but *steel* is even harder and stronger than iron.

- g When iron is made, the ore is heated in a big *furnace*.
- h Iron and steel are among the few metals which are attracted by a *magnet*.
- i If iron or steel are not painted they easily *rust* in damp air.
- j Many metals go dull, or *tarnish*, when they are left in the air.
- k Because aluminium is a very light metal it is used to make *aeroplanes* and the bodies of buses and railway coaches.
- l Because *electricity* passes along copper well, it is used to make wires and cables.
- m Unlike most metals, *gold* is found in the ground as the pure metal.
- n Plastics are made from the chemicals which come from *oil*.
- o Plastics can be coloured and *moulded* into many shapes.

Some other suggestions

How quickly does heat travel along a knitting needle?

What you need: A steel knitting needle; a brick; a candle; some candle wax; a small nail or a large pin; a saucer or candle-holder.

What you do: Roll the candle wax in your fingers until it is soft. Then push the wax on to the end of the knitting needle.

Stick the nail or pin into the wax. Rest the knitting needle on the brick.

Ask your teacher to light the candle. Then use it to heat the end of the knitting needle away from the wax and the pin or nail.

What happens? Does the heat travel along the needle? If so how long does it take to reach the other end of the needle? How do you know? What happens to the pin or nail? What happens to the wax?

You could compare different pieces of wire, all the same size and thickness, using this experiment. You could also compare pieces of the same kind of wire which are of different thicknesses. But *do not* heat plastic materials in this way.

(Expected results: The heat travels along the steel knitting needle, softens the wax at the end so that the pin or nail falls. We say that the steel knitting needle is a good *conductor* of heat.

It would be worth comparing a steel knitting needle with a piece of copper of the same size and thickness. A stopwatch would be useful for timing the period between applying the heat and the moment when the pin or needle falls.)

SAFETY PRECAUTIONS: It may be best to carry out this experiment as a demonstration conducted by the teacher, aided by members of the class. To protect the table and to reduce the risk of fire, set up the apparatus on an old metal tray.

Other suggestions for activities and experiments with metals and plastics are given in *The Young Scientist Investigates: Materials* by Terry Jennings (OUP).

Interdisciplinary activities

Art and craft

Making simple jewellery.

Model-making with metals and plastics.
Simple sculptures with expanded polystyrene.

English

Poems which mention metals.
Treasure Island by R. L. Stevenson.
Savage Gold by Roy Fuller.
The story of King Midas.

Geography

Rocks, minerals and ores.
Mining gold, silver and platinum.
Railway routes.
The steel industry.

Health and hygiene

First aid for cuts and scratches.
The 'iron lung'.

History

Life in the Stone Age, Bronze Age and Iron Age.
The Industrial Revolution.
The history of coinage.
Brass rubbing.
Industrial archaeology.
Studying hallmarks.

Mathematics

Measuring areas and volumes.
The relationship between weight and volume.
Testing the strengths of materials.
Standard weights.

Music, drama and PE

Metals and musical instruments.
Bells.

Making musical instruments from plastic bottles, yoghurt pots, and pieces of scrap metal.

Religious education and social studies

Metals and the Bible.

The decorative use of metals in churches and other religious buildings.

Unit 6: Bridges, Dams and Tunnels

Aims of the Unit

- a To demonstrate some of the problems involved in planning and building bridges, dams and tunnels.
- b To discover some structures which are strong and effective for their purpose.

Science background

The earliest type of bridge was almost certainly a *beam bridge*: logs or slabs of stone laid across a stream. In these simple beam bridges, the load on the bridge pushes down on the foundations at each end. Longer versions of the beam bridge made do with a series of vertical pillars supporting horizontal beams. The vertical pillars shared the load on the bridge with the foundations at the ends.

Big strides in bridge-building became possible when the Romans developed the *arch* as a building technique. The arch was first used in mud-brick constructions in about 4000 BC. In an arch bridge, the weight of the roadway tends to flatten the arch, and this pressure is carried by the arch to the foundations on each bank. Arches of brick or stone have to be supported on a timber framework while

they are being built, and this imposes a severe limit on the length of each span. The use of arches made of steel enabled increasingly large spans to be built. In some of these modern steel arch bridges, including the Sydney Harbour Bridge in Australia, the arch is partly above the roadway.

Beam bridges did not become obsolete with developments in arch building. *Box-girder bridges*, made of metal, are a modern form of beam bridge. In addition, the use of reinforced concrete has enabled large beam bridges to be built, particularly over motorway cuttings.

A *suspension bridge* is essentially an inverted arch, with the roadway hung from a pair of enormous curving cables supported on two towers. The bulk of the load of the bridge is carried on these cables, which are anchored to the bank. The world's longest bridges are now all suspension bridges. Suspension bridges carry road traffic or pedestrians. They are not normally suited for use by railways because the deck of the bridge is usually curved and tends to bend and sway to some extent in strong winds.

The other main type of bridge is the *cantilever bridge*. Girders are built out from the piers of the bridge, rather like shelf brackets, and then these girders are connected by a 'suspended' span supported between the cantilever arms. The distribution of the forces in the cantilever bridge is rather complicated. Basically the central, suspended span pushes down through the piers and tends to pull up the bridge at each end. The first of the great steel cantilever bridges was the Forth Railway Bridge in Scotland.

The earliest dams in the world were modest banks of soil faced with stone, and built to create a reservoir of water for irrigation or for drinking. It would be impossible to build the large modern dams without the use of reinforced concrete. In designing a large dam, the engineer has to ensure that the dam is not pushed over by the weight of water behind it, and that it does not slide bodily down the valley under the pressure of the tremendous weight of water that accumulates in the reservoir behind the dam. All large dams are constructed so that they are narrow at the top and become increasingly thicker towards their base, where the water pressure is greatest. Many dams built in rocky valleys or canyons are constructed so that, when viewed from above, they appear to be bowed like an arch. This has the effect of causing the water to push the ends of the dam into the rocky sides of the valley in which the dam is built, rather than trying to push the dam bodily down the valley.

The earliest tunnel was built before 2000 BC on the orders of a Babylonian king. The River Euphrates was diverted while his engineers built a brick-lined channel to connect the royal palace with a temple on the other side of the river. Once the channel was completed and waterproofed, the river was returned to its original course. This method of tunnel-building, known as 'cut and cover' is still used today. The Romans made extensive use of tunnels for the aqueducts they built to carry water to their towns and cities.

In the old days, tunnels were dug by hand, often with horrific loss of life. The use of explosives and modern tunnelling machines has greatly speeded up the process, although it is still dangerous. Except in the very hardest rock, tunnels usually require a lining. This is strongest and lightest if the tunnel is circular in shape. Formerly tunnels were lined with bricks, masonry, or iron or steel rings.

Nowadays, reinforced concrete sections are most often used.

Books for the children

The Young Scientist Investigates: *Structures* by Terry Jennings (OUP).

Science Workshop 2 by Irene Finch (Longman).

Starting Science: *Book 1 Working Models* by Jim Flood (Heinemann).

Science in a Topic: *Roads, Bridges and Tunnels* by Doug Kincaid and Peter S. Coles (Hulton).

The Guinness Book of Structures by John H. Stephens (Guinness Superlatives Ltd.).

Books for the teacher

Science 5/13: *Structures and Forces* (Macdonald Educational).

Materials and organisation

The construction and testing of models is an essential element of this topic. While a great deal of useful work can be carried out with cardboard and newspaper structures, the use of toy construction kits, such as Meccano or Lego, will greatly encourage the children's inventiveness.

Materials and equipment:-

- Lego, Meccano or some other toy construction kit
- pictures of famous bridges
- books or blocks of wood of equal size and thickness
- pieces of thin card or stiff paper
- stapling machine
- glue
- Sellotape
- coins or small weights
- tin lids
- drinking straws
- newspaper and wallpaper paste to make papier mâché
- 2 long pieces of rope
- a long plank
- string
- lengths of scrap wood
- 2 sets of spring weighing scales
- toy cars or lorries
- pieces of cardboard packing tube or
- washing-up liquid bottles
- pieces of stiff card about the size of postcards
- small saw or bread knife
- two bathroom scales
- identical plastic washing-up liquid bottles
- nails
- scissors
- yoghurt pots
- drawing pins
- Blu-tack
- model train set
- clay or plasticine

Bridges (pages 42–43)

Lesson objectives

- a To examine the different materials used in bridge construction.

- b To study the structure of simple bridges.
- c To test the strength of model bridges.

Setting the scene

Possible starting points include:

- 1 A visit to a road, railway or river bridge to examine its construction and use.
- 2 A display of pictures of famous bridges on the Science Table.
- 3 A model of a famous bridge, such as Tower Bridge in London or the Britannia Bridge in North Wales, displayed on the Science Table.
- 4 A study of place names containing the word 'bridge'.

New words

Parapet – the walls or upright metal supports at the sides of a bridge.

Trusses – the metal girders which form the parapets of some bridges.

Class management

A visit to study the construction and use of a local bridge or, even better, a visit to an historic or famous bridge, would greatly enhance the children's interest in this topic. The remaining work can be carried out by the children at their desks.

Safety precautions

Although the children's enthusiasm is to be encouraged, they should be warned of the dangers of making unauthorised or unaccompanied visits to railway, road or river bridges.

Answers to questions in the text

The world's first iron bridge (page 42)

The disadvantage of a bridge made of iron, rather than one made of wood, stone or brick, is that iron quickly rusts unless it is given regular treatment with paint or some other preservative. Iron, as opposed to steel, is also brittle. The advantage of iron is that it enables stronger bridges with much greater spans to be built than are possible with wood, stone or brick. Iron bridges are also lighter than those of stone or brick.

Other types of bridges (page 42)

The disadvantage of wood as a material for bridges is that it quickly rots, particularly where the wood comes into contact with water or wet ground. This rotting can be prevented by regular treatment with creosote or paint, but it is difficult to apply these preservatives regularly to the parts of the bridge which most need them. In addition, bridges made of wood are not as strong as those made of stone, brick or iron. The wooden bridge across the Teign estuary, once the longest wooden bridge in England, was destroyed by shipworm and had to be replaced.

Now try these

- 1 The river in the picture could be crossed by a suspension bridge or a cantilever bridge. The valley is too deep for a beam bridge or a series of arches. It is

important that, whatever type of bridge is chosen, the children realise the importance of the strength of the bridge's supports and foundations. Hopefully the children's drawings will also show how the road is to approach the bridge down the steep sides of the valley.

- 2 An aqueduct is a bridge which carries a canal or water pipes across a valley. Aqueducts were built and used long ago in Palestine, Greece and Egypt, but the most famous ones were those that served ancient Rome. Nowadays aqueducts are rarely built because modern large pipes are strong enough to carry water down one side of a valley and back up the other, without bursting under the pressure.
- 3 The keystone is the central stone of an arch bridge or arch. When an arch bridge or arch is being constructed of brick or stone, the curve is built up from each side, but it is not until the last stone has been fitted in the middle, that the arch can stand alone. The keystone is normally larger than those on either side of it since it has to bear much of the weight of the two halves of the bridge or arch. Some keystones on more recent arch bridges are purely decorative, since the bridge gets its strength from reinforced concrete or some other method of construction.
- 4 Bridges are often made of metal tubes, because these hollow cylinders are strong but light. For the same reason, the long bones of the body are hollow cylinders, and so is the scaffolding used by builders.

Expected results of activities and experiments

Testing model bridges (page 43)

The model bridge is stronger when the gap between the books or blocks is narrower.

The bridge will be stronger when the two sheets of card or paper are glued or stapled together, since this prevents them from bending separately.

It will be found that the model bridges consisting of cylinders, and those supported by arch shapes and roof shapes, are much stronger than those consisting simply of two flat sheets of card. Exactly which of the three types is the stronger will depend upon the method of fixing the two pieces of card used in each bridge.

Extending the learning

- 1 Carry out a survey of the bridges in the vicinity of the school. What types of bridges are they? What materials were used in their construction? What is the purpose of each bridge? When was each bridge built? What kinds of traffic use each bridge? Are the bridges adequate for today's traffic? Have any of the bridges been widened, strengthened, or otherwise altered? It may be possible to carry out a traffic survey of the number and types of vehicles using one or more of the bridges throughout the day. Make models of some of the more interesting local bridges.
- 2 Take two sheets of thin card. Place one across the gap between two books, and see what weight it will support. Leave the two books in exactly the same position. Carefully fold the second sheet of thin card lengthwise into four equal-sized strips. Use Sellotape to fix the edges of the card so that it forms a box girder. Place this between the two books, and test it to see what weight it will support. Remember that both bridges contain the

same amount of card. (The box girder arrangement will be found to be much stronger.)

More bridges (pages 44–45)

Lesson objectives

- a To demonstrate the structure and functions of arches in bridges.
- b To examine the structure of cantilever and suspension bridges.

Setting the scene

Possible starting points include:

- 1 A survey of local bridges.
- 2 Examining the use of arches in bridges, churches and other buildings.
- 3 Look up the statistics for record-breaking bridges in the Guinness Book of Records.

New words

Keystone – the central stone of an arch or arch bridge.

Cantilever – one of the large girders which sticks out from a river bank and on which a bridge is laid.

Class management

If the model suspension bridge is made, this should be done in the garden or on the playing field where the ground is soft. Apart from any visits to bridges, the remainder of the introductory work on this topic can be carried out in the classroom.

Safety precautions

Care is necessary to avoid injury from falling bricks or planks if the strengths of large model bridges are tested.

Answers to questions in the text

Arch bridges (page 44)

The part of the bridge which stands in the water, technically known as the pier, is boat-shaped so that the water flows past it easily. This reduces the force with which the water might otherwise push against the bridge when the river is in flood.

Wooden strips are a good material to use for the footway across a steep arch bridge such as the one in the picture, because it is easier for shoes to grip on them in wet weather.

The weight of the footbridge tends to press downwards and outwards, tending to try and flatten the arch. That is why there are substantial concrete foundations on the banks at either end of the bridge.

Suspension bridges (page 45)

The cables on a suspension bridge sag because of their enormous weight. This sagging has the advantage that it reduces the lengths of the hangers needed to support the deck of the bridge, and it also allows the cables to contract in cold weather and expand in hot weather without breaking.

Now try these

- 3 The children will find that at first the weight of the toy car or lorry is taken largely by one of the supporting weighing scales, then as the car or lorry reaches the centre of the bridge, the weight is shared by the two sets of scales. Finally, as the vehicle reaches the other side of the bridge, most of its weight is supported by the scales directly underneath it.

Expected results of activities and experiments

A model suspension bridge (page 45)

As mentioned under the heading 'Safety precautions', the testing of large model bridges should be carried out on a lawn or playing field where the ground is soft.

It is possible to use two pairs of old chairs, each pair placed back to back, as the supporting towers for a model suspension bridge.

Extending the learning

- 1 *A model cantilever bridge* A model cantilever bridge can be made using two pieces of cardboard packing tube about 20 cm long, or two clean washing-up liquid bottles, for the towers. Use three pieces of stiff card, about the size of postcards, for the two cantilever arms and the central span. Cut slots with a saw or a bread knife in the two towers, about 15 cm from the base. Glue a piece of card into each of these slots. Glue the central span in place so that it overlaps the two cantilever arms equally.
Ask the children how they can strengthen the bridge so that it will take greater weights. (By reinforcing the two cantilever arms.) What can they do to prevent the towers from toppling over? (Put ballast, in the form of sand or soil inside the towers to give them greater weight.)
- 2 *Which shape of arch is the strongest?* Two equal sized heavy blocks of wood or books are needed for this experiment. Cut some strips of thin card 40 cm × 10 cm to use as arches. Place the blocks of wood 7 cm apart, and bend one of the strips of card between them so as to form a very high and steep arch. Carefully balance a tin lid on top of the arch, and add small weights to it until the arch collapses. Record the height and width of the bridge, and the weight needed to make it collapse. Now move the blocks or bricks 10 cm apart and repeat the experiment with a new piece of card. What weight is needed to make this wider and lower arch collapse? Repeat the experiment with progressively wider and lower arches. What is the best shape for an arch? Which of the arches is strongest?
- 3 *Crossing a bridge* If two bathroom scales are available, the experiment described in No. 3 of *Now Try These* can be repeated on a larger scale. Stand the scales some distance apart on a level floor, and rest a plank of wood on both of them. If possible, set both scales to zero, once the plank is resting on them. Ask two children to act as recorders and to note down the readings on each of the scales as a third child slowly walks across the plank 'bridge'.

Dams and tunnels (pages 46–47)

Lesson objectives

- a To examine the problems involved in the construction of a dam.
- b To study the functions of tunnels and the methods used in their construction.

Setting the scene

Possible starting points include:

- 1 Pictures of dams or tunnels displayed on the Science Table.
- 2 A trip on an underground railway or a visit to a dam.
- 3 Films or television programmes about famous dams, eg. the Aswan, Kariba, and Tennessee Valley dams.
- 4 Dams and our water supply.

New words

Dam – a large, thick wall built across a valley where there is a river or stream. The water is held back by the dam and forms a reservoir.

Reservoir – a big man-made lake in which water for drinking, making electricity or watering crops is stored.

Class management

Apart from a visit to a dam or an underground railway, all of the other work on this topic can be carried out in the classroom. The activity on water pressure and depth should be carried out over or in a sink.

Safety precautions

The children should be warned not to make tunnels in sand or soil which are large enough for them to crawl into, because of the very real danger that the tunnel may collapse and suffocate them.

Now try these

- 1 Dams have to be strong because of the tremendous weights of water they hold back. The 242 metres high Sayano-Shusenskaya Dam on the River Yenisey in the Soviet Union, for example, is designed to withstand a load of 18,000,000 tonnes of water. Large dams are made either of reinforced concrete, broken rock, or a combination of the two.
- 2 Small tunnels (conduits) are used for carrying drainage water, sewage, and electricity cables. In some places small tunnels are constructed under motorways to enable badgers to cross in safety.
- 5 The earliest part of the underground railway in London was the section between Paddington and Farringdon, which was opened in 1863, and is now part of the Circle Line. This, and other early sections, were built just below the surface of the streets by digging a cutting and afterwards covering the top over, so that the space above could again be used for streets and buildings. Later, tunnels were bored through the ground at deeper

levels using a circular tunnelling machine. This had the advantage that it was cheaper and did not disrupt traffic on the surface. The earliest underground trains were pulled by steam locomotives.

Other cities with underground railway systems include Glasgow, Newcastle, and Liverpool, while abroad, Athens, Barcelona, Berlin, Boston, Brussels, Budapest, Copenhagen, Hamburg, Kiev, Leningrad, Lisbon, Milan, Moscow, New York, Oslo, Paris, Philadelphia, Rome, Sydney, Stockholm, Vienna and Warsaw all have underground railways.

Expected results of activities and experiments

Why is the wall of a dam thickest at the bottom? (page 46)

With the holes all the same distance from the bottom of the bottle, the jets of water will all be the same length.

With the holes in a row down the side of the bottle, the longest jet of water will come from the hole nearest the bottom of the bottle, and the shortest jet of water will come from the hole nearest the top of the bottle.

The wall of the dam needs to be thickest at the bottom because that is where the greatest pressure of water is.

How strong are different tunnels? (page 47)

Normally it is the tunnel which is circular or oval in section which is found to support the greatest weight. Indeed most real tunnels are circular or horse-shoe shaped in section.

Extending the learning

- 1 Show the children a photograph of the Dartford Tunnel in Kent, the Simplon Tunnel under the Alps between Switzerland and Italy, the Mont Blanc Tunnel between France and Italy, or some other well-known tunnel. Encourage them to make a model of a short section of one of these tunnels using card and papier mâché. The model can be painted and made to look more realistic by placing toy cars and lorries in it.
- 2 The safety problems involved in the use of railway tunnels can be demonstrated if a model tunnel, made from papier mâché or cardboard, is used in conjunction with a model train set. The children will be able to see at first-hand, the problems of signalling, ventilation, and the need for escape procedures for passengers in the case of fire or derailment.
- 3 Use clay or plasticine to build a small model valley with a dam and reservoir in it.

Checking (pages 48–49)

Thinking

- 1 Suspension bridges normally carry roadways or footpaths but not railways. This is because their decks are not sufficiently rigid, and are often curved. In strong winds the structure of the bridge may sway or twist slightly, and this would cause railway tracks to break up.
- 2 In hot weather the roadway of a bridge expands. To compensate for this, gaps are left between the sections of it. These close up in hot weather and open in cold weather. All bridges are slightly longer in hot weather, and slightly shorter in cold weather, as they expand and contract.

Other objects which expand noticeably on a hot summer's day are telephone wires (see page 40 of Course Book 2).

- 3 The roadway of the Severn Bridge is streamlined when seen in section, so that the wind flows over the deck with the least resistance.

Models of these two shapes of roadways could be made from cardboard and string and tested using a fan, or a vacuum cleaner set to 'blow'. This experiment could in turn lead on to an investigation of streamlining in motor vehicles, aircraft, trains etc.

- 4 When a tunnel is being planned or built, the following precautions have to be taken:
- a Air supply: On some tunnels shafts are sunk from the surface at intervals along the route of the tunnel. These help in ventilation. Long road and railway tunnels often have huge fans to circulate fresh air and to disperse the traffic fumes.
 - b Light: It takes time for the eyes to become accustomed to the change from bright daylight to artificial light. The lights at the entrance to a tunnel have to vary in intensity so that they match the daylight outside.
 - c Drainage of water: A tunnel has to be watertight, and drainage has to be provided for rainwater which may flow into the entrances.
 - d Breakdowns and accidents: In most modern tunnels closed-circuit television cameras are situated along the tunnel so that, in the event of an accident or breakdown, further entry to the tunnel can be halted to allow the emergency vehicles to reach the scene of the incident.
 - e Fire: As well as the closed-circuit television mentioned above, fire-fighting equipment is situated at close intervals along a tunnel.
- 5 One of the main additional problems for traffic if a road tunnel was dug under the English Channel, between England and France, would be the need for vehicles to change from one side of the road to the other. Some kind of cross-over or flyover would be necessary for traffic to ensure that vehicles entering France were on the right-hand side of the road, while vehicles arriving in England would have to be on the left-hand side of the road.
- 6 The television mast is not made of solid metal since this would increase its weight and also mean that the wind would exert a great force against its whole length. The metal lattice-work allows the wind to pass through the mast. The guy-ropes take the strain of the mast in all directions, effectively giving the mast a large foundation, without increasing its weight or the wind resistance to any significant extent.

The lighthouse is a rounded shape so that the waves sweep round it with the minimum of pressure. (Test the effectiveness of model lighthouses that are round and square in section when water is thrown at them in a bowl or sink.)

Doing

- 1 A ford is a shallow place where a river can be crossed by wading. Many early towns were established where rivers could easily be crossed either by bridges or by a ford.

Place names containing the word 'bridge' include: Ironbridge, Cambridge, Stourbridge, Devil's Bridge, Bridgewater, Ferrybridge, Fordingbridge and Coatbridge.

Place-names containing the word 'ford' include: Oxford, Stamford, Burford, Bradford, Bedford, Brockford, Castleford, Brentford, Winsford, Woodford, Fordingbridge, Eggesford, Shefford, Bishop's Stortford, Dartford and Stafford.

- 4 The longest road tunnel in Britain is the Mersey Tunnel, linking Liverpool and Birkenhead. Including branch tunnels it is 4.62 kilometres long. The longest main-line railway tunnel is the Severn Tunnel linking the counties of Avon and Gwent. It is 6 kilometres long.
- 5
- a The first bridge was probably a *tree* which had fallen across a stream.
 - b Wood is not a good material for a bridge because it soon *rots*.
 - c A *parapet* is the name given to one of the uprights on either side of a bridge.
 - d The *keystone* in the centre of an arch bridge is usually larger than the others.
 - e Modern steel arch bridges usually have the road or railway suspended *under* the arch.
 - f Cantilevers act like enormous shelf *brackets*.
 - g The main parts of a suspension bridge are a pair of *towers*.
 - h Each cable of a suspension bridge is made of a large number of *wire* strands spun together.
 - i A *dam* is a large thick wall built across a valley where there is a river or a stream.
 - j The deeper you go down in water, the greater the *pressure*.

