SCIENCE IN A TOPIC

TEACHER'S GUIDE

DOUG KINCAID

PETER S. COLES

HULTON

SCIENCE IN A TOPIC
Teacher's Book

To Roy:-

26.2.85.
Best Wishes.
Doug.

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A TEACHER'S GUIDE TO THE SERIES

DOUG KINCAID
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HULTON EDUCATIONAL

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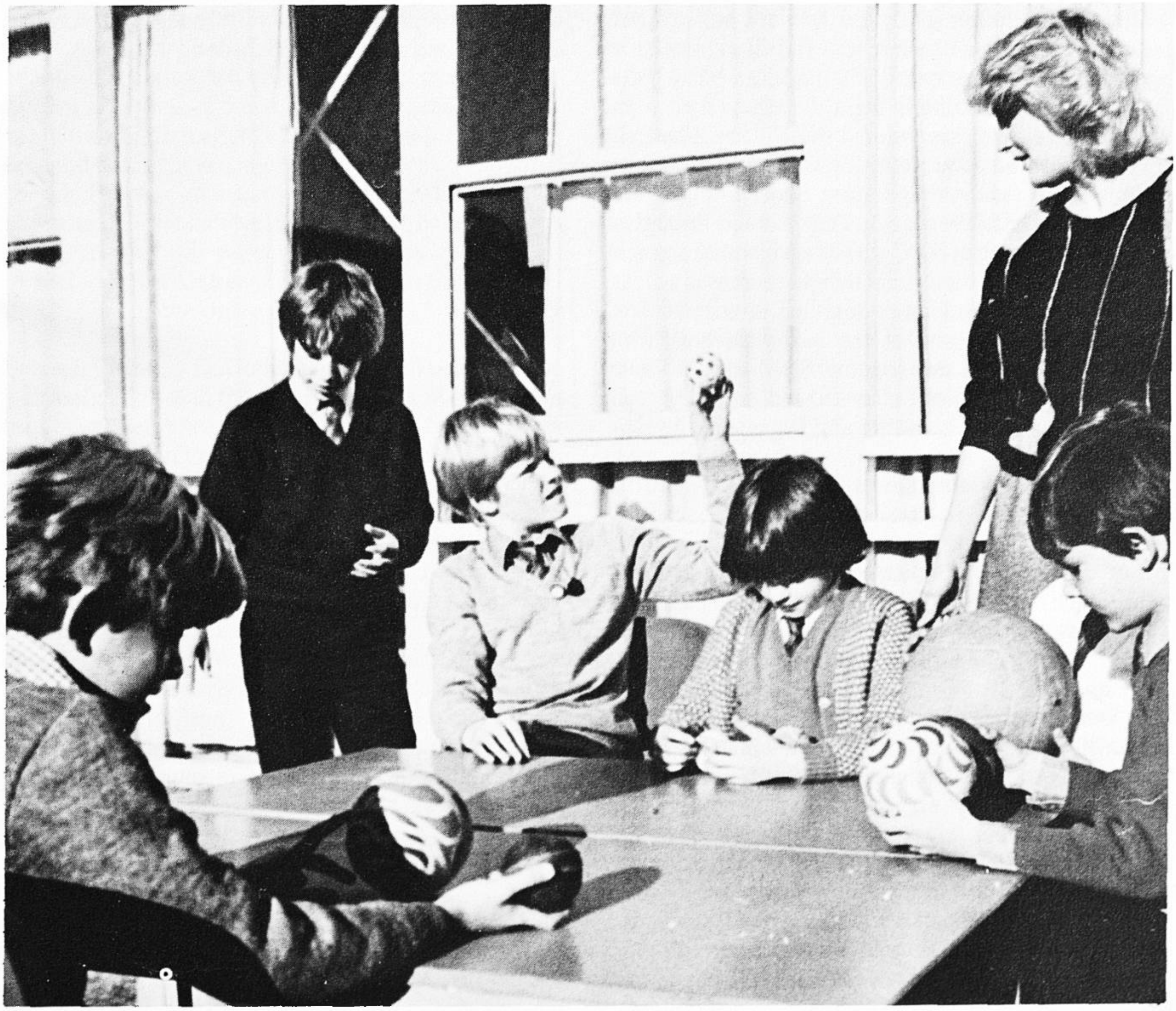
INTRODUCTION

Miss Carol taught mixed ability ten-year-olds. Her school often used stimulating collections and displays as starting points for children's work.

As it was Olympic year there was a lot of interest, and the classroom walls were covered with sports stars, maps showing the countries taking part and the journey of the Olympic flame. Miss Carol started her class off with a collection of balls used in different sorts of games—football, tennis, cricket, rounders, golf, table tennis, bowls, squash, croquet—and there was also a wide variety of rubber balls. The collection kept growing as the children added to it. There was much discussion. What games were they used for? What other things were used in these games? Who were the famous players, where were the games played, when and where did the games start?

A science investigation started with an obvious question, 'Which ball would bounce best?' They tested them. The test had to be fair, so they dropped them from the same height and measured the height of the bounce. The difficulty in measuring this bounce made them think they should make several



'Miss Carol' introducing the theme of the ball investigation.

observations for each ball. There were other questions. They wondered if the surface would make much difference. Would the balls bounce twice as high if they were dropped from twice the height?

The tests were nearly finished when David said that his Dad played squash, and that the coloured dot on the ball meant that it was 'fast' or 'slow'. Miss Carol in mock disbelief questioned him, 'How can a coloured dot make any difference?'. Could he prove it? The bounce test they had just done did not show a difference. He thought a bit and then explained, 'The squash ball is really whacked at the wall.' They soon found that throwing the balls at a wall was not really a fair science test. They needed to find a way of firing them.

The first effort was a dismal failure, as the ball just managed to trickle off the table end. It was back to the drawing-board to modify and remake. The final tests were a great success. Then Helen ventured, 'My Dad plays squash too, and he told me that you really have to warm the ball up before you can start the game.'

'First it's coloured dots and now it's warm balls bounce better! I don't believe it.' Miss Carol was once again provoking response. The children tried balls from the fridge and balls from the oven, then with Miss Carol's help they refined their ideas. The ball was put into hot water for two minutes and then tested. The water temperature was dropped ten degrees and the test repeated. They worked through a temperature range of 80°C to 0°C and plotted a graph of their results. To their great delight there was a clear correlation between temperature and bounce.

Miss Carol was one of the many teachers who helped to trial and develop the *Science in a Topic* materials. The children also showed how they can play a vital part in extending and suggesting investigations.

Working on an integrated study has always been a popular approach in primary and middle schools. Although this seemed to result in excellent work in history, geography, English and art, it rarely included real scientific enquiry. Even when teachers claimed to have included science, this was often only English comprehension about the 'stuff' of science, rather than children working as scientists. *Science in a Topic* was developed to encourage and help teachers to include a vital first-hand experience which embraces the skills, processes and methods of scientists within their classroom work. It was written to encourage all primary teachers to organise science within the normal activities, rather than allowing it to be regarded as a separated, sterile session. By working with science as a part in an integrated study, the teacher can deal in a more realistic way with the organisation of practical science activities. Instead of having thirty-plus children all doing a set science lesson—with the problems of limited apparatus, a fixed amount of time, and no reference to individual children's interests—a class, working on a common theme, can be divided into groups. These individuals, pairs or larger groups can first be briefed on some of the wider aspects, which may impinge on other disciplines such as history and geography. Social surveys could be planned where appropriate. Once this work is set pupils can go ahead with little demand on teacher time. The teacher can then devote attention to helping children to set objectives and then plan and control their investigations and tests. As the topic progresses, more groups can work in this way.