Going further – some other suggestions

- 1 Investigate the burrowing habits of moles, rabbits, badgers, ants and other animal burrowers and tunnellers. Collect pictures of the burrows of these animals.
- 2 Find out more about beavers and dam-building.
- 3 Investigate the structure of towers, cranes and oil drilling-rigs. Use Lego, Meccano or some other model construction kit to make models of these structures.
- 4 Investigate the structure of roads and cranes. Some activities and experiments are suggested in *The Young Scientist Investigates: Structures* by Terry Jennings (OUP).

Interdisciplinary activities

Art and craft

Model-making.

Landscape layouts for model trains or roadways.

Collages and thread pictures of bridges.

Paper sculpture.

English

Chesterton: *The Rolling English Road*.

The House at Pooh Corner by A. A. Milne.

Poems which mention bridges eg. those by William McGonagall.

Far out on the Long Canal by Meindert DeJong.
Swallows and Amazons by Arthur Ransome.
We didn't mean to go to Sea by Arthur Ransome.
The Blue Nile by Alan Moorehead (children's edition).
The Story of Brunel by L. T. C. Rolt.

Geography

Natural barriers to transport.
Maps, map-reading and routes.
Irrigation, hydro-electricity and the world's great dams.
Britain's railways and motorway networks.
The Channel Tunnel – past, present and future.
The Young Geographer Investigates: *Rivers* by Terry

Jennings (OUP).

The Young Geographer Investigates: *Mountains* by Terry Jennings (OUP).

Health and hygiene

Road safety.
The domestic water and sewage systems.

History

General Wade, Isambard Kingdom Brunel, Abraham Darby, Thomas Telford.

The Tay Bridge Disaster.
The origins of place names.
Roman roads, bridges and aqueducts.
The history of the London Underground system.
A canal study.
Brunel and the Great Western Railway.
Bessemer and steel.

Mathematics

Elementary surveying – measuring slopes and levels.
Calculating the scales of models.
Measuring or estimating heights, lengths and spans.
Simple geometry.
Metal bridges and tessellation.

Music, drama and PE

'London Bridge is falling down'.
'Under the bridges of Paris'.
'Sur le pont d'Avignon'.

Religious education and social studies

Pilgrimages to holy places.
Pilgrim's Progress by John Bunyan.
The Crusades.
The journeys of the Israelites.

In scientific terms, work is defined as a force multiplied by the distance through which it moves. If we carry a heavy shopping bag up two equal flights of stairs, we do twice as much work as if we stopped on the landing after the first flight of stairs. To provide the force to do this requires energy: when we lift something the energy comes from the food we eat which enables our muscles to do the work. In the world around us, most work is done by machines whose energy comes from fossil fuels such as coal, oil or natural gas. Other sources of energy include the wind, moving water in rivers and estuaries, the rise and fall of the tides and, most controversial of all, nuclear energy.

Mechanical energy exists in two basic forms: potential or stored energy, and kinetic energy which is the energy of movement. Potential energy is the energy of position. The suitcase carried up two flights of stairs has twice the potential energy of the suitcase carried up to the first floor only. This can be seen if the suitcase is dropped over the bannister from each of the two positions in turn. When a clock is wound, energy is stored in the spring. When this potential energy is released, it becomes kinetic energy as the clockwork mechanism turns. The gunpowder in a rocket or some other firework contains potential energy, and when it is lit the hot gases produced by the burning gunpowder push the rocket skywards.

Since work is defined as a force multiplied by the distance through which it moves, the same amount of work can be done slowly or quickly. A bicycle pedalled 20 kilometres in an hour does exactly the same amount of work as the bicycle pedalled 20 kilometres in two hours. However, to do the work more quickly uses more power or energy, and the cyclist who has travelled quickly may feel much more weary than his more leisurely counterpart.

Energy can exist in various other forms. The energy to move a car comes from the petrol in its fuel tank. When the fuel tank is empty, the car comes to a halt. The petrol is a form of potential energy, or chemical energy. When the fuel burns inside the engine, the chemical energy is converted into heat, another form of energy. The heat makes the gases in one of the cylinders of the engine expand, and in doing so it pushes down the piston. This is an example of the conversion of heat energy into mechanical energy, and it is mechanical energy which is required to drive the wheels of the car.

The energy stored in our food is also chemical energy, and this energy is released when the food combines with oxygen in our muscles. One of our most convenient forms of energy is electrical energy. From electrical energy we can obtain heat, cold, light, movement, sound and other forms of energy.

Energy cannot be created or destroyed. It can only be converted from one form to another. We can use these conversions to change energy into a more useful form, as for example when we burn coal to convert chemical energy into heat, or to use the kinetic energy of the wind, as captured by a windmill, to produce electricity which can be used to light and heat a building. Unfortunately these conversions are never 100 per cent efficient. Whenever we change energy from one form into another, we also produce heat, which is frequently unwanted. Only about 28 per cent of the energy in petrol, for example, is converted to movement, the remainder of the energy in the petrol is wasted as heat. This energy loss can be reduced by using more efficient engines. In diesel engines only 60 per cent of the energy is wasted as heat. In an ordinary electric light bulb, only 10 per cent of the

Unit 7: Energy and Movement

Aims of the Unit

- a To describe examples of work and the use of energy.
- b To show that energy can be stored and later used in a different form.
- c To show that most of our energy comes directly or indirectly from the sun.
- d To describe the action of fuels as stores of chemical energy.

Science background

Physical work involves moving something from one place to another. This entails overcoming some force or resistance, such as the force of gravity when throwing a ball in the air or the friction of the water when swimming.

electrical energy is used to produce light, the rest is wasted as heat. Fluorescent light tubes are much more efficient, and only 60 per cent of their electrical energy is wasted as heat.

About 99 per cent of the Earth's energy resources come from the sun. The remaining 1 per cent of the Earth's energy comes from three main sources: radioactive materials such as uranium or plutonium, geothermal energy obtained from hot rocks deep in the Earth's crust, and tidal energy caused by the pull of the moon and sun on the oceans.

Books for the children

The Young Scientist Investigates series: *Energy*, *Heat*, *Light and Colour*, and *Food* by Terry Jennings (OUP).
Science in a Topic: *Moving on Land* by Doug Kincaid and Peter S. Coles (Hulton).

All About Earth: *Energy at Work* by John Satchwell (Methuen/Walker).

Books for the teacher

Experiencing Energy: *Book 1 Moving Things*, *Book 2 Burning, Warmth and Sunlight*, *Book 3 Working with Electricity* (Association for Science Education).
Science 5/13: *Change* (Macdonald Educational).
Science 5/13: *Science from Toys* (Macdonald Educational).

Materials and organisation

This is another topic which provides plenty of opportunities for the children to make simple working models and also to carry out worthwhile investigations using mechanical toys.

Materials and equipment:-

cotton reels
rubber bands
paper clips
clean lollipop sticks
thin slices of candle with the wick removed
rulers or tape measures
sharp knife
stiff card
scissors
short pieces of pencil
forked twigs
elastic
small polystyrene balls
magnets
squares of coloured paper
thin nails
large-headed pins or drawing pins
drinking straws
thin sticks about 30 cm long
thermometers
plastic bottles
aluminium foil
short knitting needles
glue
corks
wire
clock or watch with a second hand
balloons
Sellotape

thread or fishing line
skate boards or roller skates
bricks or heavy weights
hair-drier
milk cartons or small washing-powder packets
string
small blocks of wood
long nails

Doing work and using energy

(pages 50–51)

Lesson objectives

- a To show that work involves pushes and pulls.
- b To demonstrate that energy can be stored.

Setting the scene

Possible starting points include:

- 1 Demonstrate a clockwork toy and ask the children where the energy to propel it comes from.
- 2 Make a display of pictures showing people and machines doing work and using energy.
- 3 A discussion during or after a PE or games lesson as to where the energy comes from that enables the children to carry out the various activities.

New words

Work – moving an object using pushes and pulls.

Class management

All of the work on this topic can be carried out by the children at their desks.

Safety precautions

Care is necessary if the children cut notches in the edges of the cotton reel when making the cotton reel tank. This is much easier to do with the older wooden cotton reels than with the modern plastic ones. If one is available, it is much safer to grip the cotton reel in a vice while cutting it.

Answers to questions in the text

Doing work and using energy (page 50)

The sprinter in the picture is pushing against the ground to enable him to run fast. The energy comes from the food being used up in his muscles.

The wheels of the racing car are pushing against the ground to make the car go forwards. The energy comes from the petrol being burned in the car's engine.

The wheels of the lorry are also pushing against the ground to make the lorry go forwards. The energy comes from the oil being burned in the lorry's engine.

The wheels of the electric train are pushing against the tracks to make it go forwards. The energy comes from the electricity which drives the electric motors in the locomotive.

The oxen are pulling the plough. The energy comes from the food being used up in the oxen's muscles.

The jet aircraft is being pushed through the air by the hot gases coming from the rear of the aircraft's engines.

The energy comes from the kerosene (paraffin) being burned in the aircraft's engines.

The boy is pushing down on the pedals of his bicycle. This makes the rear wheels of the bicycle turn, pushing against the road so that the bicycle moves forwards. The energy comes from the food being used up in the boy's muscles.

The energy to work the refrigerator, the light, and the television comes from electricity.

The energy to work the fire comes from the coal or other solid fuel which it is burning.

The energy to work the trumpet comes from the man's food. Some of this is used up by the muscles in the man's chest which help him to blow into the trumpet.

The energy for the firework display comes from the burning up of the gunpowder and other chemicals in the fireworks.

Energy can be stored (pages 50–51)

Caroline could show that her marble has stored energy simply by letting the marble go. The marble will then roll down the plank. The energy stored in the marble came from Caroline's muscles when she lifted it up to the top of the plank.

Now try these

- 1 When you rub your hands together, they soon feel warmer. This is because the friction of the hands being rubbed together produces heat. Some of the energy of movement is being changed to heat energy.
- 2 Most of the machines in a modern kitchen use electrical energy, including the washing machine, refrigerator, waste-disposal unit, microwave oven, deep-freeze, and food mixer, liquidiser or blender. Even the carving knife may be electrically powered. The refrigerator is sometimes powered by gas, while the cooker may be powered by electricity, oil, gas or solid fuel. Hand mixers and some tin-openers and mincing machines still use the energy produced in human muscles to power them while others are electrically operated.
- 3 Our earliest ancestors cooked their food and heated and lit their homes with the aid of wood, charcoal or peat fires. Later, torches were made which burned animal fat to produce light. The early forms of travel on land involved either walking or using energy from the muscles of horses, asses or other domestic livestock. Primitive rafts, canoes or coracle-like craft were used for transport on water.
- 4 The main reason there are not more electric vehicles on the roads is because they have the disadvantages of low speed and a very limited range. They also need to carry large numbers of heavy batteries in which the electricity is stored. These vehicles have the big advantages that they are quiet, relatively inexpensive to run, and they do not pollute the air.
- 5 The ways in which energy can be stored include: batteries (electricity); in hot liquids kept in vacuum flasks; in hot water storage tanks; in chemical fuels; in manufactured foods; in springs (clocks and clockwork toys). Energy can also be stored by raising objects above the ground. If an object is lifted to a greater height, energy is used in raising it. However the object now has potential (stored) energy, because it is now able to do work when it descends again. If water is stored in a reservoir behind a high dam on a hill, the

water possesses potential energy. This can be used by leading some of the water out through a pipe and letting it turn a turbine coupled to a generator, so producing electricity. Some hydro-electric power stations actually use electric pumps to pump water up to a high reservoir at night (when the need for electricity by towns and cities is less), and then letting the water come down again in the daytime, producing hydro-electric power when the demand for electricity is at its peak.

Expected results of activities and experiments

Make a cotton reel tank (page 51)

The tank is usually found to work better when notches are cut into the edges of the cotton reel, since these enable the cotton reel to grip the floor and other surfaces better, ie. the notches increase the friction between the cotton reel and the floor.

It is interesting to compare two cotton reel tanks which are identical in every way except that one lacks the disc of candle wax. This latter tank will be found to work less efficiently because of the greater friction created as the rubber band unwinds, ie. the candle wax acts as a lubricant, reducing the friction as the rubber band unwinds.

Another extension of this experiment would be to measure how far a tank will go on different surfaces, such as a carpet, a piece of rough wood and a smooth floor, when it is wound up the same number of times.

Extending the learning

- 1 *Make spinning tops* The children can use a compass to draw a circle 7 or 8 cm in diameter on a piece of stiff card. They can then cut out the circle and colour it. A short piece of pencil is pushed through the centre of the card, and the top is spun. Ask the children what colours they see as the top spins. Where does the energy come from which makes the top spin? (From their muscles which perform the twisting movement with their fingers.) What makes the top stop spinning? (The friction between the top and the surface it is turning on.)
- 2 *A catapult* Make a small catapult from a forked twig and a piece of elastic tied to the top of each arm of the Y-shape of the twig. Let the children take it in turns to use the catapult to fire a small polystyrene ball. Ask them to notice what pushes and pulls are involved, and where the energy comes from. (The elastic is stretched as it and the polystyrene ball are pulled back. When the elastic and ball are released, the elastic returns to its original length, pushing the ball forwards. There are obvious dangers involved in using a catapult, and the children should be warned not to fire one at another child, and not to use a catapult outside of the classroom.)
- 3 Study the pushes and pulls involved in the use of magnets. Some activities and experiments are described in *The Young Scientist Investigates: Electricity and Magnetism* by Terry Jennings (OUP).

Energy from the sun (pages 52–53)

Lesson objectives

- a To demonstrate that the energy we obtain from our food came originally from the sun.

- b To show that most of the other energy we use comes directly or indirectly from the sun.

Setting the scene

Possible starting points include:

- 1 Letting the sun evaporate the water from a saucer and discussing where the water has gone and where the energy comes from.
- 2 A visit to a windmill or watermill, and asking the children where the energy to drive the mill comes from.
- 3 Using a magnifying glass to focus the sun's rays on to a sheet of paper to demonstrate the heating (and burning) power of the sun.

New words

None.

Class management

Most of the work on this topic can be carried out by the children in the classroom. If, however, they make windmills, they will undoubtedly want to test these on the playground or playing field right away.

Safety precautions

None.

Answers to questions in the text

Energy from the sun (page 52)

The two main kinds of energy illustrated in the picture are light and heat, both from the sun.

The energy in bread comes from the flour the bread was made from. This in turn came from wheat grains which grew on wheat plants. These wheat plants obtained their energy for living and growing from the sun. As a result, the energy in the bread came, indirectly, from the sun.

Energy and our bodies (page 52)

Any physical activity, such as running, jumping, skipping, climbing, swimming and digging, uses a lot of energy. We can tell when we have used a lot of energy because we feel tired, and our muscles may ache from the exertion.

Now try these

- 1 The temperature of water left in a plastic bottle on a sunny windowsill will normally rise during the course of an hour or two. The rise in temperature will be least if a white bottle is used, and most if the bottle is painted black or some other dark colour. The children could go on to investigate the efficiency of different coloured bottles of water in absorbing the sun's heat.
- 2 In hot countries people generally wear white or light-coloured clothing which fits loosely. This is so that the material reflects the sun's rays while at the same time enabling heat to escape from the body, thus keeping it cool. In colder climates, clothes are closer fitting, darker coloured and made of thicker materials such as wool or even fur. This is so that the clothes absorb the sun's rays, and also trap layers of air around the body. These layers of air act as an insulator, keeping the body's heat in.

- 3 It is usually hotter inside the classroom than outside because, a) there is less movement of the air, b) because in cold weather the radiators or some other form of artificial heating may be in use, c) because of the heat produced by the bodies of the occupants of the classroom, and d) because the classroom is built of materials which have good insulating properties, so keeping heat in.
- 5 Windmills and watermills are not used much nowadays because their energy supply is not consistent, but is dependent largely upon the vagaries of the weather. In addition, there are only a limited number of suitable sites where windmills and watermills could be built, and in many of these it is likely that people would object to an attractive view being spoilt by a large obtrusive building.

Expected results of activities and experiments

Make a windmill (page 53)

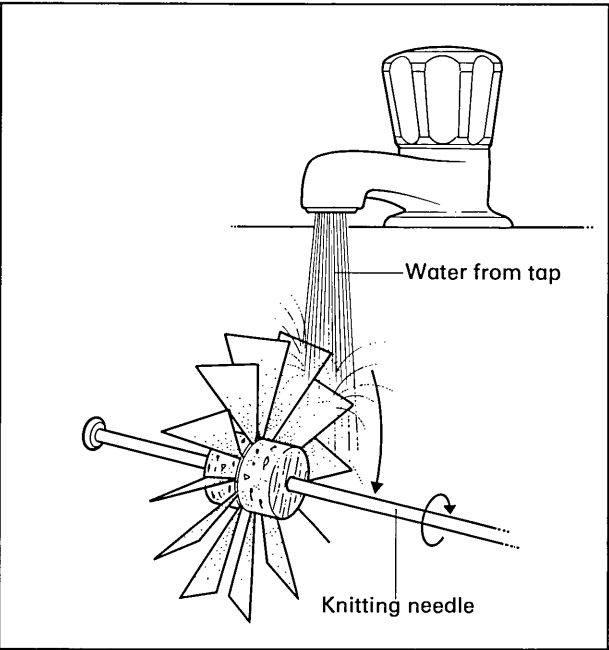
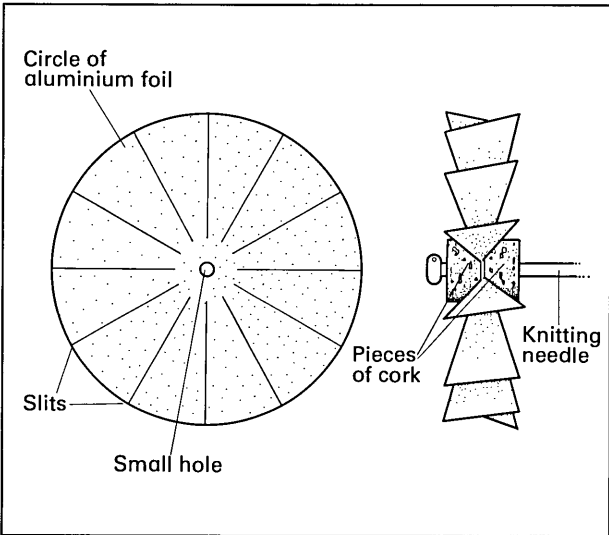
The faster the children run with their windmills, the faster the windmills will go round. This is because the air is moving past the blades of the windmill faster (ie. there is more 'wind').

If several children run at the same speed, the windmills will go round at the same speed if they are all exactly the same size and made in exactly the same way.

It is not possible to predict which windmill goes round fastest, the largest or the smallest. In theory, the larger windmill will catch the wind more. However, large windmills are also heavier, and it takes a proportionately greater amount of wind to turn them. The optimum size for a windmill is probably somewhere in between the two extremes.

Extending the learning

- 1 *Make a water wheel* This simple model demonstrates the principles behind a water wheel in a watermill, or a turbine in a hydro-electric power station.
Cut a circle from aluminium foil. The tops of some coffee, cocoa and drinking chocolate tins have suitable discs of foil at the top.
Make a small hole in the centre of the circle of foil. Then use an old pair of scissors to cut slits towards the centre of the circle. Twist the pieces of foil between the cuts to make the water wheel. Twist the blades so that they all face in the same direction. (See next page.)
Carefully push a short knitting needle through the hole in the middle of the water wheel. Glue a small circle of cork on either side of the foil to hold it in position. Support the wheel on a bent piece of wire, making sure that the wheel turns freely.
Turn on the cold water tap so that the water runs in a *thin* stream. Hold the water wheel so that the water just catches the blades, when the water wheel will turn.
- 2 *What changes take place when you use more energy?*
What you need: A clock or watch with a second hand; a friend to help you.
What you do: Sit quietly on a chair and ask your friend to count how many times you breathe in a minute. It is best to do this three times and find the average.
Then find out how many breaths you take in a minute after you have:
a been standing for five minutes;



- b walked quickly around the playground;
 - c run around the playground;
 - d jumped up and down for a few minutes.
- Have a good rest between each of these exercises.
Show your results in a table like this:

Number of breaths per minute					
	When sitting	After standing	After walking quickly	After running	After jumping up and down
1	22				
2	20				
3	18				
Average 20					

What do you notice about the number of times you breathe each minute after you have carried out these exercises? When do you breathe the fastest? When do you breathe the slowest?

What can you say about energy and the number of times you breathe in a minute? What is the air you breathe used for?
SAFETY PRECAUTION: Extreme care is necessary to ensure that children who are delicate or in some other way unfit do not exert themselves unduly. (Expected results: The actual breathing rates are subject to individual differences. However, the more vigorous the activity, the more energy is used and the faster the rate of breathing.
Oxygen in the air which is breathed into the lungs, passes into the bloodstream which carries it to all parts of the body. Some of the oxygen is used to combine with ('burn') food in the muscles to produce energy. The more energy we use, the faster we breathe to use up the food to produce energy.)
Further activities and experiments concerned with energy will be found in *The Young Scientist Investigates: Energy* by Terry Jennings (OUP).

Fuels (pages 54–55)

Lesson objectives

- a To show that fuels burn to produce energy.
- b To show how engines use fuels to produce the energy for movement.
- c To explain that, although it is not possible to make energy, it is possible to change one kind of energy into another.

Setting the scene

- Possible starting points include:
- 1 Painting a picture of a bonfire.
 - 2 A barbecue with a charcoal fire.
 - 3 A demonstration of a toy steam engine or a model aircraft engine.

New words

Fuel – any material which will burn and produce energy.

Class management

All of the work on this topic can be carried out by the children in the classroom. The understanding of the work would be enhanced, however, if the children could be shown the engine of a car, lorry or some other motor vehicle.

Safety precautions

If the children are shown how beads bounce around inside a saucepan of boiling water, ideally this should be done in one of the modern glass saucepans. The children should be warned not to carry out this activity without permission, and then only if an adult is present.

Answers to questions in the text

Engines (page 55)
It should be pointed out to the children that the account given here of how a car, lorry and jet engine work is very

much simplified. All of these engines operate by the expansion of gases, and the energy to produce the expansion comes from burning a fuel. In a petrol engine, for example, a mixture of petrol vapour and air are compressed in one of the cylinders, and then exploded by means of an electric spark. The resulting expanding, high pressure gases force the piston down inside the cylinder.

Different kinds of energy (page 55)

In the picture, the kinds of energy being used are electrical energy to detonate the explosives; chemical energy in the explosives and the fuel for the lorry, and food energy in the muscles of the people and of the cat. The man falling off the ladder is very affected by gravity.

Now try these

- 2 Vehicles driven by steam are no longer common because they are inefficient in their use of fuel. There are large losses of heat between burning the fuel and using the steam, and these losses are considerably greater than in a petrol or diesel engine. As a result a steam engine uses more fuel than a petrol or diesel engine of the same power. In addition, if the fuel used is coal, this is dirty to handle. However, before World War 1, buses driven by steam engines ran in London, and these were notable for their quietness.
- 3 A sheet of paper held by one edge over a hot radiator will move up and down. This is because the hot radiator warms the air above it, and the lighter warm air rises, making the paper move. Cooler air moves in to take the place of the air which has risen.
- 4 When an inflated balloon is released it will travel erratically across the room. Air rushing from the nozzle of the balloon pushes the balloon forwards. The balloon can be made to travel in a straight line if it is partially inflated, fixed to a drinking straw on a taut thread, and then fully inflated and released. This experiment is described in detail below.
- 5 Most modern oil wells are made by boring with a revolving bit, which is a giant-sized version of the ones used by a carpenter to drill holes. The bit is fixed to lengths of drill-pipe suspended from a tall tower called a derrick. As the hole deepens, fresh lengths of drill-pipe are added. The derrick may be located on land, or situated on a floating or fixed rig for drilling for undersea oil.

Teachers can usually obtain posters, booklets, films and other information about oil exploration and drilling, by writing to one of the major oil companies, some of whose addresses are listed on page 127 of this book.

Extending the learning

1 Make a balloon rocket

What you need: A balloon; Sellotape; a drinking straw; a length of thread or fishing line.

What you do: Pass one end of the thread through a drinking straw. Tie the thread tightly across the room.