Teachers who often are put off by the idea of Science with a capital S feel much more confident within their more familiar chosen themes.

We are grateful to all the children and teachers in Buckinghamshire and Berkshire who have contributed to the production of this series by trying out ideas and sharing them with others.

CLOTHES AND COSTUME

Section One, p.5. The work suggested in this section has proved a successful starting-point for the topic. One teacher duplicated outline pictures of people through the ages. The children each chose one that interested them, coloured it in, and then went on to find out: When and where did these people live? What kind of house and home did they have? How did they travel? Which famous men and women were alive at that time? Some children kept a 'diary' for one of these people for a week.

Section Two, p.9. This section on raw materials involves studying the origins and manufacturing processes of the various fibres. Some preparation to enable the children to undertake the geographical and historical aspects of the topic, once organised, would mean the children could occupy themselves with less demand on teachers' time. In practice this meant that the teacher was able to organise those things which she valued more: an investigative, first-hand research approach. For this aspect of the study *Finding out from Books*, by Andrew Fergus, Hulton Educational, 0 7175 0751 3, can prove most helpful.

Section Three, p.17. Understanding and using a *key* is a classification skill that is very important. Usually it requires observation only, the matching of specimens to diagrams and/or descriptions, to arrive at an identification. Here is an opportunity for children to participate in the key-making. Fibres and threads are tested, using *all* appropriate senses. A dossier of information can be compiled and used to compare and identify unknown threads. (This particular activity could be extracted for 'detective work' in another topic 'The Police'.) The seven variables (a) to (g) on p.19 are a basis for passing on the test to other children, who can also experience measuring strength and dealing with forces. However, they will *not* merely be repeating a test, rather choosing a fresh investigation with an unknown outcome. The experiment on p.20 could be done on a larger scale and metre-lengths tested (see p.58 *Roads, Bridges and Tunnels*). p.21 links with art and craft.

Section Four, p.23. Children who have not had much experience of reading a scale may find it difficult to use a thermometer. It is worth taking time to ensure that your pupils can read the thermometer accurately. Do pay attention to the sentence in the middle of p.24: 'Leave one unwrapped—why?' This idea of a control in an experiment is fundamental to science. The work on pp.24 and 25 should be linked with safety rules when outdoor pursuits are involved. P.28: Make sure that you discuss the meaning of 'a fair experiment', that is, the amount of water in the pots, each sample being immersed to the same depth at the same time.

Section Five, p.29. Use this page to discuss examples of special clothing, e.g., parents' work clothes, those seen on TV, and in normal surroundings. Museums often have displays of such clothing. This helps to put the work that follows into a real-life context. All section title pages in the book can similarly promote discussion. There is a gallery in the Science Museum, South Kensington, London, which is devoted to special clothing.

Section Six, p.37. The measuring activities on p.38 provide a means of looking for links and relationships. For example, does the heaviest person have the largest foot area? Is there a link between age and shoe size? P.39 gives children a practical experience which brings in the idea of pressure—a difficult concept, as it involves force and area. p.40: Friction experiments rarely go according to the text books. The truth of the children's own observations, however, is what really matters.

Section Seven, p.41. The observation that it is attraction that takes place in both static electricity and magnetism often gives rise to confusion in children's minds. Instead of dealing with both phenomena in an electricity/magnetism science lesson, the setting of these tests within the separate context of 'clothing' will help to avoid this frequently occurring confusion with magnetism. When experimenting with static electricity it is better to have a dry atmosphere.

Section Eight, p.45. The test on p.46 is a splendid example of children working as scientists. They are involved in dealing with several possible variables. Everything should remain constant except the washing powder. One group even insisted that they should use the *same* spoon for measuring the powder. Many texts treat surface tension as a 'skin on water'. The activities on pp.47 and 48 will help children towards the more useful concept of surface tensions as forces. A feature of this series is that *measurement* is encouraged wherever possible. Often children are expected to measure unusual things. P.49 gives an interesting example, using soap flakes to measure the hardness of water. P.50: *Take care with bleach*; it is poisonous and can damage skin, eyes and clothes.

Section Nine, p.53. 'Dyes and Dyeing' has proved to be a most popular and worthwhile activity. Initially there will be great excitement as dyes are obtained from unexpected sources and used to colour cloth. Do go on to encourage the investigations; there are six enquiries at the foot of p.54. These provide an opportunity for pupils to be involved, and encourage them to work as part of a science team.

Section Ten, p.57. The moth life-cycle on p.59 could well link with the earlier suggestions on p.12 of rearing silkworms. P.60: Some burning tests might seem dangerous. It is important that children come face-to-face with potential danger and are taught safe and reliable ways of using equipment which could entail risks. They will, inevitably, have contact with matches; we all need to ensure that they have due respect for such hazards and are given safety training. The samples used must be small, and this activity *must* be closely supervised.

Section Eleven, pp.61, 62. Scientists have to gather and sort data and information. This often leads to questions and further investigations. A coral necklace could lead to extraction of information about the Great Barrier Reef, and about the life story of coral. Tiger's eye jewelry is relatively inexpensive and p.63 shows how a school has taken materials like this and polished and mounted them. A stone polisher is sometimes available on loan from a Teachers' Centre. Polishing stones is quite a popular hobby, and there may be a chance to invite a knowledgeable adult into school to demonstrate and talk about the craft.

Equipment and Materials

*denotes equipment to be made

Section One: *no special apparatus is needed.*

Section Two: wools, stretch apparatus*; methylated spirits, silkworm-rearing cage*; microscope, force meter (newtons), balsa cement.

Section Three: fibres/threads (a variety of wool, cotton, nylon, silk, terylene, linen), microscope, burning apparatus, metal tray, tongs, lamp with flame, strength test apparatus*; micrometer, stretch test apparatus*; elastic, lens, cloth stretch apparatus*; fabric samples, magnifying glass, knitting needles, simple frames for weaving. Note: The use of an asbestos tray is no longer recommended (p.18).

Section Four: thermometer, electric kettle, cans or plastic squeezy bottles, funnel, a variety of insulating materials, fan or hair-dryer, candle, variety of fabrics, some thin and open-weave, two tins—one painted matt black, one matt white, aluminium foil, dropper, plastic bag, balance*, stand for absorption test*, yoghurt pots.

Section Five: variety of materials (some open-weave, some close-weave), white paper, 'dirt', ink, oil, force meters, large tins, bottle and eye-dropper, pressure apparatus (manometer)*; paints, card, and paper for camouflage experiments.

Section Six: tape measures, bathroom scales, pressure apparatus*; friction board, blocks and materials, e.g., linoleum, carpet, cork, wood, plastic, concrete, ice, grass; force meter, bucket of sand.

Section Seven: static electricity test materials (listed pp.42, 43 and 44), test tube, glue, cork, four pins, 15cm pointed stick; polythene and ethulon plastic sheets, electroscope or home-made equivalent*; anti-static rinse products for use in washing machines.

Section Eight: washing powders, white cloth (old cotton sheet), substances for stains, ink, fruit juice, oil, tea; thermometer, dropper, jars, yoghurt pots, pieces of cellophane, waxed paper, cloth, plastic, aluminium foil; balance*; soap flakes, household detergents, squares of materials, razor blade, starch, washing soda, bleach, coloured liquids, distilled water, pieces of rigid plastic sheet, squeezy bottle, spin drier*; old electric iron, 34swg nickel chrome wire plus electric circuit.

Section Nine: natural materials for dye extraction (see p.52), thermometer, pieces of old cotton sheet, plus wool, linen, rayon, nylon for tests, mordants (alum, salt, Iron II sulphate), water of different hardnesses.

Section Ten: wooden blocks, sandpaper, cloth samples, nail in wood strip, burning apparatus; for flame-resistant tests: salt, alum, borax.

Section Eleven: bowl, gravel, gold(!) or, more realistically, brass filings, gauze, (possibly) stone polisher.

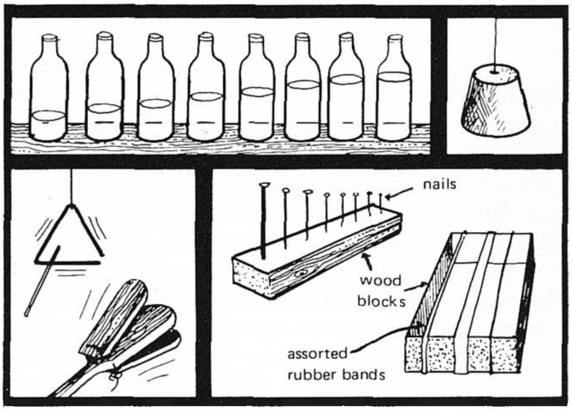
Back Cover: *spinning wheel**.

COMMUNICATION

Section One, p.5. This section introduces the wide scope of the topic. Many children are stamp collectors. Themes like 'The Royal Mail' and 'Stamps' have proved profitable starting-points and link in well with 'communication'. Many schools have parents who are willing to talk with children and demonstrate their special interests. Following up the idea of 'pigeon post', several schools have had pigeon-keepers bring birds to school, let the children examine them and see them released to return to their loft. Pp.6 and 7: This test with colours on different backgrounds can be linked with road signs and advertising. Some children may be able to devise ways in which their micro-processor can help produce and break codes, using those on p.8.

Section Two, p.9. The section title page could bring in aspects of communication relating to (a) geography (see map); (b) drama and mime (see lip-reading and hand-language); (c) R.E. (study of the Tower of Babel story). P.10: An important connection is made between science and language, leading on to the notion of classification in science. Simple research projects feature eminent scientists and important systems. P.11: Codes and signs could lead on to work on road signs (*Highway Code*) and international signs, as seen at airports. P.12: Further extensions could be: warning, attracting and sorting. A colour sorting comparison is suggested in *Learning through Science* pack, *Colour*, Macdonald Educational, 356 07550 8.

Section Three, p.13. The section title page poses the question 'What is sound?'. From the experiences that follow, children appreciate that sound is *vibrations.* Something always moves to make sound. P.14: There is no substitute for real experience, and although the exploration of sound *is* a noisy affair, it *is* worth while. P.15 provides three welcome quieter investigations. The last problem sets out to think of ways to test how sound travels through water—and may puzzle children. Two suggestions: they could use a swimming pool and ring a bell under water, while they duck below the surface, or fill a balloon with water and place it against their ear, with a watch held on the other side. P.16: The string telephone is a well-



Some suggested sound-makers

tried favourite. Children have shouted into the mouthpiece, and been heard across a playground without a *telephone*. The six questions, (a) to (f), should be a challenge to make real use of it as an investigation. They will need to think all the time about a 'fair' test and to control the variables. P.17: The bottle experiment will help to reinforce the idea of vibration producing sound. When the bottles are tapped, the bottle and water vibrate. When air is blown across the top, the air column vibrates. Thus the scale is opposite, and the larger the amount of air, the lower the note.

Section Four, p.19. This section title page can be linked with pages 11 and 24. Here is a chance to link science with art work. One school did some excellent work when challenged to use colours *only* to depict an idea, e.g., 'jealousy', 'toothache', 'laughter', 'spring' and 'pain'. This link between science and art could be extended; reference to Leonardo da Vinci the great scientist/artist would be appropriate. Look at various painting styles, e.g., Georges Seurat and pointillism, and so to modern colour printing. Let the children look at a picture in a magazine with a lens to see how the reproduction is built of coloured dots. An opportunity to experiment with various ways of mixing and applying colour would be good. Try mixing and applying colour with various media, e.g., water, oil, paste, tempera. Try applying with other means than the usual brush, e.g., a roller, cotton wool, crumpled paper, a sponge.

Pp.21, 22, 23: The light-box could be borrowed from a friendly secondary school. The very different results of mixing pigments and mixing light are surprising, even to many adults. It is important for children to realise that the spectrum is continuous. Newton 'invented' the *seven* colours, because he had an obsession with the number seven. It would be interesting to ask your children to name the colours *they* see.

Section Five, p.25. The experiences suggested in this section have given many children a feeling for the problems of blind people. As a result of this work, one school invited visitors from the Royal Institute for the Blind to attend their morning assembly, and another invited a blind man with his guide dog.

Pp.26 and 27: The emphasis here on looking for links and patterns is important. To collect data, and simply stop at that, is not science. Encourage the science, take the further step. To find that there is *no* link is itself an answer. Children will need help to appreciate this.

Section Six, p.29. Many schools who have used this topic let children try the various writing methods depicted. Pp.31 and 32: Chromatography is one of the most widely-used separative techniques in science. A further extension could be to try different papers, e.g., kitchen towels, blotting papers, newspaper and paper towels. 'Detective work' is also possible: ten different black felt pens—'who wrote the ransom note?' A comparison of the separations could pinpoint a particular make of pen.

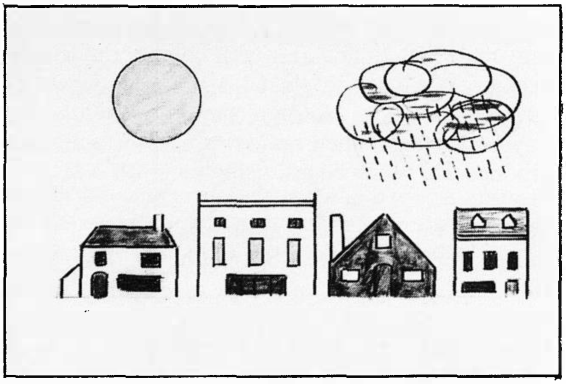
P.33: One child wrote to pencil manufacturers after this experiment, asking why there was a difference in the conductivity. The firms replied that they made pencils to draw with, and nobody had ever asked about electricity! They did explain that the harder pencils had more clay and the softer pencils more graphite; it was the graphite that conducted electricity. P.34: Further work on paper is included in the *Learning through Science* pack, *Materials*, Macdonald Educational 356 07551 6.