Cut two strips of Sellotape. Blow a little air into the balloon and Sellotape it to the straw.

Blow some more air into the balloon. Squeeze the end to stop the air coming out, or use a bulldog clip.

Now let the balloon go.

What pushes the balloon along? Where does the energy come from? How far does the balloon travel? Does it travel as far as it did when it was not on the thread? Why is this?

In what ways is the balloon rocket similar to a real rocket? In what ways is it different?

Can you fix a balloon to a toy car or lorry and make it go along?

(Expected results: The balloon goes along the taut thread because the air rushing out of it under pressure pushes it in the opposite direction. The energy comes from the child's mouth and muscles which were used to force air into the balloon under pressure, causing the balloon to stretch. It is almost impossible to measure how far the balloon travels when it is not on the thread because of the erratic course it follows. However, the balloon will travel a shorter distance when it is on the thread because of the friction between the drinking straw and the thread.)

Apart from size, the major difference between the balloon rocket and a real rocket is that cold air rushes out of the balloon rocket, pushing it along, while hot gases come from the real rocket, pushing it along.)

- 2 Let the children experiment with a skate board or a roller skate by letting it run down a slope. Measure how far the skate board or skate travels. Repeat the experiment by fixing progressively increased loads (eg. bricks) to the skate board or skate and seeing how far it travels down the same slope. Is it more or less than before? (Less.)
- 3 Experiment with model parachutes and paper darts. Details are given on page 25 of *The Young Scientist Investigates: Air* by Terry Jennings (OUP).

Checking (pages 56–57)

Thinking

- 1 The kind of energy we use the most is probably chemical energy. We use the chemical energy in coal, oil, petrol and natural gas, sometimes directly, sometimes to make electricity, and we also use the chemical energy in our food.

The kinds of energy we do not use very much at present include wind-power and wave-power and the tremendous amounts of energy inside the atoms of which matter is made (nuclear energy).

- 2 There are *no* straightforward answers to these questions, if all the *forms* of energy are taken into account. If only the people in the pictures are referred to, then the children watching television are using less energy than the children playing chess. However the television set is using electrical energy. The motor cyclist is using less energy than the pedal cyclist, but at the same time the motor cycle is burning precious fossil fuels. The person in the sailing dinghy is not only using less energy than his counterpart in the motor boat, but the sailing dinghy is also using the unlimited supply of energy in the wind while the motor boat is helping to use up the world's rapidly diminishing supplies of oil or petrol. Similar problems arise in the comparison of the children playing tennis and those in the heated swimming pool. If the swimming pool is heated with the aid of solar panels then it is having a lesser impact on

our world energy supplies than one which is heated using electricity or one of the fossil fuels.

These pictures are intended to encourage children to think about the short-term and the long-term effects of their activities on the world's supplies of energy.

- 3 Much less energy is used when a saucepan of water is heated with a lid on than when it is heated without the lid.

It is not easy to design a *fair* experiment to test this. Ideally two identical saucepans would be needed containing exactly the same amount of water at the same temperature. The lid is placed on one saucepan and both are heated to the same extent (using two identical burners or heaters). The time taken for the water to just begin to boil in both saucepans should be compared.

- 4 Normally a shower uses considerably less heat energy and water than a bath. Again it is not easy to construct a fair test. You would need to know the duration of the average shower, the amount of hot water used in it, as well as the amount of hot water used in the average bath.

A rough and ready comparison would be simply to compare the amounts of water (hot and cold combined) used in the average shower and the average bath.

- 5 Coal is sometimes called 'stored sunlight' because the energy released when coal is burned is some of the sunlight energy which was absorbed by the plants growing in the coal swamps millions of years ago. These plants later died and helped to form coal.
- 6 The luggage is weighed carefully before it is put in an air-liner.
 - a For safety reasons, to ensure that the aircraft's performance is not jeopardised because it is overloaded;
 - b Extra, expensive fuel is needed by the aircraft if it is to carry additional weight.

- 7 The diesel-powered boat is using the chemical energy in oil to turn its propellers.

The windmill could use the power of the wind to turn its sails.

The people on the boat are using the chemical energy obtained from their food to enable them to move around, talk and perform other bodily activities. Grass and green plants use sunlight energy to make food.

Doing

- 1 The hair-drier uses electrical energy. In the hair-drier electrical energy is changed to movement (of the air), heat and sound energies.
- 2
 - a It takes *energy* to move things.
 - b Energy can be *stored* and used later.
 - c We get two kinds of energy from the sun; *heat* and *light*.
 - d Plants use sunlight energy to help make their *food*.
 - e When we eat something, the energy in that food came originally from the *sun*.
 - f People use the energy of running water in *watermills* and some kinds of power stations.

g Anything that will burn is called a *fuel*.

h Engines can work because heat can cause *pushes* and *pulls*.

i In most car engines *petrol* is burned as fuel.

j We cannot make energy, we can only *change* one kind of energy into another.

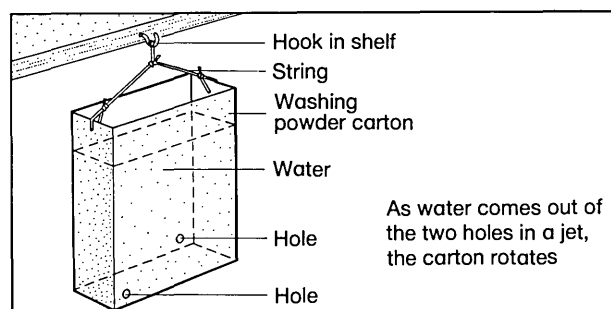
Going further

Make a model hovercraft

The model hovercraft will usually fly over a slippery rough surface such as a carpet or a piece of corrugated cardboard. It will also fly over the smooth surface of water but there is always the risk that the circle of card at its base will become waterlogged.

The model hovercraft is being pushed along by the downward push or pressure of the air leaving the balloon. The energy to drive the hovercraft came from the energy used by the chest and lungs in blowing up the balloon. This energy in turn came from food.

Real hovercraft ride on a cushion of air created by a powerful fan driven by the engines. The engines also drive one or more propellers which push the craft forwards or can be swivelled to drive the craft astern. Steering is by one or two air rudders similar to the tailplane on an aircraft.



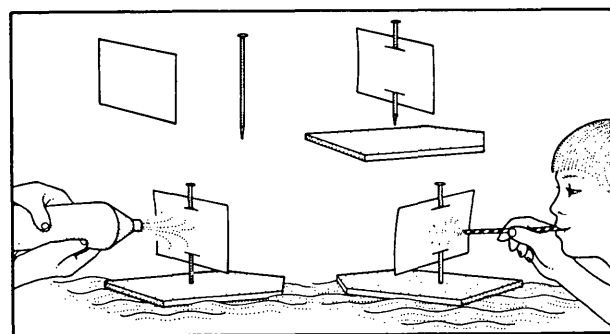
- 1 Ask one of the children to make this simple model using a milk carton or a small washing powder packet.

Fill the carton with water and hang it from a hook in a shelf above a sink or bowl. What happens? (The carton turns.) Where does the energy come from? (The force of the two jets of water coming from the packet and falling under the influence of gravity.)

- 2 *Sailing boats* Make a toy sailing boat from a small block of wood.

Cut the front of the boat in a pointed shape. Make a sail from thin card. Push a nail through the sail in two places. Tap the nail into the wooden hull of the boat.

Float the boat on a bowl of water. If it topples over, weight it with a little bit of plasticine or drawing pins until it floats upright.



Use a straw or an empty plastic washing-up liquid bottle to blow air on to the sail. Always blow air into the centre of the sail, but try setting the sail at different angles.

Does the boat move? How can you make the boat go faster or slower? How can you make it turn to the left or right?

Make another sailing boat from a block of wood the same size as the first. This time do not cut the front of the boat into a pointed shape. Does this boat sail faster or slower than the first one? Why is this?
(Expected results: The harder the children blow on the sail, the faster and further the boat will move. The boat can be steered by blowing to one side or the other of the sail, or by setting the sail at different angles. The boat without the pointed front will be much harder to blow along because of the increased resistance of the water on the front of the boat. In other words, the boat is not streamlined.)

Interdisciplinary activities

Art and craft

- Designing and constructing simple models.
- Drawings or paintings of windmills and watermills.
- Drawings or paintings of energy at work.

English

Journeys in poetry eg. *Night Mail* by Auden and *The Train* by Anderson.

- Three Men on the Bummel* by Jerome K. Jerome.
- Around the World in Eighty Days* by Jules Verne.
- Stories of travel and exploration.

Geography

- Clothes in different climates.
- Pollution and the use of fossil fuels.
- Acid rain.
- Measuring wind speed and direction.
- Alternative technology and the Third World.
- The Young Geographer Investigates: *Our Universe* by Terry Jennings (OUP).
- The Young Geographer Investigates: *The Earth* by Terry Jennings (OUP).

Health and hygiene

- Keeping warm, keeping cool.
- Energy and exercise.
- Breathing rates, pulse rates and exercise.

History

- People and the muscle power of animals.
- Windmills, watermills and the grinding of corn.
- The Industrial Revolution.
- The steam engine in history.
- Diesel, Benz, Daimler and Ford.
- Sir Frank Swift and the jet engine.
- Energy and weapons of war.

Mathematics

- Land, air and water speed records.
- Simple calculations on work done.
- Recording temperatures.
- Traffic counts.
- Braking distances.
- Force, work and power.
- Timetables.
- Fuel consumption figures at different speeds.
- Time, speed and distance.

Music, drama and PE

- Percussion band – car, train and aircraft sound effects.

Timing races.

Studying breathing and pulse rates during PE or games lessons.

Transport in music, eg. *Coronation Scot* by Eric Coates.
Religious education and social studies

Journeys and transport in biblical times.

Pilgrimages to Mecca, the Holy Land, Lourdes, etc.

Energy supplies in Third World countries.

Unit 8: Electricity and our increasing need for Energy

Aims of the Unit

- To describe the various kinds of electrical generating stations or power stations.
- To show how electricity is used in the home.
- To demonstrate the principles of an electric circuit.

Science background

The energy of an electric current is one of the most convenient forms of energy that we have. It can be switched on and off easily, and it is clean and versatile to use.

Electricity can be produced from the fossil fuels peat, coal, oil and natural gas, or from nuclear fuels. In all these cases, chemical energy in the fuel is converted to heat energy which is used to produce steam.

When one of the fossil fuels is being used to produce electricity, it is burnt in a large boiler in the power station. Heat from the burning fuel converts water to steam at a temperature of about 560°C. In a nuclear power station, the fuel consists of large atoms of radioactive elements such as uranium or plutonium. When the nuclei of these atoms are split in a nuclear reactor, large amounts of heat are released, and this too changes water to steam at about 560°C.

However it is produced, the steam then passes from the boiler or reactor into a turbine. The pressure of the steam makes the blades of the turbine turn. The turbine is connected to a generator (rather like a large version of the dynamo which provides electricity for the lamps on a cycle), and the generator also starts to turn, producing electricity.

A power station is only about 30 per cent efficient. This means that most of the energy in the fuel is wasted. The energy conversion can be summarised thus:

chemical energy→	heat→	movement→	electrical
(in the fossil fuel	energy	energy in	energy
or nuclear fuel)	in steam	the turbine	
		or	
		generator	

If water is trapped in mountainous areas, this can also be used to produce electricity. The running water is used to turn a turbine directly, and this is connected to a generator in the normal way. The energy conversions are:

potential→	movement→	movement→	electrical
energy	energy	energy	energy
(water in	(falling	in the	
a reservoir)	water)	turbine and	
		generator	

Hydro-electric power is very clean and efficient, and cheap to produce once the initial heavy expenditure for the power station and reservoir have been met. There are, however, a limited number of suitable sites for this kind of power station.

The action of the sun and moon on the oceans causes regular tides, and some of this energy can be removed by using special turbines built into dams. There are two small pilot stations at La Rance in France and Murmansk in the Soviet Union. Hot water springs and geysers have been used in Iceland, Italy, New Zealand and the United States of America to supply heat energy and electricity, and small amounts of electricity are also produced in large windmills that turn generators.

The generator at the power station usually produces electricity at about 25,000 volts. A transformer at the power station increases the voltage to 275,000 or 400,000 volts, and this electricity is fed along pylons across the country. At convenient points, transformers reduce the voltage to 132,000 volts and send electricity to cities, and large towns. At the edge of towns and villages, further transformers and local sub-stations reduce the voltage, eventually to the 240 volts we receive in our homes. Factories, hospitals and light industries take their electricity supply at a higher voltage.

When a light is switched on in a house, the electricity moves through the wire in the form of billions of tiny particles, or electrons. The path along which the electrons flow is called a circuit. For an electric current to flow there has to be a complete circuit without any gaps, and in most electrical appliances it is the switch that completes the circuit by forming a bridge over a gap in the wiring making up the circuit.

Substances which allow an electric current to flow through them are called conductors. Metals are particularly good conductors of electricity. Solutions of some chemicals will also conduct electricity. Substances which will not allow a current to pass through them are insulators or non-conductors. These include rubber, china, plastics and most other non-metallic substances. Wires and cables have to be good conductors, and usually they are made of copper. The coverings around cables and electrical switches and sockets have to be made of insulating materials such as plastic or rubber.

As well as being produced in a generator, electricity can also be made chemically in a battery or dry cell. When one of the components of the cell is used up, the cell ceases to give a current. In addition there is another type of battery, like the lead-acid accumulator found in a car, which stores electricity for later use.

Books for the children

The Young Scientist Investigates: *Electricity and Magnetism* by Terry Jennings (OUP).

The Young Scientist Investigates: *Energy* by Terry Jennings (OUP).

Science in a Topic: *Houses and Homes* by Doug Kincaid and Peter S. Coles (Hulton).

Starting Science: *Book 1 Working Models* by Jim Flood (Heinemann).

Books for the teacher

Experiencing Energy: *Book 3 Working with Electricity* (The Association for Science Education).

Science 5/13: *Early Experiences* (Macdonald Educational).

Materials and organisation

Electricity is a topic that many primary school teachers are apprehensive about, largely because of their failure to understand the subject in their own secondary school days. Nevertheless, children find this an interesting and exciting subject, since they are familiar with the benefits of electricity and want to understand more about where it comes from and how it works. There is the added advantage that once the concept of a simple circuit has been mastered, the children can use this knowledge in making working models at home as well as at school.

It may be possible for teachers to obtain films, posters, leaflets and other information from:

Electricity Council,
30 Millbank,
London SW1P 4RD.

Central Electricity Generating Board,
Sudbury House,
15 Newgate Street,
London EC1A 7AU.

Information Services,
United Kingdom Atomic Energy Authority,
11 Charles II Street,
London SW1Y 4QP.

Materials and equipment:-

- pictures of different domestic electrical appliances
- torch bulbs
- electric light bulbs
- short and longer lengths of insulated wire with the ends bared
- 4.5 volt batteries
- lampholders for torch bulbs
- small blocks of wood
- paper clips or pieces of tin foil or milk bottle tops
- small screwdrivers
- washing-up liquid bottles
- clean paste jars
- clay or plasticine
- dry sand or soil
- keys
- scissors
- coins
- pencils
- rubbers
- pairs of metal cans all the same size
- thermometers
- mat black paint
- paint brushes
- large corks

Electricity (pages 58–59)

Lesson objectives

- a To describe the main kinds of electrical generating stations or power stations.
- b To show how electricity is sent to our homes, schools, shops and factories from power stations.

Setting the scene

Possible starting points include:

- 1 A display of pictures of household and other appliances which use electricity.

- 2 The children could compile a list of all the uses of electricity they can think of.
- 3 Bring a bicycle, fitted with a dynamo, into the classroom and show how it generates electricity if one of the wheels is turned.
- 4 Ask the children to write a story, or make up and act a play, describing what life would be like if the electricity supply failed for several days.

New words

Power station – a large building in which electricity is made.

Generator – a machine which makes electricity. It is often called a dynamo.

Turbine – a large wheel or fan which can be turned by running water or steam, and which drives a generator that makes electricity.

Hydro-electric power station – a power station which uses the force of running water to turn its generators.

Nuclear power station – a power station which obtains its energy, called nuclear energy, from the metal uranium.

Cable – a thick covered wire which carries electricity.

Class management

All of the work on this topic can be carried out by the children at their desks. The topic will be much more meaningful if a visit to a power station can be arranged, or if a film or television programme describing the generation and uses of electricity can be shown to the class.

Safety precautions

While the children should be encouraged to experiment with torch bulbs and batteries, they should be warned that electricity from the mains is dangerous and can kill if misused.

Answers to questions in the text

Electricity (page 58)

The power station in the picture was built by the side of a railway so that trains can bring the coal needed as fuel direct from the mines.

Oil and gas are better fuels than coal for a power station because they are cleaner and easier to handle, and when they burn they produce less smoke and other forms of atmospheric pollution. Oil and gas also produce little or no waste materials, whereas quite large quantities of ashes are left when coal is burned. Weight for weight, oil and gas produce more energy than coal when they are burned. They are, however, more expensive and we have less of them than we have coal in Britain.

The large tanks near the power station in the picture are used to store the oil which is used as a fuel. The power station has been built near the sea so that it can extract water from the sea for use in its boilers, and put the water back there when it is finished with.

Now try these

- 1 Electricity wires are often put on pylons and poles, because this is less expensive than burying them underground. It is also easier to repair a break in an overhead wire than it is in one which is buried.

- 2 A large department store may use electricity for lighting, heating (and if it is air-conditioned, for cooling the air), to operate the lifts, escalators, and also to work the computers in its offices and stock-rooms. The burglar and fire alarms use electricity, and so do the hot-air hand-driers in the cloakrooms. Electricity may be used to operate the cookers, refrigerators and deep-freezers if the store has a restaurant, canteen or food department.

- 3 The advantages of hydro-electric power stations are that the actual cost of the electricity is very low and the power stations do not pollute the air or water. The disadvantages are that these power stations are expensive to build, and often the electricity has to be carried great distances from the hills and mountains to the towns and cities where it is needed. In addition, the dam, reservoir and power station may spoil the appearance of an area of beautiful countryside.

- 4 Electricity provides the power to enable us to travel from place to place in lifts, escalators, moving walkways, electric trains, trams, trolley-buses, and some cars. Even in those cars, lorries, buses and other vehicles which are not electrically powered, electricity is vital to start the vehicles and also to light and heat them. In addition, in aircraft, ships, taxis and other vehicles, electricity not only provides light and heat, but also powers the communications systems.

Extending the learning

- 1 Ask the children to make a table of the ways in which electricity in the home or school is changed into light, heat, movement, and sound. Two examples are shown in the table below. Ask the children if they think these are completely right.

	Light	Heat	Movement	Sound
Lamp	✓			
Vacuum cleaner			✓	

(A lamp also produces heat, while a vacuum cleaner makes a lot of noise and its motor may soon become warm. In addition, some vacuum cleaners have a built-in light.)

- 2 Electricity is expensive to produce. Discuss with the children how we could save money by using less electricity.
- 3 One kind of electricity is known as static electricity. Two experiments to investigate this are described on pages 30–31 of *The Young Scientist Investigates: Electricity and Magnetism* by Terry Jennings (OUP).

Electricity in the home (pages 60–61)

Lesson objectives

- a To describe how electricity reaches our homes from the power station.
- b To show how electric lights and torch bulbs work.

Setting the scene

Possible starting points include:

- 1 Looking at electricity meters.
- 2 Examining fuses and fuse wire (perhaps an old fuse box could be loaned from an electrician).
- 3 A display of different kinds of battery powered lights.

New words

Electricity meter – an instrument which measures how much electricity is being made or used.

Fuse – a thin piece of wire which melts easily and which causes the supply of electricity to be cut off when something goes wrong.

Class management

All of the work on this topic can be carried out in the classroom, but a demonstration, perhaps by the caretaker, of the school's switch-gear, electricity meters and fuse boxes, would be instructive.

Safety precautions

The children should be reminded not to interfere with the mains electricity supply. They should also be instructed to handle light bulbs and torch bulbs with extreme care.

Answers to questions in the text

Electricity in the home (page 60)

In many older houses, the electricity meter, mains switches and fuses are in the hallway or in the cupboard under the stairs. In most modern houses, they are in the garage.

Now try these

- 3 Time switches in houses may turn the central heating or cooker on and off at pre-set times. They can also switch on some or all of the house lights, usually as a deterrent to burglars. In town and village streets, time switches are frequently used to control the street lights and illuminated road-signs.
- 5 In the home, fluorescent lights are most often found in the kitchen or utility room, where they give a bright even light at a lower cost than that obtained with light bulbs. Smaller fluorescent lights may also be found above bathroom mirrors and dressing tables, and in display cabinets, cocktail cabinets and some other pieces of furniture.

Expected results of activities and experiments

Bulbs (page 61)

The two ends of the wires supporting the filament of a torch bulb are connected to the two contacts or terminals through which electricity enters and leaves the bulb. One of these contacts is the small grey metal swelling at the very base of the bulb; the other is the metal case below the glass globe.

Apart from the difference of size, a torch bulb and a light bulb are very similar. The filament of the light bulb is larger and more complicated, and the two wires leading to it are supported within a glass rod. The two electrical contacts on the light bulb are the two grey metal ovals at the very base of the bulb. Torch bulbs and light bulbs often

differ also in the way they fit into the bulb-holder or light socket.

Some light bulbs are coated with a substance to make them translucent. This makes the bulbs give a more even light, and prevents the filament casting shadows.

Extending the learning

- 1 Ask the children to find out what the word 'voltage' means. Let them examine various electrical appliances (NOT while they are connected to the mains, though), or advertisements for electrical appliances, as well as torch bulbs and batteries, to see what voltages these items require or provide.
(Voltage is a measure of the electrical push or pressure. The children will probably also come across the term 'watts' or 'wattage' on, for example light bulbs and electric motors. This is a measure of the power or energy supplied or used in a second. Finally, 'amps' measures the quantity of electricity flowing in a second, and there is the mathematical relationship between these three terms: Volts $\times$ Amps = Watts.)
- 2 Let the children find out more about the life and work of Michael Faraday, whose discoveries paved the way for the manufacture of electricity on a large scale. Further activities and experiments on electricity and magnetism are detailed in *The Young Scientist Investigates: Electricity and Magnetism* by Terry Jennings (OUP).

Electrical circuits (pages 62–63)

Lesson objectives

- a To show how electricity can be obtained from chemicals in a battery (a dry cell).
- b To demonstrate the principles of the electrical circuit.

Setting the scene

Possible starting points include:

- 1 A display of different kinds of batteries on the Science Table.
- 2 Demonstrate a simple circuit set up with an electric bell or buzzer.
- 3 Examine a car battery *in situ*.

New words

Circuit – the complete path or way round of electricity from a battery or generator, through a lamp or some other piece of electrical equipment, and back to the battery or generator.

Battery – a device in which chemicals act together to produce electricity, or a device for storing electricity.

Class management

All of the work on this topic can be carried out by the children at their desks.

Safety precautions

Again the children should be reminded of the dangers of

experimenting or interfering with the mains electricity supply.

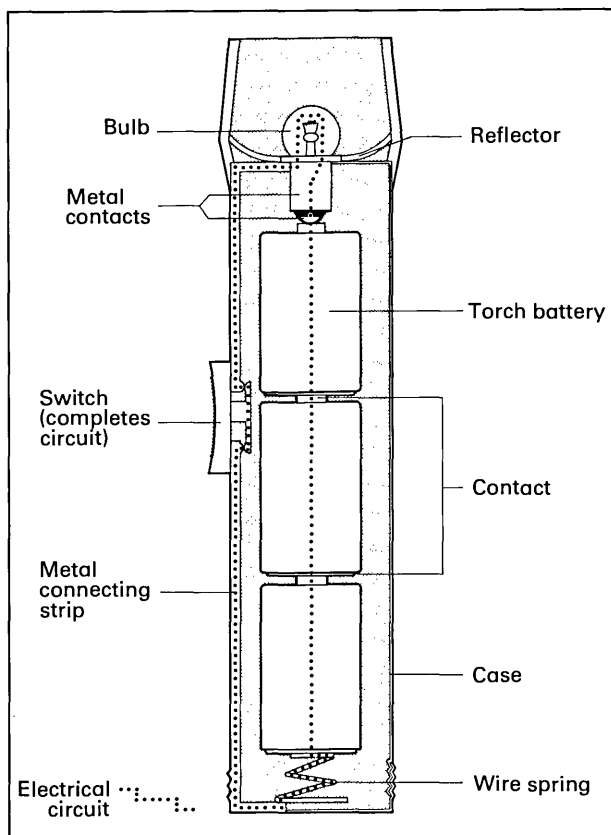
Answers to questions in the text

Electrical circuits (page 62)

Some of the things which use batteries include: clocks, watches, radios, tape-recorders, cassette-players, cameras, photographic flash-guns, torches, certain mechanical toys, pocket calculators and some portable computers, and some electric razors and burglar alarms.