Section Seven, p.35. It can be interesting to find out which newspapers children have heard of, and simple studies of contents—including advertising—can be made, comparing different papers. The manufacture of newspapers is another subject for investigation. A visit to a local printing works might also be arranged. Children and teachers could make many interesting mirror study cards. Those on p.37 give only a foretaste of what is possible. Here is another example:

4

Use your mirror to make a street that has four houses and two storms.

- two houses and one big storm.
- one house and one sun.
- if you make eight houses what is in the sky ?



Section Eight, p.39. Children enjoy this section. The whole idea of flashing and buzzing seems to have great appeal. Some basic electrical circuit work may be needed. Pp.48 and 49 of *Houses and Homes* will help. There would be possibilities for extensions to this work into flashing lights, where else they can be spotted, e.g., lighthouse, car indicators, warning hazard lights, aeroplanes, pedestrian crossings.

Children have electronic sets, and someone may be able to make an electronically controlled flashing device. The study could include library research about Samuel Morse and the telegraph, and such historical uses as the arrest of Crippen, the sinking of the *Titanic* and distress calls, and the story of submarine cables, so to teleprinters and perforated tape transmitters.

Section Nine, p.43. The telegraph and telephone introduction is used to develop work with magnetism.

Pp.44 and 45: It is important that children have access to a wide range of various magnets. Then questions and problems will arise. *Nuffield Junior Science* told of the boy who defined a magnet as 'a piece of metal painted red, with an N on one end'. For building sound and accurate scientific concepts, a wide-ranging experience is necessary. It is important that the pre-thought/prediction process is carried out, as suggested on p.45. On pp.46 and 47 there is a lot of valuable experimental work, but it is essential that children have first had experience with magnets and basic electric circuits. These pages may be best kept for use with older children, as with pp.48 and 49 which are colour-designated as advanced work.

Section Ten, p.51. Research into the questions posed on this section title page will enable the children to discover the development of the story of photography. The first 'camera' was discovered in the tenth century A.D. by Arabian scholars. They found that light entering through a small hole in the wall of a darkened room cast an upside-down picture of the scene outside on to the opposite wall. This principle became known as the 'camera obscura', literally a 'dark chamber'. Library research about Thomas Wedgwood, Sir John Herschel, Louis Daguerre, William Fox Talbot and George Eastman will 'put them in the picture'. A science or photographic club could go into the developing and printing processes. Discussion could arise and examples of some of the applications of photography could be collected. They include press, work studies, medical, radiography, microfilm; and in science, time lapse and ultra-fast photography provide invaluable records. For success with a pinhole camera (p.53) the black shield is vital; it is often overlooked. Many children own cameras and should be encouraged to use their science to take better photographs.

Section Eleven, p.55. Historical research into the development of radio and television could be undertaken. The building of a radio is designated as advanced work; perhaps suitable for a science club.

Section Twelve, p.59. Communication is an aspect of animal study that children often have not encountered or considered. The study of animal behaviour is comparatively new, and is being dealt with increasingly, particularly in television natural history programmes. Careful observational work on pets should be encouraged. For bird studies, especially of water fowl, a visit to a reserve such as Slimbridge in February/March, when courtship displays can be seen, will be fascinating.

Observations of birds around the school and in gardens will also provide opportunities to see bird 'language' at work.

An awareness of the fact that animals can communicate in a variety of ways will be a satisfactory outcome of this study.

Equipment and Materials

*denotes equipment to be made

Section One: large tin*; coloured papers; invisible inks: dilute copper sulphate solution, cobalt chloride solution, milk, lemon juice, vinegar, salt solution.

Section Two: no materials required.

Section Three: for sound-makers and musical instruments: bottles, wood and metal pieces, boxes and rubber bands, large nails, wires, tuning fork, rods of wood and metal, hose and funnels, pin, tin, plus piece of balloon; for string telephone: strings, cups, tins, boxes.

Section Four: art materials (paints, paper, brushes); light/ray box, possibly borrowed.

Section Five: 'feely' boxes and bags, odd objects, screws, coins, cubes and spheres, etc; sandpaper of various grades; cork, plus three panel pins, warm water, containers; A feely maze*.

Section Six: a quill feather for pen-making; dropper, pots, filter/blotter/chromatography paper, containers; pencils, grades 6B–6H, electric circuit; paper tissues to saturate and pulp for paper-making, fine mesh and mixing bowl.

Section Seven: mirrors; newspapers; test stands*.

Section Eight: *electric apparatus (bulb-holders on blocks, switches)**; batteries, bulb-holders, wood for bases.

Section Nine: magnets, a variety, plus collections for testing, see p.45; electromagnets, wire (cotton/plastic) covered copper 26–30swg, soft iron rods, electric circuit, compass; resistance wire tests: nickel chrome 34swg, nickel chrome 26swg, constantan 26swg, copper 26swg (to enable the comparisons to be made under control).

Section Ten: light-sensitive paper (obtainable from an office supplies firm), card, tin with black paper sleeves; lens.

Section Eleven: Radio building, parts as listed on p.57.

FOOD

Section One, p.5. A useful starting point and organisational aid for this topic is the link with geographical and historical studies. Adults working with groups at cooking activities could be a first stage in this topic. P.5: This could be expanded into the nutritional aspects of food—which foods provide energy and which are needed for healthy growth. The role of proteins, carbohydrates, fats, minerals and vitamins could be discussed, and the big issue of healthy eating and diet raised. The environmental studies aspect of 'Shops and Shopping' suggested on p.8. has started much interest. Children have been surprised to learn of the revolution in shopping styles through grandparents—parents—and even within their own lifetimes.

Section Two, p.9. Bread-making (see inside front cover) is an activity which junior children should have the chance to try. Note also the variables suggested on p.15. P.11: Wheat seed is readily obtained from health shops, pet shops and seed merchants and will germinate within a few days. Here is an opportunity to encourage children in a responsible, sustained study, as measurement of the plants' growth will take a period of weeks. The investigation could be extended by studying the effects of: depth of sowing; crowding; the use of fertilisers (a) mixed with soil, (b) sprinkled on top. Controls and 'fair' tests will have to be dealt with. P.12: There will be surprise at the force needed to grind the corn. Millers speak of the first and second 'break'. The meaning of this will become apparent. P.14: The strength of flours is important to bakers. With some flours the dough will not hold the gas bubbles, and would result in an unacceptable texture. Tests similar to these suggested to the children are carried out on each batch of dough by the large bakeries. P.15: Yeast is a living plant, a fungus. In certain conditions it grows, and in so doing produces carbon dioxide. Here the children have a chance to observe this, and experiment with varied conditions. In break-making, when temperatures reach about 55°C, the yeast is killed, so that the gas-producing process is halted. P.16: Caution is needed when using iodine. This test is used again on pp.60, 61.

Section Three, p.17. 'Under the cow hangs the milk, which is arranged for milking. When people milk, the milk comes and there is never an end to the supply. How the cow does it I have not yet realised.' So wrote one nine-year-old. Another, when visiting an Environmental Studies Centre, upon seeing cows in a field, asked if they were concrete. It emerged that the only cows he had seen were concrete models in Milton Keynes. This section title page might, therefore, stimulate worthwhile discussion. P.18: Note that the flames round the saucepan are merely an artist's *symbol* for heat; also on p.25 warn children that the gas should *never* be turned up to that degree. P.19: The bacteria tests on milk should not be undertaken unless there is a laboratory with the appropriate facilities. In an ordinary classroom it would be dangerous. The making of butter and cheese is popular with children—as Lewis Carroll had the Dodo state, 'Why! the best way to explain it, is to do it.'

Each of the books in the series features a great scientist. The story of Louis Pasteur's work is an excellent study, as it so well brings out the scientific approach.

Section Four, p.23. After discussion of this page the children may like to try a 'Can you tell sugar from saccharine?' test. P.24: This is always a popular test. Some less able children who were carrying out the 'Can you tell the flavour, *just* by taste' test, came to a boy who complained, 'It's no use me doing it, I've got a cold.' Their response was, 'We're not going to stick it up your nose!.' This led to the question, 'Is he saying that because he cannot smell, he cannot taste?'. Experiments were then devised to test this theory. (See also pp.34 and 35.) P.25: It is useful to make a sugar collection similar to that depicted, for children then see how a great variety of things can be described under one category. P.26: The first experiment is showing *osmosis* (the flow of a solvent through a semi-permeable membrane; the solvent always flows from the weaker to the stronger solution). The process is not defined by name here. The crystal-growing is extended on p.32.

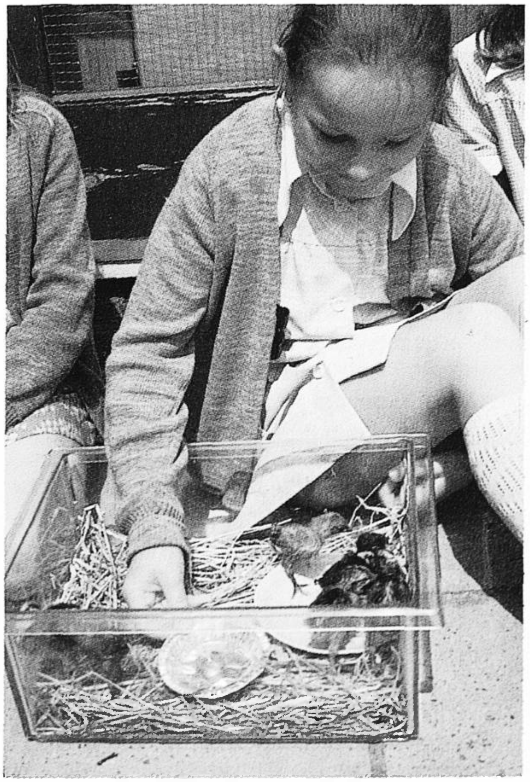
Section Five, p.27. There are many other sayings and references to salt, and researching them could lead to further reference-book studies. P.28: This deals with dissolving. Extension work could include: 1. rate of dissolving; 2. the effects of temperature; 3. the effect of stirring; 4. looking at other kitchen food powders, to find which are soluble and which are insoluble. P.29: This page once provided a whole term's work, as follows. The heaviness of other liquids led to ideas of density and weighing liquids. Floating and sinking in different liquids led to ideas of upthrust. Measuring the density of liquids led to making hydrometers and using them (see *Ships*, pp.16, 17). Layering the different coloured liquids was fun. P.30: Two important science techniques are introduced: filtering and evaporation. Other uses of these methods of separation could be looked for. Examples are: tea bags, air filters in cars, drying washing, and puddles drying up. P.31: Crystal-growing is fascinating, but meticulous care and patience are needed. Both are worthwhile attitudes to encourage.

Section Six, p.33. A herb 'garden', grown either in small garden plots or in pots, would be a worthwhile project for some boys and girls to undertake. Pp.34, 35 and 36: Children will enjoy doing these tests on smell and taste. You may have to watch that the 'fun' does not end in losing sight of the questions to be solved. The ways of conducting the tests must be 'fair' and hygienic.

Section Seven, p.37. Women's magazines and cookery books will provide a mass of illustrations to show how colour is used in presenting food. It could be fun and interesting to make some deliberately odd-coloured food and test people's reactions. For example, mashed potatoes could be coloured blue. Pp.38, 39: Other work on chromatography will be found in *Communication*, Section Six. Pp.40, 41: For too many children a 'magic' liquid, litmus is introduced and they then use it to study acids and alkalis. It will take some of the 'magic' away if they can produce their own *indicator*. Red cabbage is an excellent indicator, though the one great disadvantage is its strong smell. Do not therefore try to keep and store your cabbage indicator. Make it and use it. There are other suggestions for indicators; usually the purple/blue coloured things in nature have this quality. P.42: This work on acids and anti-acids will call for quite precise observation and chemistry skills.

Section Eight, p.43. The set work could be extended to fruits/vegetables; edible/inedible; roots/seeds/leaves. P.44: A rather special and unusual example is taken of a school that kept a cow (they also kept sheep, ducks and pheasants). Equally valuable work could be done with small animals: rabbits, guinea pigs and particularly chicks reared with an incubator. (See *Learning through Science* pack *Time, Growth and Change—Chicks*, Macdonald Educational 356 07560 5). P.46: Children could rear trout. (See *Learning through Science* pack *Time, Growth and Change—Trout*, Macdonald Educational 356 07560 5.)

Section Nine, p.47. An important language point is picked up here. Often words have everyday meanings, but the same words have a more precise meaning in science. 'Animal', 'insect', 'power', 'machine', 'work', are examples. 'Fruit' is precisely defined here and follow-up work suggested. Pp.48, 49, 50: Growing things are of intrinsic interest to children. Encouragement is needed, as results are not immediate, and, even with the best intentions, follow-up care can be forgotten.



This school borrowed an incubator, then hatched and cared for the chicks.

Section Ten, p.50. Children should be able to identify: refrigeration, canning, dehydration, salting, bottling and the use of the thermos flask. P.52: Further investigations with ice are found in *Moving on Land*, p.63. P.54: This looks at the idea of 'Change', a theme without end. (See *Science 5/13* Units *Change*, Macdonald Educational, 356 04105 0 and 356 04346 0.) P.55: There is more about magnets in *Communication*, Section Nine.

Section Eleven, p.57. One school asked parents to let them have unwanted kitchen utensils. They ended up with a museum of fascinating odds and ends, plus a valuable collection of such things as sieves, strainers, spoons, beaters, whisks and timers, all of which were used for their enquiries. P.59: The digestion diagram could be traced and cut out to build a model in which the organs could be placed under and over each other in a 3D effect. Pp.60 and 61: It is important to note the remarks concerning burning tests made in *Clothes and Costume*, p.60 and always to exercise the greatest care. Note, too, the use of paper bun cases and foil cases. This will save much time and waste in trying to clean glassware and, of course, avoid using glass altogether. P.62: This is useful chemistry experience for younger children. They enjoy it and can gain quite a lot. P.63: These are some suggestions for using the kitchen equipment collected as a result of the appeal to parents.

Equipment and Materials

*denotes equipment to be made

Section One: no specific equipment required for this research and survey work, but children should be helped to draw up simple plans and questionnaires.