Now try these

- 2 Some of the things we can do in our homes to save electricity (and other fuels) include:
 - a Turn off lights in rooms that are not occupied.
 - b Turn down the room thermostats a few degrees and wear warmer clothing.
 - c Switch off the immersion heater when not in use, or have a time switch fitted.
 - d Turn off the taps fully (particularly where the water is heated by electricity) and, if they still drip, have new washers fitted.
 - e Have a shower instead of a bath, since this uses less hot water.
 - f Do not wash up under constant running hot water. Use a bowl or the sink instead.
 - g Only use the washing machine with a full load.
 - h Use a clothes line to dry clothes rather than a tumble-drier whenever possible.
 - i Lag hot water tanks and hot water pipes, insulate roof spaces, reduce draughts, and close the curtains as soon as it gets dark to keep the heat in.



- 3 Electrical conductors are materials such as copper and other metals along which electricity passes easily. They are used for wires, the cores of cables, the terminals of batteries, switches and electrical plugs and sockets, and for the filaments of light bulbs. Rubber, plastic, glass, porcelain and most other non-metals are insulators, and electricity passes through them with difficulty or not at all. Insulators are used for the coverings on electrical cables, switches, plugs, and other parts of electrical appliances which people might touch.
- 4 A diagram of a typical torch is shown below: (left)
- 5 One method of making a working model lighthouse is described below.

Expected results of activities and experiments

Make your own electrical circuit (page 63)

With care it is possible to rest the torch bulb on top of one of the terminals of the battery and to connect the metal collar of the bulb (the other electrical contact) to the second terminal of the battery with a single strand of wire or even a penknife or a pair of scissors, so that a circuit is made and the bulb lights up.

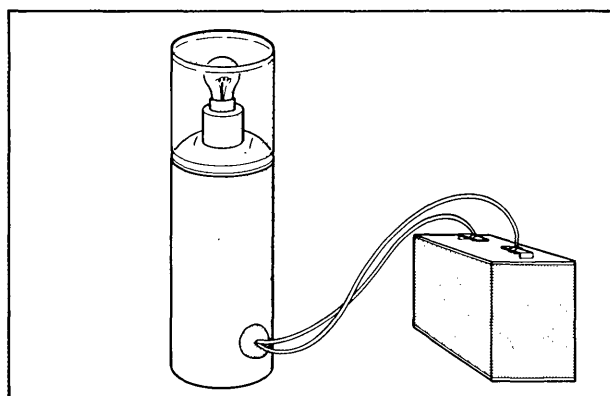
Make an electrical circuit with a switch (page 63)

Pieces of cooking foil, or strips cut from the metal disc in the tops of some coffee, cocoa or drinking chocolate tins, can also be used to make the switch.

Extending the learning

- 1 *Make a model lighthouse* You will need a clean empty washing-up liquid bottle, a small jar such as a paste jar, a bulb in a lampholder, a battery, and two pieces of wire about 50 centimetres long.

Make a small hole near the bottom of the bottle. Ask your teacher to cut off the top of the bottle so that the lampholder just fits into the top of the bottle.



Thread the two pieces of wire through the hole in the bottom of the bottle, and join them to the terminals on the lampholder.

Plug the space around where the two wires go into the bottom of the bottle with clay or plasticine. Lift up the lampholder carefully and pour a little dry sand or soil into the bottle to make it less easy to knock over.

Join the other two ends of the wires to the terminals of the battery. The bulb should light up.

Cover the lampholder with a clear glass jar. Paint the tower of the lighthouse. If you wish, you can add a third strand of wire and a switch to your model lighthouse.

- 2 Make houses, churches, theatres, cars, spacecraft and other models with junk, and illuminate them with the aid of a simple circuit.
- 3 *Which materials are conductors and which are insulators?* Not all substances let electricity through them. Those which do are called conductors. Substances which do not let electricity pass through them are called insulators.
What you need: A battery; 2 paper clips; a lampholder with a bulb; three pieces of wire; 2 drawing pins; a small block of wood; a screwdriver; a key; a pair of scissors; a coin; a pencil; a rubber, and a selection of other materials.
What you do: Set up a circuit like the one in the picture. Notice that it is not a complete circuit.

Lay the blade of a screwdriver across the two drawing pins. The bulb should light. The blade of the screwdriver is a conductor. Now lay the handle of the screwdriver across the two drawing pins. Does the bulb light now? Is the handle of the screwdriver a conductor or an insulator?

Now test other materials.

Make two lists, one of materials which are conductors of electricity, and the other of materials which are insulators.

(Expected results: If the handle of the screwdriver is made of plastic or wood, as most are, then the bulb will not light. If the handle of the screwdriver is made of metal the bulb will light.

In general metallic objects are conductors, while non-metals such as wood, glass, plastic, cotton etc are insulators.)

Further experiments and activities on electricity, including making and using an electro-magnet, are described in *The Young Scientist Investigates: Electricity and Magnetism* by Terry Jennings (OUP).

Checking (pages 64–65)

Thinking

- 1 Electricity pylons have to be very tall for safety reasons, so that trees, tall vehicles and farm machinery do not touch the wires on them.
- 2 In towns electricity is carried by underground cables to save large numbers of unsightly poles and pylons having to be used. The cables, in their underground pipes, are also protected from interference and damage by people and vehicles, for the safety of all concerned.
- 3 The advantages of using windmills to make electricity are that the electricity is obtained cheaply and without polluting the atmosphere or water. The disadvantages are that a large number of windmills are needed to produce the same amount of electricity as one power station, and these would have to be sited in exposed areas, such as on hilltops or by the sea, where they would look unsightly. Secondly the electricity cannot always be made at the times when it is needed most, but only when the wind blows. Often the best sites for windmills are a great distance from the towns and factories where the electricity is required.
- 4 Most hydro-electric power stations are to be found in Scotland and Wales because there are many mountains and fast-flowing rivers in those two countries. The fast-flowing rivers are needed to turn the turbines.
- 5 The advantages of obtaining heat energy from solar energy are similar to the advantages of using windmills to make electricity: the heat energy is cheap and the method does not pollute the air or water. The disadvantages are that large numbers of solar panels are needed, and they can be unsightly. In addition the sun does not shine regularly in this country, so that in winter, when the skies are overcast, an additional source of heat energy is often necessary.
- 6 Coal and oil have many other uses besides acting as fuels in homes and power stations.
 From coal, smokeless fuels such as coke and anthracite can be manufactured. From the impurities given off when these smokeless fuels are made, various chemicals are produced which are used to make tar, ammonia, drugs, disinfectants, perfumes, fertilizers, plastics such as nylon, dyes and explosives.
 From oil (strictly speaking petroleum), we obtain petrol and other motor fuels, kerosene or paraffin, gas and diesel oil, lubricants, bitumen, waxes and greases. Other petroleum by-products include candles, polishes, scents, cosmetics, insecticides, nail-varnish, artificial rubber, plastics, washing-up liquids and detergents, medicines, paints and explosives.

Doing

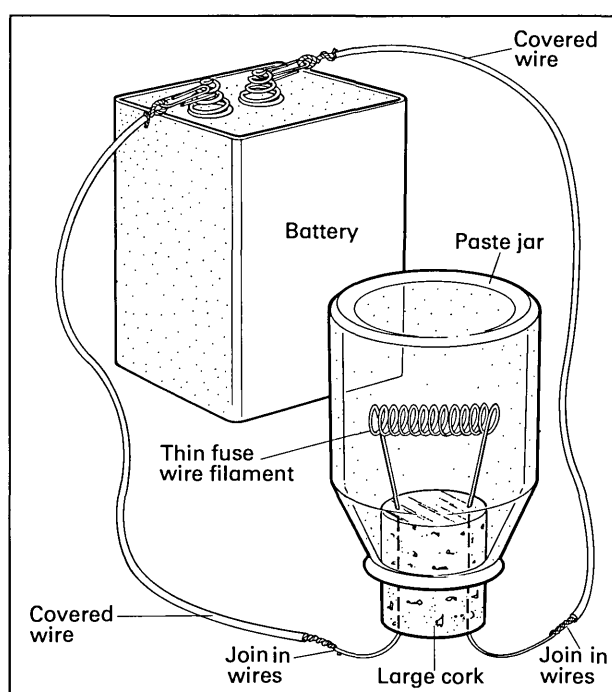
- 1 The cheapest way of producing the biggest reduction in heat loss from a house at the time of writing is to insulate the loft, because hot air rises and may escape through the roof.
- 2 In most areas, the addresses of the local power station will be found in the telephone directory under the heading *Central Electricity Generating Board*.
- 3 For this experiment to work effectively, one can should be painted with matt black paint. The other should have all traces of the label and glue removed so that its whole surface is shiny.
 The black-painted can warms up the fastest because black paint (and other dark colours) absorb heat better. Lighter colours, and particularly smooth shiny surfaces, tend to reflect both light and heat.
- 5 The rate at which domestic appliances use electricity varies, but in general the appliances which use most electricity are cookers, freezers, immersion heaters, and all kinds of electric fires and heaters. The appliances using least electricity include electric lights, radios, record players, tape recorders, electric shavers, doorbells and telephones. The drill uses 1200 watts.
- 6
 - a Electricity is one kind of *energy*.
 - b The electricity we use in our homes, shops, schools and factories is made in a *power station*.
 - c The electricity which is made using the energy of fast-flowing rivers is produced in a *hydro-electric* power station.
 - d The machine which turns in a power station to produce electricity is called a *generator*.
 - e A *nuclear* power station uses the energy from a small piece of metal called uranium.
 - f Electricity is moved from one place to another along *wires*.
 - g The tall towers which carry wires are called *pylons*.
 - h Materials which allow electricity to pass through

them easily are called *conductors* of electricity.

- i A *fuse* contains a thin piece of wire which melts easily.
- j The thin piece of wire inside a light bulb is called the *filament*.
- k A torch battery makes electricity from *chemical* energy.
- l Wires which have protective covers on them are called *cables*.
- m Materials which do not allow electricity to pass through them are called *insulators*.

Going further

- 1 Make a model light bulb using a small paste jar. Connect it up to a battery.



What happens to the fuse wire filament of the model bulb? How is this model bulb different from a real electric light bulb?

(Expected results: The fuse wire filament of the model bulb will become hot. In a darkened room it may be seen to glow (depending on the voltage of the battery and the resistance of the fuse wire used). The model bulb differs from a real light bulb in that the glass globe is not sealed. In a real bulb the glass globe is filled with a mixture of the gases argon and nitrogen. These allow the temperature of the filament to be raised sufficiently to give out large amounts of light.)

- 2 Let the children carry out a survey among their friends. Ask them to find out whether their friends' homes are heated by electricity, gas, oil, solid fuel (coal, coke, anthracite, etc) or some other fuel. Get the children to make a block graph or histogram of their results.

Discuss which fuel is the most popular. Why? Ask the children to write down the reasons people give.

The children could carry out a similar survey to see which kinds of fuel people use for cooking their food.

- 3 What happens when torch bulbs share a battery?

What you need: A 4.5 volt battery; 4 torch bulbs in lamp holders; 6 short pieces of plastic-covered wire each about 15 centimetres long; a pair of scissors; a small screwdriver; 2 wire paperclips.

What you do: Use the scissors to remove 1 to 2 centimetres of the covering from each end of each wire.

Take two of the pieces of wire and fix a paperclip to one end of each. Fasten one paperclip on to each of the two terminals of the battery.

Use the screwdriver to connect the bare ends of the wires to a lampholder. When the bulb lights, see how bright it is.

Now connect up the battery to two bulbs and lampholders. See how bright the bulbs are. See if the battery will light up three or four bulbs at the same time. What effect does the number of bulbs have on the brightness or dimness of the light?

What happens if you carefully unscrew one of the bulbs? Can you think why one faulty bulb on a Christmas tree will put all of them out?

What happens if you now wire up two bulbs to one battery, but this time give each bulb its own circuit? What happens if two batteries power one torch bulb? Can you make your own experiment to find out? (Expected results: The more bulbs that share a battery, the less bright each bulb is. If one of the bulbs is unscrewed, there is then a break in the circuit, and all the bulbs go out. This is what happens with most Christmas trees when one bulb fails, although in a few cases each bulb in a set of Christmas tree lights has its own separate circuit. Then if one bulb fails, the remainder stay alight.)

If two bulbs are wired up to the same battery, but each has its own separate circuit, both bulbs will be of equal brightness, assuming they are both of the same voltage.

If two batteries power one torch bulb, the bulb will give a very bright light, but its life will be much shorter than normal, since the filament will burn out at twice the rate.

Other simple activities and investigations the children could carry out include:

- 1 Test the brightness of torch bulbs of different voltages with the same battery.
- 2 Compare the life of different makes of the same size torch battery.
- 3 Groups of children could pass messages to each other using the Morse Code and flashing lights or a buzzer.

Interdisciplinary activities

Art and Craft

Model-making.

English

Electricity and communications.

Stories and poems which mention electricity.

Creative writing about the benefits of electricity.

Geography

Fossil fuels and their origins.

The siting of power stations.

Pollution from power stations, and the effects of acid rain.

The use of hot water from power stations for fish-farming.

Electricity and transport.
Alternative sources of energy.
Health and hygiene
Traffic lights, pelican crossings and road safety.
Electrical safety and First Aid.
History
Heating and lighting throughout history.
The lives of Michael Faraday and Alessandro Volta.
Windmills and watermills as sources of power.
Mathematics
Calculations on the cost of using electrical appliances.

Reading the electricity meter.
Simple calculations on electrical consumption.
Music, drama and PE
Flood-lighting at sports stadia.
Electronic musical instruments.
Electronic timing of sporting events.
Theatrical lighting and effects.
Religious education and social studies
Heating and lighting in biblical times.
Energy supplies and the Third World.

Theme: Change

Unit 9: Weather

Aims of the Unit

- a To describe the atmosphere and to demonstrate that air has pressure.
- b To describe the causes and effects of movements of the air.
- c To show the effects of water in the atmosphere, and to introduce the concept of the water cycle.

Science background

The Earth is surrounded by the atmosphere which consists of a mixture of gases. The atmosphere is most dense at ground level and thins out as it stretches upwards until, at about 500 km, it is almost a vacuum. Even at a height of 250 km, the atmosphere is so thin that the air resistance on a space shuttle or artificial satellite is negligible.

Although we cannot see air, we are conscious of it every time we take a breath, and we feel it when the wind blows. Although pure air is invisible, it has substance and consists of atoms and molecules in the same way as solids and liquids. One cubic metre of air weighs about 1.25 kg and, because air has weight, it exerts a pressure on all the surfaces with which it is in contact. At sea-level this pressure is equivalent to about 1 kg on every square centimetre.

The pressure of the air varies slightly from time to time, and these changes can be measured with a barometer. Such changes are useful in forecasting the weather: usually high pressure means fine weather, while falling pressure usually presages rain. Since the higher you go, the less air is above you, the pressure it exerts is less. Because of this a barometer can also be used to estimate height or altitude. The special form of barometer in an aircraft which measures altitude is called an altimeter.

The atmosphere in one place is rarely still. Winds are movements of large quantities of air set in motion by differences of temperature between two nearby areas. Winds operate in a similar way to the effects of a radiator heating a room. The heated air around the radiator expands as it is heated, and rises, while cooler air, which is heavier and denser, is drawn in to take its place. These movements of air are called convection currents. On the Earth, the heat of the tropics acts like a radiator, to heat the air and make it less dense so that cooler air is drawn in

to take its place. As a result, most winds that blow over the Earth move from the cold polar regions towards the Equator. But it is not quite as simple as that. As the warm equatorial air moves towards the poles it gradually cools, so that by about latitude 30 degrees north or south, it sinks and forms new high pressure regions. In addition the rotation of the Earth also deflects the winds.

The sun evaporates tremendous quantities of water from the sea and land. Every day, millions of tonnes of water are carried into the atmosphere as invisible water vapour. Warm air can carry far more moisture than cold air, so that when air cools it can no longer retain the water vapour. It then condenses around the tiny particles of dust and other matter always present in the air, to form microscopic droplets of water that are light enough to float in the sky. These are clouds, of which there are three basic types: cumulus (Latin for 'heap'), stratus ('layer'), and cirrus ('curl'). The Latin word 'nimbus' is often added to indicate rain clouds.

Why clouds turn into rain is not known for certain. Most meteorologists think that in temperate regions rain starts high up at the top of clouds as ice crystals. Some of these melt and fall as rain; and others freeze again after melting to become sleet or snow. Hail forms when raindrops pass up and down through a thundercloud. As a raindrop rises it freezes. As the raindrop descends through the cloud more water sticks to it. When it rises again it freezes. These processes are repeated until each piece of ice is so heavy that it falls to the ground as hail.

When rising warm moisture builds up into the towering cumulus clouds we call thunderclouds, the clouds become electrically charged with millions of volts. As the electricity discharges from one cloud to another, or from cloud to Earth, the electric current heats the surrounding air to white heat – a lightning flash. Instantly the heated air expands, and it is this expansion that causes the sound waves of a thunderclap. As sound travels about 3 km in one second, for every second between the lightning flash and the thunderclap, the storm is 3 km away.

There is only a finite quantity of water on Earth, and the sun provides the energy to keep this water in circulation. It warms the surface of the oceans and seas, changing water into vapour. Water also evaporates from lakes, ponds, streams, glaciers, puddles, the soil and the leaves of plants and the bodies of animals. High in the air this water vapour condenses and forms the minute droplets that make up clouds. Eventually the moisture in the clouds returns to Earth as rain, snow or other forms of

precipitation. From there it evaporates once more, continuing the so-called *water cycle*.

Books for the children

The Young Scientist Investigates: *Air* by Terry Jennings (OUP).
The Young Scientist Investigates: *Water* by Terry Jennings (OUP).
The Weather by Bill Bailey (Macdonald Educational).
Spotters Guide to The Weather by F. Wilson and F. Mansfield (Usborne).

Books for the teacher

Science 5/13: *Early Experiences* (Macdonald Educational).
Science 5/13: *Change* (Macdonald Educational).
Science 5/13: Using the Environment: *1 Early Experiences* (Macdonald Educational).

Materials and organisation

This topic has important links with Geography. It has the big advantage from the teaching point of view that it can be carried out at any time of the year, and because of the highly changeable nature of the British weather, there is never any shortage of topics for discussion. Although sophisticated weather recording instruments would be ideal, a great deal of valuable data can be collected with the aid of simple, home-made instruments.

Materials and equipment:

sheets of paper or thin card
rulers
polythene bags, all the same size
string
balloons
plastic beakers
wine bottles (clear glass)
bowls
drinking glasses
clean, narrow-necked bottles
drinking straws
clay or plasticine
sink plungers or other rubber suction cups
rubber or plastic tubing
different shaped bottles, jars, bowls and dishes
jam-jars
measuring jugs
labels
small pieces of cloth
wall thermometers
matchsticks
corks
old pen tops (plastic)
steel knitting needles
plastic bottles
sand
pine cones
stockings or tights
thin wire
ice or snow
clean yoghurt pots
large metal spoons or ladles
kettle
clean washing-up liquid bottles
scissors

shoe boxes
tablet bottles
saucers
dessertspoons
pocket mirrors
potted plants
rubber bands
garden hose
goldfish bowl
glass prism

The atmosphere and air pressure

(pages 66–67)

Lesson objectives

- a To describe the atmosphere and the pressure it exerts on the Earth.
- b To demonstrate ways of feeling or recording the pressure of the air.

Setting the scene

Possible starting points include:

- 1 A discussion of how, even though we cannot see it, we know that there is air all around us.
- 2 Present the children with a collection of pictures showing various aspects of the weather. Ask the children to describe the weather conditions they think were prevailing when the pictures were taken. Alternatively, if the pictures show clouds, the children could be asked to predict what the weather conditions became like after the pictures were taken.
- 3 A discussion of why we need to be able to forecast the weather and who most needs the information.

New words

Atmosphere – the huge layer of air which surrounds the Earth.

Air pressure – the force or weight of the air in the atmosphere pressing downwards on the Earth.

Barometer – an instrument which is used to measure the air pressure. It helps us to tell what the weather is going to be like.

Class management

All of the work on this topic can be carried out by the children in the classroom.

Safety precautions

Although blowing air into polythene bags should be perfectly safe for children of this age group, they should be warned not to carry out this activity in front of younger brothers and sisters. The children should also be reminded of the dangers of suffocation if a polythene bag is placed over the head.

Answers to questions in the text

The atmosphere and air pressure (page 66)
A typical exercise book measures 20 by 16 cm, and the

weight of the air pressing down on it is 320 kg. The weight of the air pressing down on a typical desk or table will run into thousands of kilogrammes. The reason the desk or table does not collapse under this weight, is because air is also pressing upwards from underneath the desk or table and sideways too.

The children may also ask why our bodies do not collapse under the enormous pressure of the air. The reason is again that the air presses in all directions. In addition there is air inside our bodies which is pressing outwards.

Read a barometer (page 67)

In general, the air pressure drops as cloudy or wet weather is approaching, and rises as clear, dry weather approaches. Very low air pressure usually indicates stormy weather, while very high pressure usually heralds a period of fine and dry weather. If the air pressure stays the same, a continuation of the current weather is expected.

Now try these

1 If you climb a mountain or go up in an aircraft, the air pressure will decrease. This is because there is less air to press down on you. At the top of Mount Everest, which is 8848 metres above sea-level, the air pressure is only about 30 per cent of that at sea-level. The air is so 'thin' that mountaineers have to carry oxygen with them to breathe. The air becomes thinner still at 10,000 metres, the height at which jet aircraft normally cruise. The thin air offers little resistance to the movement of the aircraft, but it does mean that the cabin of the aircraft has to be pressurized, so that the air inside is close to the normal air pressure at sea-level.

3 Some weather sayings include:
Red sky at night, shepherd's delight,
Red sky in the morning, shepherd's warning.
(Red sunset – fine day to follow; red sunrise – wet day to follow.)

Grey mists at dawn,
The day will be warm.
(Misty mornings in summer lead to a fine day.)

Rain before seven,
Fine before eleven.
(Early morning rain is followed by a fine day.)

A sun shiny shower,
Won't last half an hour.
(Showers during sunny weather are short-lived.)

If the sun goes pale to bed,
'Twill rain tomorrow it is said.
(A weak, anaemic sunset means rain the next day.)

Ne'er cast a clout,
Before May is out.
(Beware late cold weather.)

If the oak is out before the ash,
Then you'll only get a splash. (a fairly dry summer)
But if the ash beats the oak,
Then you can expect a soak. (a wet summer)

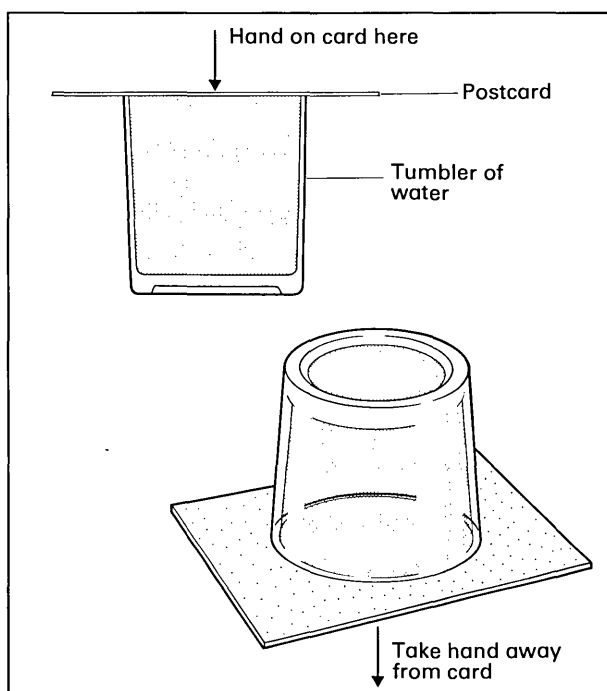
Mackerel sky, mackerel sky,
Never long wet, never long dry.