Section Two: for cereal-growing; wheat, barley, maize and oats seeds, pots, germination sandwich apparatus*; flours, include strong and weak, wheat seed, (available from health shops, pet shops and seed merchants); muslin, bowl; dough strength testing*; for yeast tests: tubes, balloons, sugar, warm water; iodine—**caution**; 'kitchen powders': sugar, chalk, bicarbonate of soda, starch, mashed potato, flour, ground rice, salt, milk, soap, baking powder, tapioca, arrowroot.

Section Three: milk, 75ml vinegar, saucepan, muslin, bowl; hydrometer (straw, lead shot, plasticine)*; for butter and cheese-making: milk, cream, lemon juice, salt, muslin, bowls, containers.

Section Four: sweets, various, include fruit gums, sugar collection; sugar beet, saucepan, funnel, filter, jar; potato, sugar, jar, saucer.

Section Five: salt, measuring cylinder, scales (sensitive); food colourings, droppers, tubes; sand and salt, funnel, filter paper, beaker/jar, evaporating dish, heat source; for crystal-growing: sugar, Epsom salts, copper sulphate, chrome alum, potash alum, sodium thiosulphate (hypo). **Note:** chemicals can be **dangerous.**

Section Six: lemon juice, salt water, sugar water, aloes (in solutions); taste and smell collection.

Section Seven: containers; for chromatography: paper, dropper, pots, food colourings, coloured sweets, indicators (red cabbage, beetroot, blackberry juice, elderberries, blackcurrant juice, etc.); test liquids (vinegar, salt water, washing soda, lemon juice, bath salts, tea, garden lime, health salts) all in solution; litmus; indigestion cures, white vinegar, universal indicator.

Section Eight: no specific apparatus needed for this section; an opportunity to observe and measure animal growth and also to make a collection of bones.

Section Nine: fruit and vegetable collection; apples and scales; potatoes; growing medium (soil compost); various fruits and vegetables, pips, seeds, tops.

Section Ten: ice, containers, methylated spirits, thermometer, muslin, bowls; dehydrated foods; tin cans.

Section Eleven: collection of kitchen equipment; orange, filter paper, beaker, funnel; white food powders (flour, bicarbonate of soda, sugar, salt, mashed dried potato, milk powder); paper bun cases, metal foil cases; burning apparatus, tongs; vinegar, iodine—**caution**; microscope; water; containers; baking powder, vinegar, tubes, candles, spoons (wooden, metal, plastic), sieves and strainers, timers, beaters and whisks.

HOUSES AND HOMES

Section One, p.5. The questions suggested could lead to observations and recording using the following guidelines for answers:

1. tessellations, brick bonds, symmetry
2. rubbings of texture and patterns: wood, stone-brick, metal, etc.
3. triangles giving rigidity; noting geometrical shapes
4. screws, nails, glues, clamps, bolts, welding, mortar, locks and clips are some possibilities
5. A definition of a tool is: 'an implement for working upon something, and usually held in the hand'. A definition of a machine is: 'a device that does work'. Children could look for examples of each
6. metal, plastic and earthenware pipes of various diameters and shapes. They are used for drainage, water supply, electrical conduit, waste disposal, and gas supply
7. Children are often vague about the different metals. They should look for copper, lead, iron, sheets of galvanised metals, lead, stainless steel, aluminium
8. examples of plastic superseding more traditional materials, plastic guttering, damp-proofing, insulation, cladding
9. For a useful booklet on the story of cement write to: The Cement Marketing Company Limited, Blue Circle Group Publicity Department, Portland House, Stag Place, London SW1E 5BJ.
10. Mortar is dealt with later in the book on p.22.

P.6. A building-site visit makes an invaluable starting-point. Arrangements must be made with the site foreman. Avoid any potentially dangerous areas. The chance to observe and talk is all that is needed. A tape recorder will prove most useful, especially if small groups can make succeeding visits. Pp.7, 8: The geography/history aspects in studying houses and homes are suggested here. Library research, painting, drawing and model-making will all help in the planning and organisation of the science studies.

Section Two, p.9. A collection of woods, plastics and metals is really a 'must'. It has uses far beyond the immediate topic and is a valuable resource for any school. Pp.10, 11: The difference between hardwoods and 'hard' woods, softwoods and 'soft' woods is often not understood. Hardwoods come from broad-leafed trees and softwoods come from coniferous trees. It is not a question of *hardness*; balsa wood is very 'soft' but is classified as hardwood. P.11: Varied methods of 'hardness' testing could be encouraged. The specially-designed apparatus could be made by a parent. Children confuse hardness with strength. This is another enquiry (see *Roads, Bridges and Tunnels*, p.50).

P.12. Advanced work dealing with density is indicated by the blue panel. However, most children can take a first look, as shown at the top of the page. P.13: Children may have some experience of wood warping—and hence the need for seasoning—so the test can be set in a real context. P.14: Children's experience and knowledge of metals is often very limited. (For further ideas for creative work using metals, see *Creative Metal Craft*, Creative Play Series 8, by Ullrich Klante, Batsford.) P.15: The specialised piece of apparatus in the lower picture might be borrowed from a secondary school. The paper-clip experiment, however, is a quite satisfactory first look at metal fatigue. P.16: Secondary schools might help again with the small quantity of chemicals, and on their use. P.17: An advanced page, demanding sophisticated equipment and intended only for those with such facilities. P.18 looks at plastics and suggests two enquiries: strength of plastics, and electrostatics. For further work see *Science 5/13* Unit *Children and Plastics*, Macdonald Educational 356 04352 5. Other static electricity investigations will be found in *Clothes and Costume*, pp.42, 43, 44.

Section Three, p.19. The survey work looking at walls is a good base for the investigations that follow. P.20: A chance to see foundations of a building being dug and prepared would be valuable. This is a first experience of the idea of *pressure*, a force acting on an area. It is a difficult concept, but the experiences suggested will help. P.21: The collection of bricks is a helpful starting point and resource. Looking at and handling them will raise questions as indicated in the pink box. Answers will be on these lines:

1. Sizes will be approximately the same (convenient to fit the hand).
2. Sizes have changed and this is used as a dating method for buildings.
3. The mass varies considerably, the engineer's brick and the concrete load-bearing types being the heaviest.
4. Work on density for the faster children.
5. Count the bricks in one course; count the courses.
6. Number of bricks multiplied by the mass of one.
7. The frog is a key for the mortar to lock into.
8. Similar to the frog.
9. The bricks with no holes or frogs are usually load-bearing bricks.
10. The colour of the clay, the temperature of firing and various impurities.

P.26: The notion that water will rise upwards through a wall is not obvious to children. It occurs through 'capillary attraction'; the rise of water through small tubes.

Section Four, p.27. The silhouette of roof shapes could be recorded in painting or drawings, seen against varying skies. Roof materials are another topic to investigate. P.18 extends this to other countries. Water-resistance of various materials, and water run-off from varied slopes and roof pitches could be investigated. P.29: The model roof structures are easily made; many children will know the technique from building model aircraft. P.30: Applying a *force* fairly to such a structure was found to be quite a problem. This is an answer one teacher came up with; there may be other ways.