(A mottled cloud pattern means unsettled weather ahead.)

All of the sayings seem to have some scientific basis, with the exception of the one referring to the opening of the leaves on oak and ash trees. In reality, the timing of these seems to be a reflection of the weather conditions of the spring past rather than of the summer to come.

4 Balloons and car tyres are inflated with air which is under pressure. The drills used to dig up the roads (pneumatic drills) are also worked by compressed air. The drill is connected to a compressor which compresses, or squeezes, the air which is then stored in a strong steel container. In many pneumatic drills, a piston goes up and down, pushed by the compressed air, and this pushes the drill downwards into the road surface in a bumping action.

5 For this experiment, a piece of card about the size of a postcard is best. As long as there is no air in the inverted tumbler, only water, the air pressure will hold the card over the mouth of the tumbler, keeping the water in until the card eventually becomes saturated.



The experiment works because the air pressure pushing up on the card is greater than the air pressure down on it, because the tumbler is in the way. It is a wise precaution to carry out this experiment over the sink though!

Expected results of activities and experiments

Air pressure (page 66)

The ruler is much more difficult to knock off the table when it is covered by the sheet of paper. If thin card or thick paper is used which will not tear easily, it is often possible to break the ruler in attempting to knock it to the floor.

It is quite a simple matter to show that it is not the weight of the paper which makes the difference to the

effort needed to knock the ruler to the floor. Weights can be gently rested on the end of the uncovered ruler until it falls to the floor. Then the procedure is repeated with the ruler in exactly the same position, but covered with the paper or card. It will be found that the extra weight needed to knock the ruler to the ground is much greater than the weight of the paper or card.

Make a simple barometer (page 67)

The most important information to be gained from a barometer is whether the atmospheric pressure is rising or falling. There are two needles on a barometer, one of which shows the current air pressure, while the other can be turned to act as a marker to indicate whether the pressure is rising or falling.

Squeezing and throwing air (page 67)

The bag containing air can be thrown further because of the weight of the compressed air in it. Ideally, to make the experiment 'fair', the empty bag should be squashed flat and then tied with a piece of string of the same length and weight as that used for the bag of compressed air.

Squeezing air (pages 66–67)

The compressed air trying to stretch the balloon pushes against the sides of the beaker, enabling the beaker to be picked up.

Extending the learning

- 1 Ask the children to try to drink water through a straw from a perfectly clean, narrow-necked bottle. This is quite easy. Then get them to carefully pack clay or plasticine around the top of the bottle so that there is an air-tight seal around the straw. The children will now find that it is impossible to drink with the aid of the straw, proving that it is the pressure of the air on the surface of the water in the bottle which helps to make the water rise up the straw. (Safety precaution: the bottle used should be perfectly clean, and should not be used by a second child unless it has first been washed in hot soapy water.)
- 2 Experiment with rubber suction cups, such as those found on sink plungers or some kinds of coat hooks. Press the suction cup onto a smooth surface. Try to remove the cup with a straight pull. Wet the inside of the suction cup and press it onto the same smooth surface. Try to remove the cup with a straight pull. Repeat these activities on a rough surface.
Ask the children why the suction cup has to be pressed before it will stick? (To eliminate the air from inside the cup.) Why does a wet suction cup stick better than a dry one? (The water helps to make the seal around the base of the cup completely air-tight.) Why does the cup stick to smooth surfaces but not rough ones? (On rough surfaces, air can get under the edges of the cup, equalising the air pressure on both sides.)
- 3 Demonstrate to the children, with the aid of a length of rubber or plastic tubing (such as that used in wine-making) and a bowl or jar of water, how a siphon works. Ask the children why the air has to be sucked out of the tube before the siphon will work. (To ensure that the pressure on the surface of the water in the bowl or jar is much greater than the pressure of air and water back up the piece of tubing.)
Other experiments and activities concerned with air and air pressure will be found in *The Young Scientist Investigates: Air* by Terry Jennings (OUP).

Moving air (pages 68–69)

Lesson objectives

- a To describe how winds are formed.
- b To show how the speed of the wind can be estimated.
- c To demonstrate how evaporation occurs.

Setting the scene

Possible starting points include:

- 1 A collection of pictures showing the beneficial and harmful effects of winds.
- 2 Trying to measure the speed of the wind by timing a small piece of paper blowing along a measured course on the playing field.
- 3 Making and flying a kite.

New words

Anemometer – an instrument used for measuring the speed of the wind.

Beaufort Scale – a method of describing the strength of the wind.

Evaporation – the gradual changing of a liquid into a vapour or gas.

Class management

All of the work on this topic can be carried out by the children at their desks.

Safety precautions

None.

Answers to questions in the text

Moving air (page 68)

Some of the ways in which we make use of the wind include: windmills for grinding corn, pumping water and generating electricity; to provide the driving force for sailing boats, sail-boards etc; for drying washing on a clothes line; to help kites to fly.

Grasses and most trees, as well as a few other plants, use the energy of the wind to carry their pollen from one flower to another of the same kind. Many plants also use the wind to disperse their seeds away from the parent plant.

Looking at evaporation (page 69)

The water from the puddle had evaporated, turning into the invisible gas water vapour, which disappeared into the air.

Now try these

- 1 In the past the energy of the wind was used in windmills to grind corn, to pump water and to power large and small ships.
- 2 There are already some modern windmills being used to generate electricity. Sailing and sail-boarding are popular pastimes, while sail-powered cargo ships are being tested.
- 3 A 'head wind' can hinder a cyclist's progress considerably, while a following wind can help to push

him along. The easiest way the cyclist can reduce the wind's unhelpful effects is to lessen the amount of his body exposed to the wind by bending over the handlebars, as is necessary with racing and other sporting cycles.

- 4 The hottest places in the world are those on and near the Equator, where the sun shines directly overhead all the year round. The coldest regions are around the North and South Poles of the Earth.
- 5 The wet pieces of cloth could be hung up in the classroom, hung out of doors on a dry day, laid over a hot radiator and possibly even 'blow dried' with a hair-drier. It would also be instructive to leave one piece of wet cloth rolled up in a ball. It is not possible to predict which piece of cloth will dry first, it depends upon local conditions.

Expected results of activities and experiments

Evaporation from different shaped containers (page 69)

The water dries up last from the container with the narrowest top. This is because this container has the smallest area of water exposed to the air.

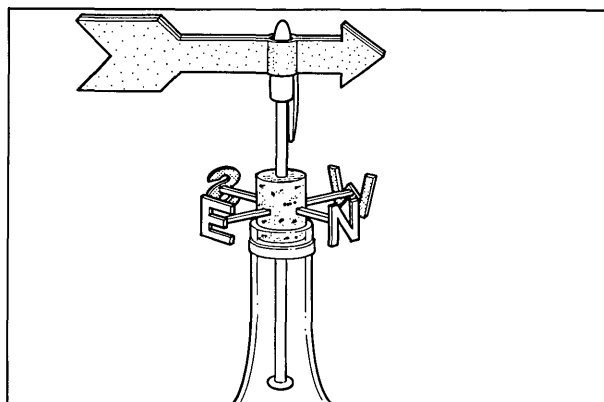
How does the temperature affect evaporation? (page 69)

The water will evaporate fastest from the jar kept in a warm place.

In a windy or draughty place, water will evaporate faster than where the air is still. One way to show this would be to place two saucers, both containing the same amount of water, on a raised, flat surface, such as an old desk, on the playground. While one saucer is left exposed to the wind, the other is placed inside a large open-topped box where it is sheltered from the wind. Water will evaporate faster from the exposed saucer.

Extending the learning

- 1 *Record temperatures* Use a wall thermometer to measure temperatures inside the classroom and outside in the playground. Encourage the children to notice the difference between temperatures in the sun and the shade out of doors. Hang the thermometer outside on a wall in the shade. Ask the children to read the temperature first thing every morning. Keep weekly charts of the temperatures, and compare temperature charts made at different times of the year. Ask the children why they think the thermometer is hung in the shade and not in full sunshine. (Because in the shade it is the air temperature which is being measured, not the temperature of the sun's rays. In exposed places there are considerable fluctuations of temperature while clouds pass over the sun. In addition, in full sun the wall or other object on which the thermometer is hanging will absorb the sun's heat and then radiate some of it on to the thermometer, giving an artificially high reading. All the temperatures given in weather reports are shade temperatures.)
- 2 *Make a wind-vane* Cut two arrows out of thin card. Make them about 30 centimetres long and exactly the same size. Colour the arrows.
Obtain an old pen top and break the clip off. Glue one side of each of the two arrows, and stick them together around the pen top.
Stick four matchsticks into the cork. Cut out four



points of the compass (N, S, E, W) out of thin card. Stick them on to the matchsticks as shown in the illustration.

Put some sand in a plastic bottle to weight it down. Push a steel knitting needle a little way through the stopper of the bottle. Balance the wind vane on top of the needle. If the wind-vane does not balance, weight it with paperclips.

Take the wind-vane outside to an open place. Tell the children which direction is North (or use a compass). Point the N on the wind-vane in that direction.

The arrow on the wind-vane will turn in the wind and show *from which direction* the wind is blowing. Many children do not know that a North wind blows from the North.

Keep a record of the wind direction each day for a month. From which direction does the wind blow most often? From which direction does it blow least often? The children could also record the wind strength each day.

- 3 *Moisture in the air* Keep some pine cones on a windowsill or shelf away from radiators and heaters. Encourage the children to observe how the cones change according to how much moisture is in the air. (The cones open when the air is dry, and close when the air is moist. Do not introduce the term 'humidity' at this stage, though.)
- 4 *Make a windsock* Another way of showing the direction of the wind is to use a windsock, like the ones to be seen at airfields and airports. A simple windsock can be made from an old nylon stocking or one leg of a pair of tights. Cut the foot section away, so that a tapering tube remains. Hold the widest end of the tube open with a circle of thin wire, and use string to hang the windsock from a post in an exposed part of the playing field.

Water in the atmosphere (pages 70–71)

Lesson objectives

- a To describe how rain, snow and other forms of precipitation occur.
- b To explain the formation of dew, frost and ice.
- c To describe the water cycle.

Setting the scene

Possible starting points include:

- 1 A discussion of a display of pictures showing the effects of severe weather conditions.
- 2 Investigate evaporation by using a drinking straw to place one drop of water on a saucer. Time how long it takes to evaporate. Repeat in different parts of the classroom and playground.

New words

Water vapour – the invisible gas which is formed when water is heated.

Crystal – a regularly shaped solid form of a substance.

Water cycle – the process by which water evaporates from the sea, lakes and other wet places and forms water vapour. This cools, falls as rain or snow, and eventually goes back into lakes or the sea. And so the same water goes round and round.

Class management

All of the work on this topic can be carried out by the children at their desks.

Safety precautions

The children should be warned of the dangers of scalding from steam or water vapour.

Answers to questions in the text

Thunderstorms and hail (pages 70–71)

The layers in the hailstone show how many times it ascended and descended through a thundercloud, with new layers of ice being added each time, before it finally fell to the ground.

Dew, frost and ice (page 71)

Frost is formed when tiny droplets of moisture in the air turn into ice crystals when they touch the trees, grass, windows and other cold surfaces.

The water cycle (page 71)

Our drinking water is taken from rivers, cleaned by filtration, and any germs in it are killed with the aid of the gas chlorine, before it is passed to our homes. The dirty water from our homes goes down the drains, into a large pipe called a sewer, and eventually to the sewage works. At the sewage works the dirty water is cleaned by passing it through beds of sand or gravel, after which it is passed into a river or the sea.

We should be careful not to waste water because it is expensive to clean it, and there is only a certain amount of water on Earth. Since we use the same water over and over again, if we poison it, that poison may eventually finish up in someone else's drinking water. The children can read more about these topics in *The Young Scientist Investigates: Water* by Terry Jennings (OUP).

Now try these

- 1 Rain is formed from water vapour which has evaporated from oceans, seas, lakes and other wet surfaces on the Earth. The warm air carrying the water vapour rises higher and higher and is progressively cooled. Soon the water vapour in the air changes back to millions of tiny droplets of water. Although each of these is too small to be seen, many millions of them form clouds. This change of water vapour back to water

is called condensation. Sometimes the droplets in a cloud keep on increasing in size. They join together to form water drops which may become too heavy for the cloud to hold, when they fall as rain.

Some of the rain falling on a mountain will soak into the ground, some will evaporate immediately, but much of it will pass into streams. These join to form rivers which flow down towards the sea again.

- 2 Heavy rain may cause flooding on roads and farmland, and soil erosion on hills and mountains. Ice and snow cause hazards for traffic, and the snow may make it impossible for wild and farm animals to be able to move about and feed. Fog makes it difficult for all forms of transport to move safely, because of the reduced visibility.
- 4 The wettest place in Britain is Styhead Tarn, Cumbria, with an average annual rainfall of 4391 mm. The driest place in Britain is Great Wakering in Essex with an average annual rainfall of 487 mm.
- 5 If ice or snow is packed in a jar, the actual amount of water formed when it melts will depend on the degree of compaction of the ice or snow. However, there is always a smaller volume of water than there was of ice or snow to start with.

Extending the learning

- 1 *Freezing water* Is there any truth in the saying that hot water freezes faster than cold water?

Take two clean yoghurt pots. Fill one with hot water, fill the other to exactly the same level with cold water. Record the temperatures of the two pots of water. Put both pots in a freezer or the freezing compartment of the refrigerator. Examine them every 30 minutes. Which freezes first? (There is no truth in the saying. It will be found that the cold water freezes first.)

- 2 *How raindrops form* You can demonstrate to the children how raindrops form, if you hold a large metal spoon or ladle near the spout of a kettle of boiling water. The children will be able to see how the little drops of water in the steam collect together to form larger drops which begin to fall like rain. This is similar to the process by which raindrops are formed in clouds.
- 3 *Make a simple rain gauge* A simple rain gauge can be made by removing the stopper from a clean washing-up liquid bottle. The top 6 or 7 cm is then cut off the bottle to make a funnel. Invert the funnel on the base of the bottle. Stand the rain gauge in a box of sand or soil to hold it upright.

Place the rain gauge out in the open away from trees and buildings. The children can find out how much rain has fallen each day by measuring the depth of the water in the gauge in millimetres or, better, they can pour each day's rainfall into one of a series of identical tablet bottles labelled with the day of the week.

Checking (pages 72–73)

Thinking

- 1 Wind vanes are sited on the tops of churches or other tall buildings so that they are clearly visible from all directions and are out of reach of the currents and eddies caused by neighbouring buildings.

- 2 The bathroom windows sometimes get 'steamed' up on a cold day after you have had a hot bath because the window panes are cold while the air in the bathroom is warm and filled with water vapour from the bath. Some of the water vapour condenses on the cold glass, forming tiny droplets of water (the 'steam').
- 3 It is cooler the higher above the Earth we go, because the air is not warmed directly by the sun. The sun's rays warm the land and then the land warms the air above it. The higher you go above the surface of the Earth, the more you are moving away from the warming effects of the Earth. As you climb a mountain, for example, the temperature falls roughly 1°C for each 150 metres you climb.
- 4 Plants increase the amount of water vapour in the air. They take water up with their roots and this water evaporates, as water vapour, from the leaves. A medium-sized oak tree in summer may take up 650 litres of water a day from the soil. Most of this water passes into the air, as water vapour, from the leaves.
- 5 If a room is heated, the air in it is also warmed. This warm air is less dense ('lighter') and so it rises. Cold, dense ('heavier') air rushes in to take its place from other cooler rooms in the house and, by way of cracks around door and window frames, from outside. The processes by which these draughts are formed parallel exactly the way in which winds are formed.
- 6 Our ideas of 'cold' and 'hot' are very subjective, and are not only affected by the temperature but also by the season of the year, whether or not the sun is shining, and whether the air is humid or dry, and whether the wind is blowing.
 - a On a very cold day the temperature might be below 2°C.
 - b A cold day might have temperatures of between say, 2° and 7°C.
 - c A cool day would probably have temperatures in the region of 8° to 14°C.
 - d A warm day might have temperatures of about 15° to 20°C.
 - e A hot day in Britain might have temperatures above about 21°C.
- 7 The rain which falls on:
 - a a playing field is likely to soak straight into the ground;
 - b on a house roof will mostly collect in the guttering and pass down pipes into 'soakaways' built in the garden in the country, or down the drains in towns and cities and ultimately into the sewers and sewage works;
 - c a street in a town will mainly run into the gutters, down the drains, into sewers, eventually passing to the sewage works.
- 8 Water vapour is more likely to turn into tiny droplets of water high in the air than it is near the ground, because the air is always cooler in the upper parts of the atmosphere (see 3 above). However clouds of tiny water droplets do form near the ground, when we have misty or foggy conditions.
- 9 It is sometimes warmer and windier in towns and cities than in the country, partly, because of the heat generated and released by offices, shops, factories and

motor vehicles. In addition the concrete, tarmac and pavements of towns and cities, with green trees and grassy areas, absorb more of the sun's heat and retain it much longer. Cooler air (wind) then rushes in to take the place of the warmer air which has risen from these 'hot spots'.

- 10 The water which comes from melting newly-fallen snow in country areas is normally very clean because it was formed by the freezing of water vapour. When water vapour is formed, even from the dirtiest of water, the impurities are left behind. It is possible that, in urban areas, the snowflakes might be contaminated by pollutants in the air as they fall.

Doing

- 1 There are three main ways in which fruits and seeds are dispersed by the wind:-
 - a In some plants such as the white campion, poppies and antirrhinums, the flower stalk is long and the tiny seeds are contained in a dry, hollow capsule with one or more openings. The wind shakes the plant stem and the seeds are shaken out of the capsule.
 - b A number of plants have fruits or seeds with feathery hairs projecting from them like a parachute, which allow the fruit or seed to be blown great distances by the wind. Dandelion, thistle, clematis, willowherb and groundsel are a few of the plants of this type.
 - c Fruits of sycamore, ash, elm, lime and maple trees have wing-like extensions that cause the fruit to spin as it falls from the tree, increasing its chances of being carried away by the wind.
- 2 The clouds which bring rain are known as nimbostratus and cumulonimbus clouds. Nimbostratus are rumpled sheets of low, dark clouds. Cumulonimbus are heaped-up clouds with anvil-shaped tops and ragged, dark, storm-laden bases.
- 3 The wettest place in the world is Mount Waialeale in Hawaii, with up to 350 days with rain each year and an average annual rainfall which exceeds 11455 mm.
The driest parts of the world are the hot, dry deserts. The driest place of all is the Atacama Desert in Chile; in some parts of this arid wasteland, no rain has ever been recorded.
- 4 The source of the River Thames is several small streams among the Cotswold Hills between Gloucestershire and Oxfordshire. Generally its source is said to be at Thames Head near Cirencester, from where the river flows for 336 kilometres to the sea. The distance from the source of the Thames to central London is about 290 kilometres.
- 9 Mist and fog differ only to the degree to which they affect visibility. If visibility is less than 1 kilometre we have a fog; if visibility is more than 1 kilometre a mist is occurring.
- 10
 - a The *atmosphere* is the name for the huge layer of air all round the Earth.
 - b We measure changes in air pressure with a *barometer*.
 - c We call moving air, *wind*.
 - d The speed of the wind is measured on the *Beaufort Scale*.
 - e When water disappears into the air when it is heated, we say it has *evaporated*.

- f Clouds consist of tiny *drops* of water which float in the air.
- g Lightning is a big flash of *electricity*.
- h When water vapour settles on the cold surfaces of grass and stones it forms *dew*.
- i The way in which the amount of water goes round and round is called the *water cycle*.
- j When tiny drops of water in a cloud join together, they may fall as *rain*.

Going further

- 1 Encourage a group of children to work as a team and record the temperature at one hour intervals from 9 am to 4 pm for each day for a week. What is usually the warmest time of the day?

- 2 *How does water get into the air?*

What you need: a saucer; a dessertspoon; a pocket mirror; a plastic bag without holes in it; a potted plant, such as a geranium; string or a rubber band.

What you do: Put a dessertspoonful of water into a saucer. Leave the saucer on a windowsill or near a radiator. What happens to the water?

Fasten the plastic bag over the top of the potted plant with string or a rubber band. Leave the plant on a windowsill. Look at the inside of the bag the next day. What do you see? Where did it come from?

Breathe out onto the mirror. Can you see a film of water on it? Where did it come from?

(Expected results: The water left in the saucer will soon evaporate.

When the inside of the polythene bag is examined the next day, it will be found to have a coating of tiny drops of water. Since these could not have come from the soil, they must have been given off by the plant leaves.

The film of water which forms on a mirror when you breathe on it, has come from inside the lungs. When we breathe out, we exhale not only stale air but also water vapour. We can also see this on a cold day, as the water vapour turns into tiny droplets of 'steam' when it comes into contact with the cold air.)

- 3 *Rainbows* A rainbow is formed when it rains while the sun is shining. The sunlight is spread out into bands of its constituent colours (a spectrum) by the raindrops.

You can sometimes demonstrate how a rainbow is formed in the early morning or late afternoon when it is sunny. Stand with your back to the sun and point a garden hose away from you. Spray water from the hose through the air. Can the children see a rainbow? If they cannot, slowly raise and lower the end of the hose until they do.

Another way to make a rainbow is to stand a goldfish bowl of water (without a goldfish) on a sunny windowsill. Slowly turn the bowl while someone holds a sheet of white paper near it. With luck, rainbow colours will form on the sheet of paper.

A third way is to hold a glass prism above a sheet of paper in sunlight. Slowly turn the prism until a spectrum is formed on the sheet of paper.

The children may also have noticed the colours of the rainbow formed in a soap bubble and in a puddle in the road in which oil has been spilled.

These activities could lead on to further studies on

light and colour.

- 4 Keep a daily weather chart for several months. Use small symbols, like those used in some television weather forecasts, to indicate whether each day was sunny, cloudy, rainy and so on, and what the midday temperature was.

Interdisciplinary activities

Art and craft

Making kites, windmills, mobiles, windchimes.

Painting or drawing cloud formations and windy weather effects.

Foggy, misty and sunny effects in pictures.

Designing clothes for different seasons.

Rainbows and the mixing of coloured paints and lights.

The use of water in cooking, boiling, simmering etc.

Draw or paint patterns based on snowflakes.

Studying how some colours fade in the sun.

English

Weather sayings.

Weather words.

Weather poems.

Folklore and superstitions concerning the weather.

The Country Diary of an Edwardian Lady by E.

Holden.

Creative writing about extreme weather conditions.

Weather Forecasting the Country Way by Robin Page.

Geography

The work of the local water authority.

Weather conditions and the accuracy of weather forecasts.

Climate and weather.

Extremes of climate in different parts of the world.

Hurricanes, tornadoes and cyclones.

Understanding weather maps.

Weather balloons, weather satellites and radar.

Cloud formations.

The effects of rain on puddles, streams and rivers.

Shipping forecasts and sea areas.

Life on weather ships.

Skiing and ski resorts.

The Young Geographer Investigates series: *Polar Regions, Deserts, Mountains, Grasslands, Tropical Forests and Temperate Forests* by Terry Jennings (OUP).

Health and hygiene

Water, air and life.

Clean water, sewage and drainage.

Washing and hygiene.

Clean air, smoking and pollution.

Road safety in bad weather.

Keeping warm, keeping dry.

History

Famous shipwrecks.

The life of Admiral Beaufort.

Windmills and water mills.

Building materials throughout history.

Mathematics

Measuring and recording temperature and air pressure.

Capacity, volume and mass.

Sunshine, rainfall and other weather records.

Simple statistics.

Snowflakes as an example of symmetry.

Music, drama and PE

Wind instruments.

Water, rain and weather sounds.

Water and swimming pools.
Skiing and ice-skating.
Religious education and social studies
Hindus and the River Ganges.
Holy water and baptism.
Jesus calms the storm.

Unit 10: Rocks and the Weather

Aims of the Unit

- a To describe the formation of igneous rocks.
- b To show how rocks are weathered.
- c To describe the formation of new rocks from old.
- d To describe the formation and importance of soil.

Science background

All rocks were originally formed during the period when the Earth was completely molten and then cooled down. A great deal of this fire-made or *igneous rock* still exists, and more is being formed all the time. It is estimated that 90 per cent of the Earth's crust was formed when molten rock (magma) from a layer called the mantle, deep beneath the Earth's crust, cooled and solidified. This molten rock moves up from the mantle and sometimes reaches the surface.

The Earth's crust is not continuous, but is made of at least twenty interlocking sections, called plates, which are in continual but slow movement. Molten rock usually reaches the surface at the points where the plates are either colliding or moving apart. The hot molten rock forces its way out through cracks in the Earth's crust, and forms volcanoes. Igneous rocks are often rich in minerals, and well-known examples of these rocks include granite, basalt and pumice.

Sedimentary rocks are produced from other rocks. The Earth's rocks are continually being broken down, or weathered, by the action of wind, water, sun and ice, into smaller and smaller pieces such as gravel, sand and mud. These products are transported away by the wind or rivers and deposited in layers, most often where a river meets the sea. Similar breakdown of rocks, and transportation of the rock fragments, occurs where glaciers slide down valleys. At the same time the sea is constantly wearing away the land, and changing the coastline, while rivers erode their banks and bottoms, resulting in the formation of ever-deeper and wider valleys.

However they are formed, as the layers of sediment get thicker, the lowest layers of rock fragments become compressed and hardened into sedimentary rock. This can also happen to the remains of dead plants and animals, as when fossils or coal are formed. Most of the Earth's crust is covered by a thin layer of sedimentary rocks such as chalk, limestone, sandstone and clay.

Both sedimentary and igneous rocks can be changed by great heat and pressure into a different form called *metamorphic rocks*. The heat and pressure causing this change can come from hot magma rising deep inside a volcano, or the enormous forces that occur when two of the Earth's plates collide. The two best-known metamorphic rocks are marble and slate.

Sedimentary rocks are formed from the broken down fragments of other rocks. Metamorphic rocks are made when sedimentary and igneous rocks are changed by heat and pressure. In places in the Earth's crust, the existing rocks of all kinds are sucked down into the Earth's mantle, where they melt and mix with the existing magma. This may later emerge from volcanoes as new igneous rocks. These slow but repeated changes from one type of rock to another make up what is called the *rock cycle*.

Soil has been produced from rocks that have been broken down into smaller particles. This breaking down has been caused by the weather and chemicals. Physical weathering is the disintegration of rocks by the action of wind, frost, rain and alternating heat and cold. This kind of weathering generally produces fairly large particles. Anything smaller than sand has generally been produced by chemical weathering, a result of acids reacting with the rock. Rainwater is normally a very weak acid because it contains dissolved carbon dioxide from the air, and decaying plants also produce acids that attack rocks.

A fertile soil contains particles of different sizes, as can be seen if a sample of soil is shaken up with water and then allowed to stand. The particles settle in the order of size, with gravel and stones, settling first, followed by sand and then silt. Smallest of all are the clay particles, many of which are so small that they remain suspended in the water for a considerable time. It is the intermediate-sized silt particles which are present in a fertile soil in large quantities.

The other important constituent of a fertile soil is humus, the dead and decaying remains of plants and animals. These are broken down by invertebrate animals, bacteria, fungi and other soil micro-organisms. These same soil organisms slowly convert the humus into mineral salts, which plants can take in through their roots and use as food. At the same time, humus also improves the soil structure, so that plant roots can grow vigorously.

Books for the children

The Young Scientist Investigates: *Rocks and Soil* by Terry Jennings (OUP).
The Nature Trail Book of Rocks and Fossils by M. Bramwell (Usborne).
Soil by Ed Catherall (Wayland).
The Hamlyn Guide to Minerals, Rocks and Fossils by A. R. Woolley et al. (Hamlyn).
Hamlyn Nature Guide: *Fossils* by Richard Moody (Hamlyn).
Hamlyn Nature Guide: *Minerals* by Andrew Clark (Hamlyn).
The Young Geographer Investigates: *The Earth* by Terry Jennings (OUP).
The Young Geographer Investigates: *Volcanoes and Earthquakes* by Terry Jennings (OUP).

Books for the teacher

Science 5/13: *Early Experiences, Holes, Gaps and Cavities, Change, Using the Environment: 2 Investigations Part 2 and 3 Tackling Problems Part 2* (Macdonald Educational).

Materials and organisation

Like the weather, this topic also has important links with Geography. Outdoor work is a great advantage, but

fortunately suitable subjects for practical study can be found in both town and country.

Materials and equipment:

specimens of natural and man-made rocks
penknives or screwdrivers
steel files
hand lenses
sticky labels
clay, plasticine or papier mâché
paints and brushes
cotton wool
clear glass wine bottles
small plastic tablet bottles
two planks of wood, both the same thickness
Lego or some other building blocks
vinegar
limestone or chalk
clean margarine tubs
plaster of Paris powder
spoons
sticks for stirring
jam-jars
washing-up bowls
tin lids
the use of a refrigerator or deep-freeze
samples of garden soil
cress seeds
blotting paper
spades or trowels
newspaper or sheets of polythene
sheets of acetate or thin perspex
large clear-glass jars
sand, peat or powdered chalk
earthworms
black paper
screw-topped jars
small clean stones
watering can
trays
bicycle pumps
powdered clay and dry sand
funnels, all the same size
muslin or a piece of a pair of tights
saucers
radish seeds

Volcanoes (pages 74–75)

Lesson objectives

- a To show how new rocks are formed by volcanoes.
- b To demonstrate some of the properties and uses of rocks.

Setting the scene

Possible starting points include:

- 1 A display of pictures of volcanoes and volcanic activity.
- 2 A display of pictures showing cliffs, gorges, quarries and other places where rocks are exposed.
- 3 A collection of pebbles or rocks.
- 4 A visit to a museum to look at the Geology section.

New words

Volcano – a weak part of the Earth's crust through which molten rock, or lava, from inside the Earth emerges.

Lava – the hot, liquid rock which comes out of a volcano.

Earthquake – a movement of the Earth's crust which can sometimes cause great damage.

Class management

Although all of this topic, as set out in Course Book 2, can be taught in the classroom, a visit to collect rocks or to look at rocks in use is highly desirable.

If possible, when the children test rocks for hardness, they should be provided with one or two very hard rocks, such as flint, marble or granite, and some soft ones such as clay, sandstone, chalk or even brick.

Safety precautions

When carrying out the scratch test for the hardness of rocks, to avoid injury, the pieces of harder rock should ideally be held in a vice or a gloved hand.

The children should be warned not to go out collecting rocks without the consent of a responsible adult. Quarries, cliffs, cuttings and other such places are particularly dangerous.

Answers to questions in the text

Rocks in towns (page 75)

The plants growing on the brick wall are mosses and lichens. The softest part of the wall is the mortar, since that is where most of these plants are growing.

Old buildings in the country are often not as worn as those in cities and towns, because the air is cleaner in the country. The air in cities and towns contains smoke, fumes and even acids, all of which wear brick, stone and other building materials away.

What we use rocks for (page 75)

Some of the uses of rocks include building materials, gravestones, memorials, statues, bricks, pottery, the surfaces of roads and making fertilizers, cement, concrete, toothpaste and paint. In addition metals come from rocks, so do coal, oil and natural gas. Minerals and precious stones are also obtained from rocks.

Now try these

- 2 The energy of volcanoes, in the form of the hot water which comes from the springs around them, is already being used in Iceland, New Zealand and some other countries, to heat houses, shops, factories, swimming pools and greenhouses. In a few places water is pumped down wells into the hot rocks around volcanoes. The heated water is then removed for use as above.
- 3 Buildings in earthquake areas need to be able to withstand the violent shaking action of earthquakes. The building components need to be as light as possible to prevent or reduce injury as they fall.

When the Japanese earthquake struck in 1923, skyscrapers remained standing while ordinary buildings fell. This was because the skyscrapers had steel frames that were able to sway as the earthquake tremors passed. Nowadays in earthquake zones, new buildings

are placed on solid rock and they have a framework of strong flexible steel. There are few doors and windows, and sometimes the roofs are covered in rubber or plastic pads instead of tiles. The streets are wide so that they are not obstructed or blocked if tall buildings fall, and open spaces are left where people can wait until the danger has passed.

- 4 Fossils are the hardened rock-like remains of plants and animals, or the impressions made by the remains of plants and animals which have since disappeared. Fossils were formed because the plants and animals became covered by mud, sand or silt which later turned into rocks, sometime over a period of millions of years. The rocks most likely to contain fossils are chalk, limestone, sandstone, shale and clay. Fossils can teach us much about plants and animals that lived millions of years ago but are now extinct. They also enable us to see how plants and animals have evolved, or changed, over long periods of time. For example we know, from fossils, that the earliest horse was about the size of a terrier dog.

Extending the learning

- 1 *Make a model volcano* The children can make model volcanoes using clay, plasticine or papier mâché for the cone of the volcano. A tuft of painted cotton wool can be placed in the crater to represent smoke and flames coming from the volcano.
- 2 *Make a collection of sands* Collect samples of a few grammes of sand from as many different places as possible. Put the sand in thin layers in a tall, clear-glass bottle. Many wine bottles are ideal. Alternatively the samples can be kept separate in small clear-glass tablet bottles. Each sample should be labelled saying where and when it was collected.

A collection of soils can be made in a similar way.

- 3 *A model of the centre of the Earth* The children could use different coloured pieces of plasticine to make a model of a section through the Earth, like that on page 2 of *The Young Scientist Investigates: Rocks and Soil* by Terry Jennings (OUP). On the model, show the Earth's core, the mantle and the crust.
- 4 *A model earthquake* The children can gain some idea of how an earthquake is caused if they use two planks of wood, both the same thickness. The planks should be laid side by side, and then Lego or some other building blocks can be used to make model houses across the crack between the plank 'rocks'. The planks are now moved quickly, either horizontally, vertically or both, so that the children can watch the buildings topple.

The children might like to try to make model buildings which are able to withstand a model earthquake.

Breaking down rocks (pages 76–77)

Lesson objectives

- a To describe how rocks are worn down by the weather, moving water and other agents.
- b To describe how new rocks are formed from fragments of old rocks.

Setting the scene

Possible starting points include:

- 1 A collection of polished rocks and stones. It might be possible to borrow a pebble polishing machine and demonstrate to the children how it works.
- 2 Looking at examples of weathered buildings, gravestones, statues etc.
- 3 Make a pictorial graph of some famous mountains to illustrate their relative heights.

New words

Glaciers – rivers of ice which occur in some cold countries and which were once found in Britain.

Stratum – one of the layers of rocks formed originally under the sea. If there is more than one layer the word strata is used.

Class management

All of the work on this topic could be carried out in the classroom, although again outdoor work is desirable.

Safety precautions

The children should again be warned of the dangers of cliffs, quarries, cuttings etc.

Answers to questions in the text

Breaking down rocks (page 76)

The piece of rock which came from the bottom of a stream is the smooth, rounded one. It has been worn smooth by the continual tumbling and rubbing action as the water jostles the pebbles on the bottom of the stream.

The pieces of glass were also worn smooth by the rubbing action of sand, shingle and stones swept backwards and forwards by the waves. The pieces of glass probably came from a bottle dropped from a ship or discarded by some careless holidaymaker.

New rocks from old (page 77)

Chalk is made up largely of minute fossil shells, the remains of sea creatures which lived millions of years ago.

Conglomerate consists of pebbles welded together by a natural cement into solid rock.

Now try these

- 1 The ways in which mountains may be worn away (or eroded) include:
- Frost* Water freezing in crevices, expands and breaks off pieces of rock.
- Ice* Glaciers wear away their valleys with the help of the stones and boulders they push along.
- Heat and cold* Alternate heat and cold causes the rocks to expand and contract, become weakened and finally break.
- Water* Mountains may be worn away by the wave action of the sea; the chemical action of rainwater on chalk and limestone; and the wearing action of pieces of stone and rock carried by fast-flowing rivers and streams.
- Wind* In desert areas, the wind picks up sand and drives it with great force against rocks, breaking off tiny pieces all the time.

Plants The roots of plants grow into crevices, splitting off pieces of rock as they become larger; chemical substances given off by lichens and some other plants wear small hollows in the rocks.

- 5 If a small piece of chalk or limestone is stood in vinegar, the mixture will fizz, as the gas carbon dioxide comes from the chalk or limestone. If enough vinegar is used, the chalk or limestone will eventually dissolve away.

This experiment will also work with a number of other substances including egg-shells, pieces of seashells and pieces of mortar. The children could also test samples of soil to see whether they contain chalk or limestone (many do).

Extending the learning

- 1 **Making fossils** The children can make some 'fossils' of their own, using plaster of Paris.

They should begin by putting a layer of plasticine 1 to 2 cm thick in the bottom of a clean margarine tub. The surface of the plasticine should be smoothed with a flat piece of wood.

Some shapes can now be pressed down into the plasticine. Suitable subjects include seashells, thick leaves, small twigs, or even objects like buttons or keys. These shapes should be carefully removed from the plasticine so that a clear impression of each is left.

Mix up some plaster of Paris in a clean jar. Half fill the jar with water, and add a spoonful of plaster of Paris powder to the water and stir it with a clean stick. Keep adding powder and stirring until the mixture has the consistency of thin custard.

The liquid plaster is then carefully poured into the margarine tub, so that the tub is filled nearly to the top. The plaster should be left for an hour or two or, better still, overnight, until the plaster has set hard. The plastic tub is then broken away, and the plasticine peeled off. The 'fossil' can be cleaned with a soft brush and painted with poster paint or emulsion paint.

Similar plaster casts could also be made of the footprints of tame birds and mammals. The bird or mammal would have to be encouraged to place its foot in a smooth layer of mud contained in a margarine tub. When the mud has dried, plaster of Paris can be poured into the impression, and left to set as above.

- 2 **Building materials** Make a display on the Science Table of the rocks, and rock-products, which are used as building materials.

- 3 **What does frost do to rocks?**

What you need: A small plastic bottle with a screw top (such as a tablet bottle); a piece of sandstone, chalk or limestone; a small piece of concrete; a small piece of brick; a bowl of water; some tin lids. You will also need to use a refrigerator or deep-freeze.

What you do: Fill the bottle completely with water and screw the stopper on tightly. Leave the bottle in the freezing compartment of the refrigerator or in the deep-freeze overnight. What has happened to the bottle the next day? Why is this?

Put a small piece of sandstone, chalk or limestone in the bowl of water overnight. Then place the piece of rock on a tin lid and put it in the deep-freeze or freezing compartment overnight. See what has happened the next day.

What would happen to the rocks on a mountain

when the water in cracks in them froze?

Try this experiment with other kinds of rocks and building materials.

Can you think why, after a really hard winter, the roads and pavements often have large cracks in them? (Expected results: When the water in the bottle freezes, it expands as it turns to ice, splitting the bottle. For this reason a glass bottle should not be used. Similarly when water-saturated rocks freeze, the water in them expands as it turns to ice, causing the cracks in them to widen so that the rocks crumble. Water in small cracks in roads and pavements behaves in a similar way during the winter.)

Soil (pages 78–79)

Lesson objectives

- a To describe the formation and importance of soil.
- b To demonstrate the structure of soil.

Setting the scene

Possible starting points include:

- 1 Sowing seeds.
- 2 A collection of small samples of soil from different places.
- 3 A display of pictures showing crops and other plants growing in fertile and infertile soils.

New words

Fertile – a good soil which grows many plants is said to be fertile.

Humus – the decayed plant and animal remains found in the soil which help to make it fertile.

Class management

All of the work on this topic can be carried out by the children in the classroom. For the activity to show what soil contains, a sample of soil taken from the surface layers of a long-established flower bed or vegetable patch should be chosen.

Safety precautions

None.

Answers to questions in the text

Soils (page 78)

The main reason so few plants grow in the desert is because of the lack of water.

Soil and plants (page 79)

Plants need a deep, fertile soil in which to grow. However, if farmers and gardeners plough or dig too deeply, they will bring the infertile subsoil to the surface, and it is in this that the seedlings or young plants will have to establish themselves.

The pot on the right, with the strong healthy cress seedlings, contains topsoil. The pot with the straggly, unhealthy seedlings contains subsoil.

Now try these

- 2 The simplest and most effective way of making a garden on the side of a hill would be to create terraces – horizontal strips of garden on the side of the hill, each of which is retained by a wall or bank. Seen from a distance these cultivation terraces look like a series of giant steps down the side of a hill. They are common in hilly and mountainous areas where soil erosion is a problem.
- 3 Forests growing on the slopes of valleys prevent soil erosion because the multitudes of tree roots bind the soil particles together. Forests also act like a giant sponge, soaking up much of the rainwater from the soil and releasing it to the atmosphere. It is this latter effect which prevents flooding.
- 4 Cress seeds will indeed grow without soil, although it is difficult to maintain healthy plants beyond the seedling stage without soil or a soil-substitute.

Expected results of activities and experiments

What does soil contain? (page 79)

If the soil sample tested is clayey, it may take several days for the water to clear. Even then, there may still be minute particles of clay suspended in the water.

The largest and heaviest particles sink to the bottom of the jar very rapidly. The smaller and lighter particles sink much later, and the lightest particles of all are the last ones to settle out.

Extending the learning

- 1 *Find out why we dig the garden* Ask two children to dig a hole in the garden with a spade. They should carefully put all the soil they take out of the hole on to large sheets of plastic or thick paper.
The children should then carefully put the soil back into the hole without treading on any of it. Can they get all the soil back into the hole?
If they cannot return all the soil to the hole, ask them what has made the soil take up more room. Why is this important? Would the same thing happen if the garden was being dug normally or if a field was being ploughed? (Digging not only loosens and mixes up the soil, it also allows air into it. It is this air which makes the soil take up more room. Plant roots need this air if they are to breathe and grow properly. Normal digging and ploughing have the same effects.)
- 2 *Make a soil profile* Obtain a tin lid and a sheet of acetate, or thin perspex of the kind sold by garden centres. Roll the acetate or perspex into a cylinder which will just fit neatly into the tin lid. Seal the edges of the cylinder with Sellotape.
Have the children dig a hole in the garden which is as deep as the cylinder is long. They should dig the hole carefully and clean the sides of all loose soil.
Put a little soil from the bottom of the hole into the bottom of the tube. Then take some more soil from a few centimeters from the bottom of the hole and put that in the cylinder. Do this until the cylinder contains a replica of one of the sides of the hole, and so that it shows how the soil in the sides of the hole changes with increasing depth.
Ask the children to examine the soil profile carefully. Where is the darkest soil to be found? (Usually at or

near the surface.) Where is the lightest soil? (Usually near the bottom of the hole.) Where are there most stones? How far down do plant roots grow?

If possible, make soil profiles from other gardens for comparison.

- 3 *How much water is there in soil?* Take a sample of soil and weigh it. Put the soil in a tin lid and leave it to dry near a radiator (or better and quicker, in a warm oven). When the soil is completely dry, weigh it again and calculate the weight lost due to the evaporation of water. Compare other samples of soil, including before and after rain. For the comparison to be fair, either the same weights of wet soil should be used each time, or the results obtained should be calculated as percentages:

$$\% \text{ water} = \frac{\text{loss in weight during drying}}{\text{original wet weight of soil}} \times 100$$

- 4 *Why are earthworms good for the soil?* Make a wormery from a large clear-glass jar. Put in some layers of different coloured soils. See that the soils are fine and not too hard or lumpy. If possible, include thin layers of chalk, sand or peat.

Keep the soil in the wormery moist but not wet. Put in three or four medium-sized earthworms in a sweet jar, fewer in a smaller jar. Lay two or three leaves on the surface of the soil in the jar. Cover the jar with a piece of cling-film in which air-holes have been made. Cover the outside of the jar with black paper, and keep the wormery in a cool, dark place.

After a week, remove the black paper. What has happened to the leaves? What has happened to the layers of soil? What are the burrows like?

Ask the children how they think earthworms help to make the soil more fertile.

(Expected results: With the black paper in place, the worms will make some of their burrows down the sides of the jar where they can be seen. The burrows are just slightly larger than the thickness of the worms.

It is probable that the leaves will have been dragged into the burrows by the worms, where they will decay. Certainly the soil layers will be all mixed up.

The burrowing activities of earthworms mix up the soil. They also allow air into the soil and help to drain it. In these respects, earthworms have the same effects, on a smaller scale, as ploughing or digging the soil. By dragging leaves into their burrows and leaving them to decay, the worms help to produce humus in the soil.

The children may also notice 'worm casts' – soil which has been ground up in the worms' bodies and left inside the burrows or on the surface. The soil in these 'casts' is more fertile than the original soil.)

Checking (pages 80–81)

Thinking

- 1 On the land, the Earth's crust is between 8 and 40 kilometres thick. Below the crust is a layer known as the mantle, where the rocks are so hot that they are molten. The deeper you go down a mine the nearer you get to the mantle, and the hotter it becomes.
- 2 The soil on the tops of hills is often very shallow, while

it is deeper on the lower slopes. This is because, where there are no trees or other plants, rain washes the soil down from the upper slopes so that it accumulates lower down in the valley. In addition, the rocky material eroded from the hill tops also accumulates lower down where, over hundreds of years, it is further broken down into soil.

- 3 Farmers plough the soil in autumn before frosts come, and gardeners dig the garden then, partly because it is difficult to plough or dig frozen soil, but more important because the freezing and thawing action of frosty weather breaks the large lumps of soil down into a fine tilth which is ideal for seeds to be sown in.
- 4 The picture shows part of a rocky valley with a scree slope. After pieces have broken off the rocks high in the mountains because of the action of rain, frost, heat and plant roots, the pieces fall down the mountain sides under the influence of gravity.
- 5 Places where rocks are uncovered so that they can be seen clearly include: quarries, road and railway cuttings, river valleys, gorges and cliffs.
- 6 When a clayey soil cracks in hot, dry weather, the plant roots near to the cracks also dry out and the plants die.
- 7 Buildings decay and crumble for the same reasons that rocks become soft and fall apart. Fallen trees also decay and crumble, but their breakdown is largely due to the action of warmth, moisture and the effects of bacteria and fungi. Iron and steel rust because of a chemical action which occurs when the metal is in contact with both the oxygen in the air and with moisture.

Doing

- 1 Expected results: Fragments will break off the edges of the pieces of chalk, making the water appear coloured. If you leave the jar to stand, the heavier stones will settle out first, then the lighter stones then the larger pieces of chalk, and lastly the lightest pieces of all, the tiniest fragments of chalk.
- 3 Expected results: The sand will blow up into small heaps. They are often crescent-shaped if the pump is held steadily in one place. Dunes such as these would be formed on a beach in dry weather when the wind is blowing along the shore or off the sea.
- 4 Fossils are the remains of animals and plants preserved in rock. They were formed when a plant or animal died and its remains were covered by mud and sand. Over millions of years the sediments containing the fossils were formed into rock. If a plant or animal died and fell into the lava from a volcano its remains would be quickly destroyed by the hot liquid rock. As a result fossils are not found in igneous rocks.
- 5 Stalactites grow *down* from the roof of a cave. Stalagmites grow *up* from the floor. Rainwater is a very weak acid and as it soaks through the ground it dissolves a little of the limestone. But when this water drips from the roof of a cave it can no longer hold the mineral, and the limestone is slowly deposited, particle by particle over thousands of years.
The 'fur' which often builds up in a kettle is also limestone which was originally dissolved when rainwater soaked through rocks and soils containing chalk and limestone.
- 6 a Deep inside the Earth it is so hot that the rocks have *melted* and are liquid.
- b The hot, liquid rock which comes out of a volcano is called *lava*.
- c One rock which was formed by volcanoes is *granite*.
- d Not all rocks are hard, because *clay* and sand are rocks.
- e Some rocks are folded and bent because of *earthquakes* which occurred in the past.
- f Eventually, in thousands of years time, the tallest mountains will have been *worn* down.
- g When water gets into rocks it may *freeze* and make the rocks crack open.
- h Gradually streams and rivers carve *valleys* for themselves.
- i Many of the small pieces of rock washed along by streams and rivers finish up at the bottom of the *sea*.
- j Rivers of ice are called *glaciers*.
- k Over thousands of years, little pieces of rock on the sea bed may be *pressed* and hardened into new rocks.
- l The dead and decaying remains of plants and animals in the soil are called *humus*.
- m A soil which will grow good crops is said to be *fertile*.