Section Five, p.31. Note the suggested observations: window shapes; windows now blocked in; the bulbous 'bull's eye' shape; small diamond shapes in older houses; how windows are opened and shut; shutters. You could do a similar survey/environmental approach with doors and floors. P.32: The Pepper's Ghost experiment was used to create ghost effects on stage and in films. P.33: Some old locks to handle and take apart would be valuable. P.34: This sustained and quite demanding investigation of floors and flooring involves careful testing, observation and devising methods of recording. Children have delighted in reporting that some school floor surfaces are quite unsuitable! P.35: This work on shapes is capable of further mathematical development involving *area, pattern-making and tessellation*. P.36: Strength differences between concrete and reinforced concrete are quite dramatic. Keep the sample size as thin as possible, and note the suggestion 25×2·5×1cm. The apparatus needs to be constructed and a parent could help. It is a safe way of applying the quite considerable forces needed.

Section Six, p.37. This practical approach 'Can we build with newspaper?' has been very popular, something different, a challenge. It needs careful organisation, as it has proved a bit chaotic at times, but always worth while. Group work seems to be one answer. P.39: The word 'rigid' may need to be defined. (This idea of folding, rolling to increase strength is further developed in *Roads, Bridges and Tunnels*, pp.18, 19, 20, 21.) P.40: These models of homes result from the plans on the front and back inside covers. P.41: This illustrates more mathematical links with triangles and rigid shapes.

Section Seven, p.43. Use this page to focus attention on tools. How many of those depicted can be named? What is the workman called who uses that tool? Which materials are used with the tool? What is the difference between a tool and a machine? (See p.5 answer 5.) P.44: Note that 'machine' is a word with a specific meaning in science. The apparatus depicted is useful and could if necessary be improvised. P.45: Cranes could be made, using a constructional kit. P.46: This is a fairly formal investigation into levers and it is difficult for many children. The relationship tables are there if children seem to be ready. The 'feeling' experience of the brick on the pole will be quite dramatic and possibly enough for many.

Section Eight, p.47. Stress the dangerous aspect of mains electricity as compared with the quite safe battery and bulb approach. Pp.48, 49, 50: Making up the apparatus as shown may seem arduous, but once done it is a valuable and permanent resource for the whole school. Every school should include such basic electrical circuit investigations, and easy ways of making good connections are a 'must'. P.51: Many adults do not fully appreciate the use and function of a fuse. This is, therefore, something that should be dealt with. Pp. 52, 53, 54: Some advanced work, as designated.

Section Nine, p.55. Most schemes of work include 'water' as an essential. The 'Other Routes Through' reference list will enable you to pick up other aspects of this study. Pp.57, 58, 59, 60: Filtering, dissolving and evaporation are basic techniques of science. They are important and will be used in later work.

Section Ten, p.61. Useful language work can be developed from this page. Here are some suggestions:

animals and names of their 'homes'
animals' gender, names of male and female
animal parents and names of their young.

Reference to animal stories could also be made. Examples are *The Jungle Book*, *Wind in the Willows* and *Watership Down*. The search for animals on pp.62, 63 can lead to a variety of related work. This includes:

Collecting techniques: using nets, sweeping and beating, trapping.
How to collect and what a good collector must do.
Keeping mini-beasts; care and awareness of needs.
Using reference books and making and using keys.
What do these mini-beasts do? Investigate
(a) movement, (b) feeding, (c) behaviour. Also investigate and compare life stories.

Equipment and Materials

*denotes equipment to be made

Section One: no materials required

Section Two: collections—wood, plastics, metals; wood samples (showing a range of hardness), hardness testing apparatus*; *microscope; 'density' blocks of* wood, e.g., a variety of blocks of the same size; branch or large twigs; metal experience opportunities—cutters, pliers, soldering, hammer and punch; metal bending apparatus (to borrow from a *secondary school*), ball *bearing, vice;* demonstration—electroplating, copper and nickel electrodes, nickel sulphate solution; 6V battery, copper sulphate solution; from a secondary school laboratory: Bunsen burner, *lead carbonate, sand and charcoal;* plastic test apparatus*; plastic sheet.

Section Three: piece of wood, platform for load; collection of bricks, sand, cement; 'moulds' test rig to devise; model brick walls; knock-down device, tools to examine—trowel, spirit level, plumb line; tins (one to fit inside other), cork, thermometer, insulating materials (sawdust, cotton wool, paper, expanded polystyrene pieces); bricks, bowl of water, spring balance; for capillary experiments on p.26: *tubes of different bores;* water tray, glass slides, tape, stick, beaker, wool, saucer.

Section Four: balsa wood strip, soft board, sharp knife, glue, test rig apparatus*; tins, insulating materials.

Section Five: candle, glass or plastic, locks to examine, flooring samples, (*lino, carpet, vinyl,* wood, cork, tiles), for tests—oil, grease, ink, scratchers, sandpaper block, cloth, coins, force meter; shapes for tessellating, balsa wood strip; concrete-making—sand, gravel, cement, florist's wire for reinforcement; *concrete-breaking test rig**.

Section Six: newspapers, cane, broom handle, glue (remember—caution needed with all glues; *vapour can be dangerous*); string; straws; card, blocks or books, load; canes; model making—see inside front and back covers; balsa wood sheet, sharp knife, construction kit strips.

Section Seven: tools to examine; slope test apparatus*; construction kit to build crane; long rod plus load.

Section Eight: *base blocks for bulb-holders* $7 \times 5 \times 1 \cdot 5$cm; 14mm × 4 round-head screws, small washers, screw eyes 1cm diameter loop, bulb-holders and bulbs; base blocks for switches—$7 \times 4 \times 1 \cdot 5$cm; spring steel strip, 14mm × 6 *round-head screws*—**shiny** *metal*, small washers, crocodile clips, wire for leads (suggest PVC insulated 'extra-flexible' wire from: R.S. Components, PO Box 427, 13-17 Epworth Street, London EC2P 2HA); batteries (suggest *a variety, but mainly* 3V cycle lamp type 800); blocks for conductivity testing, $7 \times 4 \times 1 \cdot 5$cm with cup hooks; suggested collection for testing—steel, copper, brass, card, wood, string, plastic, aluminium, tin plate, *covered wire, bare wire, carbon* (pencil lead), glass, painted metal, zinc and lead; fuse test apparatus*; ring circuit test apparatus*; model dynamo, coil of wire, compass needle or galvanometer, magnet.

Section Nine: filtering—sand, charcoal, stones, plastic pot, various fabrics, filter paper funnel, container; samples of different waters (include 'soft' and 'hard'); soap flakes, *heat source, beaker,* watch glass, plastic bottle with hole, containers plus plastic tubing, funnel and tubing, basin; heat source, beaker, tube, crystal of potassium permanganate, heat, tongs, tube ice, gauze; coloured hot water; *ice mixture small bottle.*

Section Ten: Opportunities to search for mini-beasts; lens, small dishes, covers.