Going further

- 1 Ask the children to find out in which parts of the world earthquakes are quite common today. Where are the most important volcanoes? Plot the earthquake zones and active volcanoes on a map of the world. Do they form a pattern? (Yes. Both earthquakes and volcanoes occur in bands where the Earth's crust is weak at the margins of what are known as the Earth's plates.)
- 2 *The differences between a sandy soil and a clay soil* Sand consists of tiny pieces of rock. In clay the pieces of rock are much smaller than they are in sand.
One way to see the difference between a sandy soil and a clay soil is to rest funnels in the tops of two jars. Line each funnel with a piece of muslin or the material from which tights are made.
Half fill one funnel with dry sand. Half fill the second funnel with dry, powdered clay. (Both funnels should be the same size.) Fill up the funnels with water. Watch what happens. What does this test tell you about a sandy soil and a clay soil? Which would be the hardest to dig, a clay soil or a sandy soil?
(Expected results: It will be found that more water runs through the sand than through the clay. The clay retains much of the water, whereas the sand retains very little. The water also comes through the sand much faster than through the clay. A clay soil is the hardest to dig because it is heavy, due to the amount of water it absorbs. Clay will also stick to the spade, whereas sand does not.)
- 3 *Do seeds grow better in sand, clay or soil?*
What you need: Three plastic pots, all the same size; newspaper; sand; clay; garden soil; labels; radish or cress seeds; 3 saucers.
What you do: Make sure that the pots have drainage holes in the bottom.

Put a circle of newspaper in the bottom of each pot. Fill one pot with sand, one with clay and one with soil to within 1 centimetre of the top of each pot. Stand each pot in a saucer. Water each pot until a little water runs into the saucer below.

Sow the same number of seeds in each pot. Sprinkle them over with sand, clay or soil, according to which pot they are in. Label the three pots. Water the seeds every day for a week.

How many seeds grow in each pot? Do the seedlings grow to the same height and colour in each pot? Continue to water the seedlings two or three times each week. What happens to the seedlings in each pot? Which do you think is the most fertile: sand, clay or soil?

(Expected results: The seedlings will grow best in garden soil. They will grow reasonably well in sand, as long as this is never allowed to dry out. The seedlings will grow least well in the clay because, when waterlogged this will not allow the roots to breathe, and when dry it cracks, exposing the roots to the drying effects of the air.)

Interdisciplinary activities

Art and craft

- Drawings and paintings of volcanoes.
- Polishing and varnishing pebbles.
- Painting pebbles.
- Making patterns or models with pebbles.

English

- Creative writing about earthquakes and volcanoes.
- The Roman god Vulcan and volcanoes.
- The Greek god Poseidon and earthquakes.
- The War of the Worlds* by H. G. Wells.
- A Journey to the Centre of the Earth* by Jules Verne.
- Twenty Thousand Leagues under the Sea* by Jules Verne.

Geography

- Volcano and earthquake zones.
- Geology and rock types.
- The Richter Scale.
- Fossils.
- Minerals and precious stones.
- Geology and landforms.
- Surtsey, the new island off the coast of Iceland.
- The Young Geographer Investigates: *The Earth, Rivers, Mountains, Deserts, Volcanoes and Earthquakes* by Terry Jennings (OUP).
- Cave dwellers in the Sahara.
- Soils and soil fertility on a world scale.

Health and hygiene

- The pollution of water by fertilizers and pesticides.
- Fluoride, teeth and the water supply.
- The dangers of cliffs, quarries etc.

History

- Robert the Bruce and caves.
- Caves as Stone Age homes.
- A study of gravestones and memorials.
- Pompeii.
- Other famous earthquake and volcano disasters.
- Building materials through the ages.

Mathematics

- Calculating percentages.
- Measuring the volume of irregular-shaped objects.
- Mapping and scale drawings.

Music, drama and PE

- The use of sand for jumping pits.
- Plays about volcanoes, earthquakes and other natural disasters.
- Religious education and social studies*
- The world food problem.
- Natural disasters and world agencies such as the Red Cross.
- Joshua and the Walls of Jericho.

Unit 11: Death and Decay

Aims of the Unit

- a To introduce the concepts of death and decay.
- b To show how, in nature, nothing is wasted but that the dead or decaying remains of one organism act as food for another.
- c To introduce the concept of a food cycle.

Science background

The waste substances produced by plants and animals, or their bodies when they die, may form food for animals which are known as *scavengers*. Dead plant material, for example, including the leaves, branches and trunks of trees, may be partly or wholly eaten by earthworms, woodlice, millipedes and certain insects. Dead animal matter is eaten by maggots (the larvae of flies), burying beetles, beetle larvae, or birds such as jackdaws, crows and magpies. The dung of animals may be eaten by flies or dung beetles. These scavengers may in turn become the food for carnivorous birds and mammals, which again can be eaten by still larger carnivores. Thus, just as food chains can be constructed which begin with living plant material, similar food chains can be constructed which begin with dead plant or animal material.

Much dead material is not eaten. Instead it decays, due to the activities of bacteria and fungi. These organisms are often described as *decomposers*. They play an important role in returning valuable mineral salts and other materials to the soil in the form of humus, which can then be utilised by green plants once more.

Children often feel disgusted when they consider the lives of scavengers and decomposers, but without the activities of these organisms the world would quickly become littered with dung and the dead remains of plants and animals, and disease would become widespread. In a sense, the scavengers and decomposers are 'nature's dustmen', not only keeping the environment tidy, but also playing an essential role in the recycling of mineral salts and other nutrients, which would otherwise be 'locked up' in the bodies of dead organisms.

Books for the children

The Young Scientist Investigates series: *Rocks and Soil*, *Small Garden Animals*, and *Trees* by Terry Jennings (OUP). *Woodland Life* by G. Mandahl-Barth (Blandford).

Books for the teacher

Science 5/13: *Trees, Working with Wood and Change* (Macdonald Educational).
The World on your Doorstep by Peter Prosser (McGraw-Hill).

Materials and organisation

The concept of 'death' is a difficult one for young children to understand. It is believed that the approach adopted here will help children to understand how the death of one organism can mean life for another. With a sensitive and tactful approach, the non-human examples described in this Unit could be extended to include a consideration of death in humans.

Materials and equipment:-

rotting logs
graph paper
soil from under a rotting log
jars with screw-top lids
rotting logs and fresh ones (ideally of the same size and kind)
large transparent glass or plastic containers, such as sweet jars, fish bowls or aquaria
shingle or small stones
bark and larger stones
compost
mosses
hand lenses
cling-film or transparent plastic
newspaper
tree leaves of different kinds
flower pots, yoghurt pots or jam-jars
moist garden soil
sticky labels
large boxes
large (at least 1 litre) plastic bottles
scissors
wire gauze or perforated zinc
blotting paper or paper towels
decaying tree leaves
desk lamp
a stool or step-ladder
stop-watch (if available)
large sheets of paper or card
carrot tops
saucers
funnels and filter papers
foods such as bread or cheese, and over-ripe fruits such as bananas, apples, oranges or tomatoes
transparent plastic squash bottles
raw liver or lean meat
woodlice or millipedes
small plastic lunch boxes with lids

A miniature nature reserve

(pages 82–83)

Lesson objectives

- a To demonstrate some of the processes involved when a log decays.
- b To describe some of the many living organisms which feed on decaying wood.

Setting the scene

Possible starting points include:

- 1 Bring a small rotting log into the classroom, dissect it on sheets of newspaper, and record the animals living in or on the wood.
- 2 A survey of the life spans of different organisms.
- 3 A litter survey around the school. Ask the children to make lists of the kinds of litter which will eventually decay away, and of those which will not.
- 4 A display of pictures of nature reserves and national parks.

New words

Nature reserve – an area where wildlife is protected.

Class management

It is possible to keep a rotting log nature reserve in an old aquarium or glass- or perspex-fronted box in the classroom. However, the survey of the rotting logs will have to be done out of doors.

It is essential that permission is obtained before rotting logs are examined on, or removed from, private property. When the undersides of logs have been examined for small animals, they must be returned to their exact original position to avoid the death of the animals that live there.

Safety precautions

The children should wash their hands thoroughly after handling rotting logs and before touching food. In addition, it should be remembered that a few species of fungi are poisonous.

Answers to questions in the text

What do you think? (page 83)

- 1 If Kevin keeps his rotting log for a year or two, it will gradually get smaller and smaller as it decays away. Eventually it will disappear altogether.
- 2 There were three kinds of plants growing on Kevin's log: grass, moss and a small fungus.
- 3 The rotting log provides the grass and moss plants with support for their roots, as well as moisture and mineral salts. Fungi are not able to make their own food, and so the fungus obtains all its food and water from the log, as well as being supported by the log.
- 4 Small animals obtain the dark, damp conditions they need from the rotting log. Some of the animals, such as the springtails and woodlice feed on the decaying wood.
- 5 The small animals probably walked or crawled to Kevin's log from decaying wood or leaves nearby. The seeds of the grass and the spores of the moss and fungus plants were probably blown to the log by the wind.
- 6 The small plants help to cause the log to decay away by growing into it with their roots or similar structures (fungi have thread-like hyphae). By removing mineral salts and other foods from the log, the plants also hasten its decay.
- 7 Small animals help the log to rot away by burrowing into it or eating parts of it.
- 8 Water helps to cause the log to decay because the moist

wood encourages the growth of bacteria, which bring about much of the decomposition. In addition, in the winter the water in the log freezes, and as it does so it forces open cracks in the wood, sometimes splitting it.

- 9 The mineral salts which make up the log will eventually pass into the soil as part of the humus. From there they will be used as food by other plants.
- 10 The carnivores or flesh-eaters were the spider and the robin.
- 11 One food chain for Kevin's rotting log is:
rotting wood→earthworm→robin
Another food chain which almost certainly occurred is:
rotting wood→springtail→spider
- 12 Kevin was careful to replace the log in exactly the same position as it was originally, to prevent the log and the ground underneath it from drying out and killing the animals that lived there.

Now try these

- 3 Wood can be prevented from decaying by painting it or by treating it with a wood preservative such as creosote or Cuprinol.
- 4 There are more than 300 species of the tiny insects known as springtails in Britain. None is more than about 5 mm long. They get their name because their bodies end in a forked tail. This is usually bent forwards and fastened underneath the body by a knob which passes between the two arms of the fork. When this knob is contracted, the tail is released, propelling the insects forwards, sometimes by as much as 30 cm. Springtails are scavengers, feeding on decaying plant material. They lay clusters of tiny eggs which hatch into miniature versions of the adults.
- 5 The national organisation in Britain which is responsible for setting up and looking after nature reserves is the Nature Conservancy Council. Many other voluntary bodies own or manage nature reserves including the National Trust, Royal Society for the Protection of Birds and the Royal Society for Nature Conservation. The latter is the organising body of the county naturalists trusts, which have nature reserves in every county.

Extending the learning

- 1 *Examining the soil from under a rotting log* Take two equal-sized samples of soil, one from the garden and the other from underneath a well-rotted log. Repeat the experiment described on page 79 of Course Book 2 to see how the two soils differ. (Normally the soil from under the rotting log will contain a great deal more humus.)
- 2 *Compare a rotting log with a fresh one* Let the children compare rotting logs with fresh logs, ideally of the same kind. Suggest that they compare the weight, feel, smell, hardness, strength and water content of the two logs, and any other differences they can think of.
- 3 *Make a moss garden* Mosses are common plants on rotting logs, the bark of trees, walls, lawns, pavements and other places. There are hundreds of different species.
Any clear, uncoloured glass or plastic container can be turned in to a moss garden, including sweet jars, fish

bowls and aquaria. If possible the container should be big enough for the hands to go in.

Line the bottom of the container with clean shingle or small stones. On top of this put a thick layer of moist compost. Plant out some mosses, putting the taller ones towards the back and the shorter ones at the front. Arrange a few stones or pieces of bark amongst the mosses. Spray the mosses with water and then cover the container with cling-film or clear polythene which has air-holes made in it. Do not let the compost dry out and spray the mosses with water from time to time.

With the aid of a hand lens, the children may be able to see how mosses reproduce themselves (mainly by means of minute spores).

Falling leaves (pages 84–85)

Lesson objectives

- a To describe the process of leaf-fall.
- b To demonstrate the variety of invertebrate animals that feed on decaying leaves.
- c To examine the process of decay in a leaf.

Setting the scene

Possible starting points include:

- 1 A collection of autumn leaves or leaf skeletons displayed on the Science Table.
- 2 Painting pictures of autumn scenes.
- 3 Collecting and pressing tree leaves and noticing how their colour changes as they dry.

New words

Chlorophyll – the green substance which gives plants their colouring, and with which they trap sunlight to help make their food.

Class management

The work on studying the rate of decay of tree leaves will have to be carried out in the school garden.

As mentioned earlier in this Teacher's Guide, it is not essential that children are able to name every invertebrate species they discover. In any case, many of the lesser-known animals have no common names, only scientific or Latin ones. The children could, if they wish, invent names for some of these animals.

Safety precautions

The children should wash their hands thoroughly after sorting the decaying leaves, and before touching food.

Now try these

- 2 Common deciduous trees include willow, walnut, chestnut, poplar, alder, elder, birch, beech, hornbeam, oak, elm, plane, maple, sycamore, cherry, apple, hawthorn, pear, plum, whitebeam, ash, lime, magnolia and larch (a deciduous conifer).
Common evergreen trees include yew, fir, monkey puzzle, cypress, cedar, spruce, hemlock, pine, redwood, holly and laurel.

- 3 One of the factors that causes the leaves of deciduous trees to lose their green colour and to start to form a cork layer across their stems, is the decreasing lengths of the days in autumn. Trees growing near to streetlights have an artificially extended day, and as a result retain their leaves longer.
- 4 The leaves of evergreen trees do not last for ever but are shed from the tree a few at a time, as an examination of the ground beneath the trees will soon reveal. New leaves gradually replace those that fall, so that the tree always appears to be green.

Expected results of activities and experiments

Falling leaves (page 84)

Large leaves fall more slowly than small ones. Removing the leaf stalk usually causes a leaf to fall more slowly since its weight is reduced but its surface area remains almost the same.

Study the small animals found among dead leaves (page 85)

The animals most likely to be found among dead leaves are earthworms, beetles, fly larvae, springtails, earwigs, caterpillars (of moths), centipedes, millipedes, slugs, snails, woodlice, ants and spiders. Exactly which invertebrates are present will depend upon the species of tree leaves being examined and their state of decay.

It would make an interesting investigation to compare the numbers and species of animals present in well-rotted tree leaves of two different kinds.

How fast do leaves decay? (page 85)

It will be found that some leaves decay faster than others. The leaves which decay the fastest tend to be soft, succulent ones such as ash, lime, sycamore, maple and elm. The leaves which are the slowest to decay tend to be the rather tough, leathery ones, such as oak, beech, and pine and the other conifers and evergreens.

The leaves which decay the fastest are also, in general, those which are eaten most by animals. The animals most likely to feed on the decaying leaves are springtails, earthworms, woodlice, millipedes, slugs, snails and the larvae of certain flies.

Extending the learning

- 1 *Study leaf-fall* In the autumn, study the rate at which tree leaves fall. Record the wind-speed and direction, the presence or absence of rain, and other weather conditions, and note whether a few, some or many leaves are falling.
Try to estimate how many leaves fall from a tree during a 24 hour period. Large boxes of known area could be placed under a tree, and the leaves in them counted after 24 hours. If the approximate area over which leaves from the tree fall is known, then the total leaf-fall in 24 hours can be estimated.
- 2 *Extracting small animals from amongst dead leaves* For this activity, a large (at least one litre) plastic bottle is needed. Remove the stopper from the bottle, and cut the bottle right round, about 7 or 8 cm below where the bottle begins to taper towards its neck. Invert this funnel-shaped piece of bottle into the base of the bottle, so that it forms a trap. Cut a circle of wire gauze or perforated zinc which just fits across the narrow part of the funnel. Lay a disc of moist blotting paper or paper towel in the base of the bottle.

Fill the funnel with rotting tree leaves, and stand a desk lamp so that its light and heat fall onto the leaves. Small animals amongst the leaves, seeking to escape from the light and heat, will move down the funnel, eventually falling into the base of the bottle. They can then be examined before being released.

It would be interesting to have several of these light traps, and to compare the number and species of animals living in different kinds of tree leaf litter.

Plant foods (pages 86–87)

Lesson objectives

- a To describe the importance of mineral salts in the growth of plants.
- b To describe the role of scavengers in disposing of the bodies of dead animals.
- c To describe the importance of the recycling of nutrients in nature.

Setting the scene

Possible starting points include:

- 1 Feed a pot plant with a fertilizer, such as BabyBio, and compare its growth with that of an identical plant which has not been fertilized.
- 2 Make a small compost heap in the school grounds.
- 3 Make a display on the Science Table of advertisements and manufacturers' literature on fertilizers.

New words

Fertilizers – chemical substances that are put on the soil to make plants grow better.

Manure – the dung or waste matter produced by farm animals which is put on the soil to make plants grow better. Manure contains mineral salts and it decays to form humus.

Mineral salts – the chemical substances which plants obtain from the soil and use as part of their food.

Class management

Some outdoor work is essential if this topic is to be taught effectively.

Safety precautions

The account of the activity with the body of the bird road accident victim has been included because children often ask where wild birds and mammals die, because they seldom see the corpses. This activity should only be carried out in a school, if there is a secure area of garden to which the children cannot gain access unless accompanied by a teacher. Then the work of covering the corpse and examining it later should be undertaken by the teacher, while the children look on.

The potential dangers of this type of activity should not be underestimated. The DES publication, *Safety in Science Laboratories* states explicitly that 'no British wild mammals or birds, dead or alive, should ever be brought into schools, since they are invariably verminous and many species carry diseases transmissible to man.'

Answers to questions in the text

A compost heap (page 86)

Gardeners build a compost heap partly as a means of disposing of waste animal and vegetable matter they have collected, but more importantly because compost is a valuable fertilizer, decomposing to form humus which improves the soil structure and provides the plants with mineral salts.

A compost heap consists of layers of materials that rot or decompose quickly, such as leaves, grass cuttings, soft garden weeds, tea leaves, animal manure, vegetable peelings, fruit skins, etc. The rotting takes place because of the actions of bacteria and fungi, although some invertebrates, particularly certain kinds of earthworms, also thrive on the decaying organic matter. Often a 'starter' containing nitrogen, lime or other chemicals is added to the compost heap to speed its decomposition, and periodically the heap is turned to ensure that it decomposes evenly.

What happens to dead animals? (page 86–87)

It is believed that the burying beetles, or sexton beetles as they are often known, and other small invertebrate animals, are attracted to corpses by the smell given off by the decomposing flesh.

The maggots would turn into flies of various kinds, but particularly blowflies or bluebottles.

Now try these

- 1 Plant food storage organs were dealt with in Course Book 1. Some examples of storage organs are:
Buds – Brussels sprouts, cabbage, lettuce.
Flower buds – cauliflower, broccoli, globe artichoke.
Leaf stalks – celery, rhubarb.
Leaves – spinach, chives, parsley, onion (a bulb).
Roots – carrot, parsnip, turnip, swede.
Stems – potato and Jerusalem artichoke (both underground stems).
Seeds – broad beans, peas, lentils, nuts.
Seedlings – mustard, cress, bean sprouts.
- 2 The advantages of burning garden rubbish are that any diseased material is destroyed, so preventing the spread of plant infections. In addition, the resulting ash, and particularly wood ash, is a valuable plant food. However, if healthy plant material is composted, the organic matter in the compost will improve the soil structure, increasing the ability of light sandy soils to hold water, while making heavy clay soils more manageable. In addition, as the compost breaks down in the soil it provides valuable plant foods.
- 3 When we use coal, oil or natural gas, or products made from these fuels, we are using the remains of plants and animals which died millions of years ago.
- 5 A carrot top placed in a saucer of water will grow. Initially the young carrot plant obtains its food from materials stored in the carrot top. Later, when green leaves unfold, it is able to make its own food, using water and any mineral salts dissolved in it, carbon dioxide from the air and the energy of sunlight.

Extending the learning

- 1 *Mineral salts in the soil* The children can see examples of the mineral salts which plants use as their food if a

handful of garden soil is placed in a clean jar. Half fill the jar with clean cold tap water, and stir the soil thoroughly. Carefully pour the muddy water into a filter paper contained in a funnel which is resting on another clean jar. The water which comes out of the bottom of the funnel should be perfectly clear.

Put some of this clear water in a clean white saucer. Leave it near a radiator or on a sunny windowsill, when the water will evaporate. A smear of mineral salts will be left around the saucer.

It might be possible for the children to construct their own fair test to see which of two samples of soil contain the most mineral salts. In this case, they would need to use exactly the same amount of each soil and the same amount of water.

- 2 *Moulds and decay* Obtain a number of clean screw-top jars. Place samples of different foods on discs of wet blotting paper or paper towels on the lids of the jars. Suitable foods include bread, cheese, a piece of banana, and an over-ripe apple, orange or tomato. Invert the jars over the foods, and screw them on to their lids. Let the children observe how the foods are gradually colonised by moulds (fungi) of different kinds, as the foods slowly decay away. The children could draw coloured pictures of the succession of moulds on the different foods.

It is suggested that, on the grounds of safety, the children do not open these jars or even touch them, but merely observe through the glass. When the experiments are finished with, ideally the jars should be put straight in to the dustbin. If the jars are needed, then they should be washed in a strong solution of a household disinfectant, by an adult.

It is instructive to carry out similar experiments using the dung of horses, goats, rabbits, guinea pigs, or other domesticated herbivores. However, even more stringent security and hygiene is necessary if this is done.

- 3 *Make a fly trap* A fly trap can be made by removing the stopper from a clean transparent plastic squash bottle, and cutting the bottle in half, using a saw or an old bread-knife. Invert the neck of the bottle into the base, so that a trap with a funnel-shaped opening is formed.

Place a piece of raw liver or lean meat in the base of the trap and stand it on an outside windowsill, where the children can observe what happens. How long is it before flies are attracted by the smell of the meat? What kinds of flies are they? How many flies are caught?

At the end of the day, release the trapped flies, and observe how soon it is before maggots, which have hatched from eggs laid by the flies, start to feed on the meat.

Try baiting the trap with other kinds of animal food, such as fish, canned dog meat, cat food and so on, and compare the results.

Checking (pages 88–89)

Thinking

- 1 If trees did not fall to the ground and decay when they died, soon the countryside would be smothered with dead as well as living trees. Before long, there would be insufficient room for the roots of the living trees to

grow, and the soil would quickly become infertile since all the plant foods would be locked up in the trunks of the dead trees. Eventually all the trees would die and would not be replaced.

- 2 If an oak tree is cut down, the insects which have wings would probably be able to fly to another oak tree, if there is one nearby. But with no means of travel and deprived of their living food, all the insect larvae would die.
- 3 If the small animals which feed on dead and decaying wood became extinct, soon the ground would be littered with fallen tree branches and trunks. The soil in woodland areas would become progressively less and less fertile, as the plant foods normally recycled by the decay of tree parts remained locked in the undecayed wood.
- 4 If you compared how much water is absorbed by, say, a small piece of oak and a small piece of ash log, you would have to ensure, first of all that the two logs were exactly the same size. It would then be necessary to see that both logs were completely dry, perhaps by putting them on a radiator or in the airing-cupboard for a few days. Ideally both should be weighed, dried and then weighed again until they lose no further weight.

The weights of the two dry logs should be recorded and then they should be completely immersed in a bowl of water for say, 24 hours, blotted dry, then weighed again. The increase in weight is the amount of water absorbed by each log.

If it is not possible to make the two logs exactly the same size, the amount of water absorbed could be expressed as a percentage of the original dry weight of each log.

Doing

- 1 There are three species of woodpecker in Britain: the largest is the green woodpecker, next the greater spotted woodpecker, followed by the lesser spotted woodpecker.

It is not possible to describe them all in detail here, but they all peck deep holes in rotting tree trunks with their powerful, pointed bills. They cling to the trunks with the aid of their tail-feathers, which are very stiff and can be pressed against the tree. The feet are adapted for climbing trees, with two toes on each foot pointing forwards and two backwards. A woodpecker's skull is fitted with a shock-absorber system to take the strain as the bird hammers its beak against tree trunks.
- 2 In the autumn a collection of fungi could be made and displayed on the Science Table. A few species are poisonous, however, and if the children handle any specimens they should wash their hands thoroughly afterwards.

A useful book for identifying fungi is *The Oxford Book of Flowerless Plants* by F. H. Brightman and B. E. Nicholson (OUP).
- 3 The following are approximate average life spans of the animals listed:
 - a cat 14 years
 - b dog 13 years
 - c hamster 2 to 3 years
 - d African elephant 50 years
 - e human, male 68 years; female 73 years.

f Tortoise 25 to 150 years, depending on the species

- 4 It would be worthwhile to collect the advertising literature of such firms as Rentokil.

The children could carry out a woodworm survey around their homes and gardens. A block graph of the findings could be made, showing the places where woodworm infestation was found, and how many examples of each there were.

Other insects which eat timber in old buildings and feed on the wood of living and dead trees include the larvae of the death-watch beetle, the powder post beetle, the stag beetle, and the caterpillars of the goat and leopard moths. The larvae of the yellow-legged clearwing moth, and several species of beetle bore under the bark of trees. The most notorious of these latter is the elm-bark beetle which is responsible for spreading Dutch elm disease which has destroyed so many of Britain's elm trees.
- 5 Most *Pleurococcus* grows on the wettest side of the tree trunk. This could be proved by fixing a small container on the side of the tree trunk where there is most *Pleurococcus* and another small container on the side of the tree with the least *Pleurococcus*. Check the containers regularly to see which collects the most rain water.
- 6
 - a Small plants like *mosses* and fungi may live on rotting logs.
 - b In the autumn, the leaves of many trees and other plants begin to lose their green colour as the *chlorophyll* in them breaks down.
 - c The *soft* parts of a leaf decay first leaving a leaf skeleton.
 - d As plants grow they take up chemicals called *mineral salts* from the soil.
 - e Manure comes from the buildings where *animals* are kept.
 - f Farmers put manure and *fertilizer* on the soil.
 - g The only things we on Earth can get from space are *light* and heat from the sun.
 - h When animals die, their bodies may be *eaten* by other animals.
 - i As plants and animals decay away they become food for *bacteria*, fungi and other simple plants.
 - j Food substances are used over and over again in what is called a *food cycle*.

Going further

Do woodlice or millipedes eat rotting wood?

What you need: 4 or 5 woodlice or millipedes; some blotting paper or paper towels; a jar or small picnic box with a lid; a piece of rotting wood.

What you do: Lay wet blotting paper or paper towels in the bottom of a jar or picnic box. Lay a small piece of soft, wet, well-rotted wood on the wet paper. Put 4 or 5 woodlice or millipedes in the jar or box, and put the lid on. Keep the container in a dark place overnight.

Look at the wood every day for the next few days. Has any of it been eaten? If so can you find a way to measure how much wood the animals have eaten?

Do woodlice or millipedes like some kinds of rotting wood more than others?

Do woodlice or millipedes eat rotting leaves? Do they

like some kinds of rotting leaves more than others? (Expected results: Most species of woodlice and millipedes will eat rotting wood, although they do have preferences for different types of wood and different levels of decay.

The only accurate way to measure how much wood the animals eat is to carry out weighing experiments, but it is essential that the wood contains the same percentage of moisture before and after the experiment.

Woodlice and millipedes do eat rotting leaves, including tree leaves. However they seem to prefer the softer leaves of ash and sycamore rather than the tougher leaves of oak, pine and beech.

It would be interesting to find out whether woodlice and millipedes eat the soaked shells of hazel nuts, walnuts, and Brazil nuts.)

Interdisciplinary activities

Art and craft

- Collages from sawdust and shavings.
- Wood carving and wood-cuts.
- Driftwood sculpture.
- Leaf prints.

English

- 'Birches' by Robert Frost.
- Out of the Wood* by Graham Underhill (OUP).
- Charlotte's Web* by E. B. White.
- Folklore and legends about woodlice.
- Regional names for woodlice.
- Epitaphs.

Geography

- The Kon-Tiki balsa wood raft.
- Trees in towns.
- Tropical rainforests and shifting cultivation.
- Termites or 'white ants' as pests in the tropics.
- The formation of coal, oil and natural gas.
- The Young Geographer Investigates: *Tropical Forests* by Terry Jennings (OUP).
- The Young Geographer Investigates: *Temperate Forests* by Terry Jennings (OUP).

Health and hygiene

- The decay of food and its preservation.
- Bacteria and disease.
- Burial and cremation.

History

- Burial mounds, tumuli, pyramids etc.
- Burial rituals.
- Tombstones, gravestones and mausoleums.
- Life spans from gravestones.
- Brass rubbings.

Mathematics

- Calculations of life spans and longevity.
- Calculation of percentages.

Music, drama and PE

- 'John Brown's body' (song).
- 'Dry Bones' (song).

Religious education and social studies

- Vandalism of trees.
- Burial and cremation as religious expressions.
- Burial rituals.
- Life expectancy in the developed and developing worlds.
- The Crucifixion.
- The celebration of Easter.

Unit 12: The Changing Countryside

Aims of the Unit

- To describe some of the changes which are taking place in the countryside and the effects these changes are having.
- To show how the increasing world population is causing air, water and noise pollution.
- To describe how pollution and the destruction of habitats are leading to the extinction of many plant and animal species.

Science background

This Unit aims to show children some of the factors which are changing our environment, mostly adversely. The main aim of conservation is to allow people to enjoy the benefits of modern civilisation, without destroying living things in the process. In other words, conservation aims to achieve harmony between people and their surroundings.

Some of the threats to the world's wildlife and wild places have been for no significant purpose. Tigers and jaguars, for example, have been hunted almost to the point of extinction to produce such luxury ('unnecessary') items as fur coats, while countless thousands of elephants have been slaughtered for the sake of ivory ornaments and chess sets. Whales have been killed to provide food for pets or, even worse, to provide the basis for certain cosmetics.

Much of the damage to our British countryside has been caused by farmers. This is particularly true of the removal of hedges, the uprooting of woodlands and forests, the draining of marshes and ponds, and the ploughing of moorlands and heaths. The widespread use of chemical fertilizers and pesticides have produced their own problems. However, the children should not be encouraged to look upon farmers as villains. Much of the damage to the countryside has been caused as farmers sought ways, under government encouragement and help, to produce more food for the rapidly increasing world population. The tragedy is, that while Europe now has to cope with massive agricultural surpluses, much of the developing world goes hungry.

Our increasing demands for energy and consumer products have brought problems of noise, and the pollution of air and water. The benefits of having more, better and faster cars, for example, can easily be cancelled out by the additional noise, atmospheric pollution, and dangers to other road-users.

Conservation is too large and too important a topic to be dealt with adequately in such a small space, but it is hoped that the introduction given in this Unit will help the children to exercise greater consideration for their environment, and that they will begin to question what effects their own activities have on other people.

Books for the children

The Young Scientist Investigates series: *Energy*, *Air* and *Water* by Terry Jennings (OUP).
The World of a Hedge by Terry Jennings (Faber).
Conservation Today by Terry Jennings (Kaye and Ward).
The Young Ecologist by Neil Arnold (Ward Lock)

Books for the teacher

The Sunday Times Countryside Companion by Geoffrey Young (Guild Publishing).

The Amateur Naturalist by Gerald Durrell (Hamish Hamilton).

Environmental Education Sources of Information (Department of Education and Science).

The World on your Doorstep by Peter Prosser (McGraw-Hill).

Materials and organisation

This is an enormous and vitally important topic for us and for the children, now and in the future. Fortunately, there are many relevant films, television programmes and other teaching aids available, and no school is far away from a nature reserve.

Some of the many sources of help and information include:

Royal Society for Nature Conservation,
The Green,
Nettleham,
Lincoln, LN2 2NR.

Watch Trust for Environmental Education Ltd, (Watch)
The Green,
Nettleham,
Lincoln. LN2 2NR. (A national environmental club for children.)

Royal Society for the Protection of Birds, (RSPB)
The Lodge,
Sandy,
Bedfordshire. SG19 2DL. (Has a junior branch, the Young Ornithologists' Club.)

World Wildlife Fund,
29–31 Greville Street,
London EC1N 8AX.

Council for Environmental Education,
School of Education,
University of Reading,
London Road,
Reading, Berks.
RG1 5AG.

The Council for Environmental Conservation,
Zoological Gardens,
Regent's Park,
London NW1 4RY. (Coordinates 30 national environmental organisations.)

Materials and equipment:-

long tape measures
bamboo canes or sticks
gardening catalogues
bait for pitfall traps
plastic squash bottles
large (at least 1 litre) plastic bottles
desk lamp
scissors
yoghurt pots
rubber bands
white paper tissues

cigarette
ash-tray
white saucer or plate
large sheet of white card
coloured card
filter papers
funnels
bottles
measuring jug
nets
washed sand
washed gravel
soil
cotton wool
clean flowerpots
jam-jars

Vanishing hedgerows (pages 90–91)

Lesson objectives

- a To introduce the history of hedgerows and the reasons for their removal.
- b To demonstrate the methods for aging a hedge.

Setting the scene

Possible starting points include:

- 1 Ask the children to compare pictures showing countryside consisting of a mosaic of small fields and hedgerows, with modern landscapes consisting of huge fields separated by wire fences.
- 2 Make a display of pictures of hedges and hedgerow plants and animals.
- 3 A discussion on 'factory farming'.

New words

None.

Class management

Outdoor work is an essential part of this topic. It may not be possible to find ancient hedgerows in towns and cities where the aging activity can be carried out, but the formal hedges in town parks and gardens can still provide a useful subject for other studies.

Safety precautions

In the country, hedgerows often become a dumping ground for old cans and bottles, and the children should be warned of the dangers of injury from these objects.

Answers to questions in the text

Vanishing hedgerows (page 90)

Many hedgerows have been dug up to make larger fields, on which the huge modern combine harvesters and other machines can be used more easily and more efficiently. In addition, most farmers now specialise, and for many the need for hedges to enclose farm animals no longer arises.

Many farmers prefer barbed wire or electric fences instead of hedges because there is no need for annual trimming or cutting, and the fences do not attract litter in

the way that hedges seem to. If a fence is in the wrong place, it can be easily moved. This is almost impossible to do with a large hedge.

Now try these

- 1 A good hedge grows thick and strong at the bottom. If the bushes are allowed to grow unchecked, they become tall and straggly, with large gaps at the bottom that people and farm animals can push through. When a hedge is 'laid', the height is trimmed and a cut is made half-way through some of the longer branches. These are bent over at the cut, and woven into other branches which are cut in the same way and bent in the same direction. Stakes are stuck in the ground if needed, to reinforce the hedge.

A fuller account of hedge management is given in *The World of a Hedge* by Terry Jennings (Faber).

- 2 The advantages of keeping hedges in farming areas are that they look attractive, they provide a haven for wildlife, they help to prevent wind-erosion of the soil, and they provide shelter for farm animals and prevent them from straying.

The disadvantages of hedges in farming areas are that they may make it difficult to manoeuvre large machines, they may become a dumping ground for rubbish, they may harbour plant diseases and animal pests of crop plants, and they need regular and expensive maintenance and cutting.

- 3 Some of the wild plants with the word 'hedge' in their names include:

hedge mustard (also found on roadside verges and waste ground)

Jack-by-the-hedge (also found in woodland and on roadside verges)

hedgerow cranesbill (also found on waste ground)

hedge parsley (also found on roadsides and waste ground)

hedge bedstraw (also found in grassland)

hedge bindweed (also a weed of bare and waste ground)

hedge woundwort (also common in woodland)

- 4 An electric fence consists of one or two strands of wire supported by insulating posts. It works from a 6 volt battery, a car battery, or from the mains via a transformer which produces an intermittent high voltage. An animal touching the wires receives a mild electric shock and soon learns to avoid the fence. An electric fence is very quickly erected and easily moved. It is particularly useful in ensuring that cows and other grazing animals completely clear one strip of grassland before they move on to another. In the meantime, the grazed strip of grassland can be given a chance to grow again, fertilized by the dung and urine left by the cows.
- 5 Some of the shrubs used to make garden hedges include berberis, box, chamaecyparis, cotoneaster, escallonia, spindleberry, holly, laurel, lavender, privet, firethorn, honeysuckle, yew, beech, fuchsia, hawthorn, hornbeam, lilac, rose and snowberry.

Expected results of activities and experiments

Aging a hedge (pages 90–91)

The principle behind this method of estimating the age of a hedge, is that when a hedge was originally planted it

almost certainly consisted of one, or possibly, two shrub species. It has been found that it takes an average of approximately 100 years for each extra shrub species to become established in the hedge.

When carrying out this kind of study, it is important to avoid sections near the ends of the hedge, near gateways, and also hedges which adjoin woodland. All of these can give inaccurate results.

Make a hedge survey (page 91)

Unless there is another hedge very close by, when a hedge is removed, those animals which are unable to fly or to walk long distances will almost certainly die. The plants will definitely die, although some of their seeds may be left to colonise any suitable ground.

Extending the learning

- 1 Arrange the children in groups. Ask one child to imagine that he or she is a farmer, another a naturalist, and others a holidaymaker, an artist and finally the person in charge of the county's roads. Encourage the members of each group to discuss how they would feel about cutting down all the hedgerows in the local area.
- 2 Make a survey of hedgerow shrubs, trees and other plants, ideally in autumn, to see how their seeds are dispersed.
- 3 Use pitfall traps to find out which species of invertebrate animals live under a hedge. If possible make comparisons, either of the one hedge at different seasons of the year, or of two different hedges.
- 4 Use the light trap described on page 171 of this book, to investigate the invertebrate animals which inhabit the leaf litter under a hedge.

Our changing world (pages 92–93)

Lesson objectives

- a To describe some of the effects of the increasing world population.
- b To describe some of the causes and effects of air pollution.

Setting the scene

Possible starting points include:

- 1 A discussion of the advantages and disadvantages of living in the country rather than in a town or city.
- 2 A display of pictures showing the different kinds of pollution.
- 3 A discussion of what is meant by 'noise', with examples.
- 4 A discussion of the benefits and the disadvantages of motor transport.
- 5 A discussion of the kinds of pollution children might meet with every day, and what could be done to stop these forms of pollution.

New words

Pollution – the fouling of air, water or the land by wastes, smoke, chemicals or other harmful substances. Noise is another form of pollution.

Class management

This topic is in many ways easier for children in town and city schools to study than it is for those who live in the country. In rural areas, the most air and noise pollution is generally to be found near main roads.

Safety precautions

The children should wash their hands thoroughly after handling the tissues or leaves used in the air pollution experiments.

Now try these

- 1 Using the figures on page 92 of Course Book 2, there will be roughly 73 million more babies in the world by this time next year. Of course these will be partly compensated for by the number of people dying, but there will still be a dramatic net increase in population.
- 3 In the home, double glazing or cavity wall insulation will help to reduce the levels of noise from traffic, aircraft etc. Carpets help to reduce the noise made by people walking about. The use of earphones means that music or radio programmes need be heard only by those who want to hear them.

Excessive noise at work can be reduced by sound-proofing buildings and machines, and by compelling workers to wear ear-muffs or ear-plugs.

- 4 Some people seem to smoke because it makes them feel grown up. Others say they obtain pleasure from smoking, and that cigarettes help them to relax and 'soothe their nerves.'

There is a well-proven link between the smoking of cigarettes, and lung cancer and other diseases of the heart and lungs. Smoking during pregnancy can also damage the unborn child. In Britain each year about 100,000 people die from diseases caused or aggravated by smoking.

Expected results of activities and experiments

An experiment on air pollution (page 92–93)

The more polluted the air, the dirtier the tissues will be.

The tissue that Richard James put on the windowsill of his house in a small village is the one on the left. The tissue from the windowsill of his grandmother's flat in a large city is the one on the right. We can tell because this tissue is the dirtier of the two.

Extending the learning

- 1 *Smoking and air pollution* Allow the smoke from a smouldering cigarette, contained in an ash-tray, to rise onto a white saucer or plate held above it. After a few minutes there should be a dark stain on the saucer or plate, which will enable the children to see some of the pollutants from cigarette smoke which accumulate in the lungs of smokers.
- 2 *The costs of smoking* Ask the children to calculate how much money would be saved in a year if someone who smokes 20 cigarettes a day gave up smoking. What would be the saving over 10 years?
- 3 *How much dirt is there in the air?* Lay a sheet of white card in a corner of the classroom where it can remain

undisturbed for a month. Cut out twenty discs from coloured card. Each disc should be about the size of a 2p coin. Arrange the discs on the white card. It is a good idea to draw a line round each disc, and to number it and its position on the white card. Every day remove one of the discs. Compare the colour of the white card where it was covered by the disc with the area around which was not covered. Repeat this experiment in different parts of the school.

- 4 *How much dirt is carried in rain?* Put a filter paper in a funnel, and stand it in a clean bottle. When rain is expected, stand the bottle out on the playground or playing field. After the rain, examine the filter paper carefully, with a hand lens if needs be. Look for signs of dust, smoke, ash and other forms of air pollution washed down by the rain.

Dirty water (pages 94–95)

Lesson objectives

- a To describe the causes and effects of water pollution.
- b To show the effects of the dumping of litter.
- c To describe the causes of extinction.

Setting the scene

Possible starting points include:

- 1 A film or television programme about the effects of oil pollution on sea birds.
- 2 A display of pictures showing the effects of water pollution.
- 3 A litter survey in the vicinity of the school.
- 4 A discussion for and against wild animals being kept in zoos and wildlife parks, or appearing in circuses.

New words

Extinction – the process by which a species of plant or animal dies out, so that there are no more members of it left.

Adapt – the way in which animals and plants change to suit or fit in with their surroundings.

Class management

All of this topic, as set out on pages 94–95 can be carried out by the children at their desks. However, if possible, visits should be arranged to carry out litter surveys or to examine polluted water. Ideally, a visit should also be made to a zoo or wildlife park to observe endangered animal species.

Safety precautions

If a litter survey is carried out, the children should be warned not to handle the litter. If polluted water is investigated, the children should wash their hands thoroughly if they touch the affected water.

Answers to questions in the text

Dirty water (page 94)

Some oil pollution is accidental, as for example when a

ship collides with another or runs aground. However, much oil pollution is deliberate, when tankers use sea water to wash out their cargo tanks. To do this is illegal, but it is very difficult to catch the culprits. The only realistic way to stop this kind of thing happening is to educate ships' captains, so that they realise the consequences of their actions.

It is difficult to know why people dump their rubbish in the country like this. Presumably it must be a result of either laziness or ignorance.

Extinction (page 95)

The animals and plants shown in the picture are British endangered species. They are: Isosceles dragonfly; Swallowtail butterfly; Fritillary or Snake's Head; Wartbiter grasshopper; Smooth snake; Dartford warbler; Alpine catchfly; Red squirrel; Spring gentian; Natterjack toad; and Otter.

Now try these

- 2 The pollution of the sea by oil, tar, rubbish or sewage means that beaches are unpleasant to use, clothing is damaged, and there is the possible health hazard from germs contained in the sewage. Fishes and shellfish used for human food may be killed by the oil or tar, or contaminated by the sewage. Perhaps the biggest risk to humans comes from the fact that the bodies of the fish and shellfish we eat may accumulate poisonous metals and chemicals dumped in the sea.
- 3 Biodegradable litter, such as newspaper, apple cores, orange peel and so on, will gradually rot or decay away. The worst kinds of litter are the various forms of plastic materials, many of which are not biodegradable and will last for ever. However, some biodegradable forms of plastic wrapping for sweets and other foods are now being developed.
- 5 In most areas the rubbish we put in our dustbins is used to fill large holes caused by mining or quarrying. This is a way of reclaiming derelict or neglected land. Many large cities sort the metals from the rubbish for re-use, and burn the rest. This can, however, pollute the air. In a few cities, the burning of rubbish is carefully controlled and the energy produced is used to heat buildings or to work power stations. In a few cases the metals and plastics are sorted for re-use, while the biodegradable materials are used to make a compost that is sold to gardeners and farmers. Some towns take their rubbish to sea in barges and dump it, which of course pollutes the sea and often results in the litter being washed up on beaches elsewhere.

Extending the learning

- 1 *A litter survey* If the school is in a quiet location, it might be possible for the children to carry out a litter survey in the surrounding streets. They could make a table with the main kinds of litter written across the top, eg. glass, drinks cans, cigarette packets, sweet wrappers, crisp bags, ice cream wrappers, lollipop sticks, orange peel, apple cores, and other litter. Down the left-hand column are written the names of the streets surveyed.

When the table is complete, the children will be able to see which are the most common kinds of litter, and in which streets they are deposited. They could look for the nearest litter bin and see whether it is full. A

discussion could take place as to which kinds of litter found are biodegradable, and which are not.

- 2 *Wasting water* Find a dripping tap, or turn on a tap so that it drips. Measure how much water is wasted by a dripping tap in an hour. Let the children estimate or calculate how much water would be wasted if the tap dripped for a day, a week, and a year.
- 3 *Studying water pollution* The extent to which streams and rivers are polluted can be estimated by using a net and recording the invertebrate animals which are caught in it. The level of pollution of the particular stream or river can be read off the following scale (ideally the children should be given a chart bearing pictures of the key animal species):

<i>Invertebrate animals present</i>	<i>Level of pollution</i>
Mayfly larva; stonefly larva	None
Caddisfly larva; freshwater shrimp	Slight
Water louse; bloodworm	Medium
Sludge worm; rat-tailed maggot	Bad
None of these found	Very bad

- 4 *Making dirty water clean*
What you need: Washed sand; washed gravel; cotton wool; a clean flowerpot; 2 jam-jars; soil; water.
What you do: Put a layer of cotton wool in the bottom of the flowerpot. On top of the cotton wool, put a layer of clean washed gravel and then a layer of clean washed sand.

Shake up a little soil in a jar of water to make the water muddy.

Stand the flowerpot on top of a clean jam-jar. Slowly and carefully pour the muddy water into the flowerpot.

What is the water like which comes out of the bottom of the flowerpot?

A large filter like this is used at the waterworks to clean water for us to drink.

If you shake up salt with water, can you remove the salt from the water with the filter? If you add food colouring to water, will your filter remove the colouring?

Do you think a filter could remove oil or a poisonous chemical which had been dropped in water?

(Expected results: A filter such as this will only remove insoluble substances, such as soil, from the water. It will not remove salt, food colouring or poisonous chemicals. It would probably remove most oil, since this is insoluble in water.)

Interdisciplinary activities

Art and craft

Drawings or paintings of endangered plants and animals.

Drawings, paintings or models of dinosaurs and other extinct animals.

Making dyes from hedgerow leaves and berries.

Making bird nest boxes.

English

Stories about hunting and circuses.

Creative writing about pollution.

Oxford Junior English: 2 *Food and Farms* and 3 *The Coastline* by Oliver Gregory (OUP).

Geography

The spread of acid rain.

Soil erosion.

Fossils and extinction.
The distribution of National Parks in Britain.
Game Parks and National Parks in Africa and North America.
Stone walls and field enclosures.
Health and hygiene
The value of fresh air and pure water.
Noise and hearing.
Water safety.
Smoking, the lungs and air pollution.
Poisonous hedgerow plants.
History
The extinction of the dodo.
Buffalo Bill, buffalo and the North American prairies.
The Enclosure Acts.

Compare old maps with present-day ones to study the extent of hedgerow removal.
The Industrial Revolution.
Mathematics
Simple calculations about population increase.
Graphs of population change.
Calculations on the cost of smoking.
Music, drama and PE
Hunting songs.
Religious education and social studies
Vandalism and trees.
Factory farming.
The world food problem.
Noah's Ark.
Performing animals.