IN THE AIR

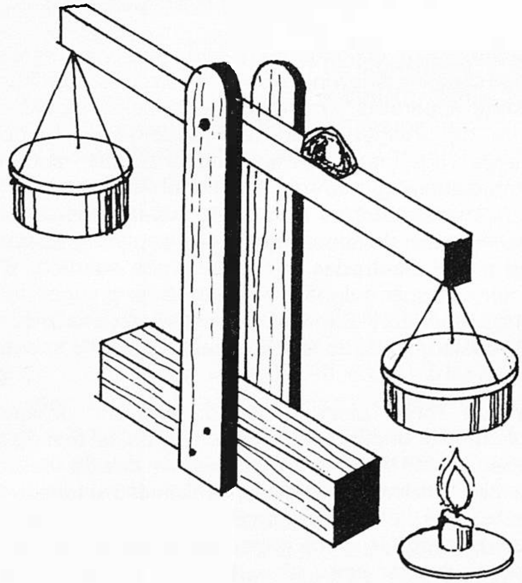
Section One, p.5. An Air Show exhibition, often started by staff and added to by children, has proved a successful 'springboard' for many schools. P.6: The children will need to 'talk through' these experiences and observations to clarify their thoughts. To them, air is rather mysterious. P.7: Two experiences of feeling air are provided, the first broad and general, but quite dramatic, the second a controlled measured test using simply constructed apparatus. P.8: The concept of the *atmosphere* above pressing down and around is difficult. The experience of the four experiments will need discussion. Let the children say how and where the air is pushing to explain these interesting observations. P.9: The 'feel' of the 'sucking' forces will help reinforce the idea of atmospheric pressure. It also introduces measurement of forces in newtons. It is obvious that *pull* **is not the same as** *mass* (measured in grams). P.10: Access to a barometer and the weather map will be very useful. Children could then understand more fully the work behind the weather forecasts they see on T.V. P.11: From atmospheric pressure this page moves to ideas of increasing air pressure and the means of achieving this and controlling it. Opportunities to handle and use pumps and valves are essential. P.12: The idea of high and low pressure is important. Understanding of weather, flight, and even cricket-ball bowling depend on this.

Section Two, p.13. Weather studies are very worthwhile, but often children lose interest in the long-term observations and records. The experiments in this section are largely immediate and short-term, and encourage a more sustained effort. Pp.14, 15: The pieces of apparatus shown for wind study are all fairly simple to construct, and most children have needed only minimal help in making and using them. Sophisticated instruments can be bought and might already be available around the school. The home-made apparatus is worth trying, as often problem-solving situations will arise: 'It does not turn freely—why?' 'It has blown over, what can we do?' Pp.16, 17: Here we deal with the idea of water in the air and how it gets there. The two experiments can measure the rate of evaporation of water into the air. The idea of a rough-and-ready estimate is useful for children to encounter. Similar techniques can be used for other problems, such as:

'How many dandelions on the field?'
'How many acorns on an oak tree?'
'How many worms in a hectare?'

P.18: Links could be made here with cloud observations and weather conditions. For example, cirrus clouds indicate fine weather, cumulo-nimbus indicate possible thunder-storms.

Section Three, p.19. A museum visit would greatly enhance the work in the following four sections. (See inside back cover.) Pp.20, 21: The six simple experiments help to establish how air expands when heated, and is therefore lighter, volume for volume, and so rises. P.21: Perhaps children could bring some of their own observations to this work, e.g., seeing the gas burner of a hot air balloon, noticing dust marks above a radiator or light bulb, or shimmering images over a hot road. Pp.22, 23: Making a hot air balloon can prove quite an exciting venture, with the whole school turning out to witness the great occasion of the launch. Children may need help in transferring the template shape into the larger scale needed.

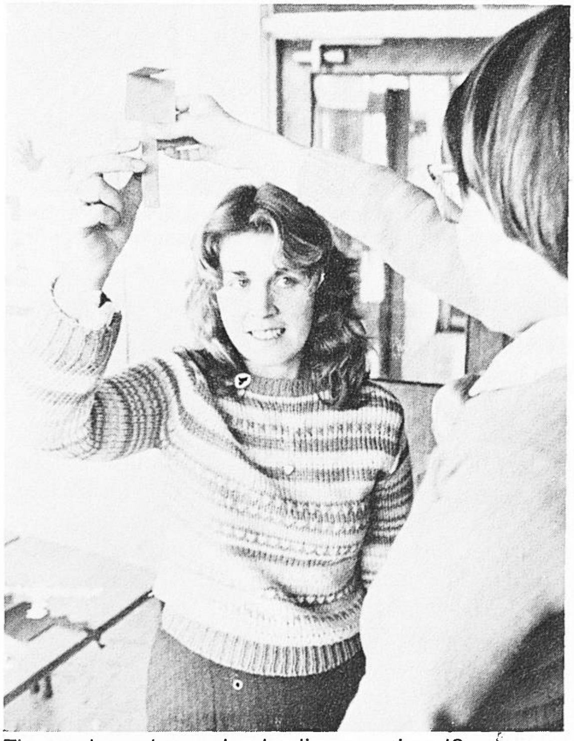


School-made apparatus to show the effect of hot air rising

Section Four, Pp.26, 27. The parachute-making and testing will give rise to a lot of good science, variables to control and some genuine experimental work. The thin plastic bags that cleaning shops return clothing in make excellent parachute material. Kites offer a study and science capable of great depth. (See *Kites* by D. Pelham, Penguin Books, 0 14 00 41776 (1976).) Pp.30, 31: The balsa-wood glider is small and needs little material, but is a really effective little flier. The only steps of any difficulty are: Number 2, where children will use the scoring but may crack in the wrong direction. Open the score mark; do not crack the reverse side. Number 6, here it is essential to *cut the end-points of the slot first*, or the wood will split. P.32: There is a childhood tradition of paper planes and many pupils will have their own favourites to suggest, compete and compare. (See also *Advanced Paper Aircraft Construction*, by Campbell Morris, Cornstalk Publishing, 0207 14502 4 (1983).)

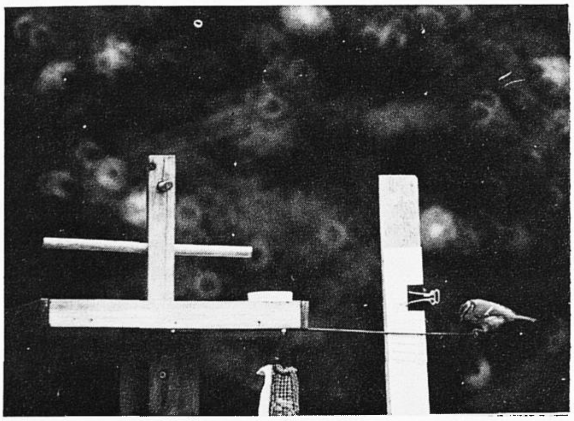
Section Five, Pp.33 and 34. These suggest additions to the Air Show display, information to research and pictures to draw and collect. P.35: This begins to look at the significance of the shape of an aircraft wing. Pp.36 and 37: Here the idea of high and low pressure areas is developed and possible results are considered. Encourage the prediction asked for. As well as being a valuable exercise, it focuses attention on the observations, rather than rushing through several experiences that could, in the end, have little significance. The follow-up drawing and marking on this of the high and low pressure areas should aid the learning. Pp.38 and 39: When the paper tissue glue has dried, a light spray with water will make the wing taut. Ceiling tile fixative or PVA is best for gluing the polystyrene; some other glues dissolve it. (*Remember:* some glues are *dangerous chemicals.*) Pp.40, 41: Having made the rotor-arm tester, children have observed, 'It is like a machine: can we make it work other things?' This attitude should be encouraged. Children have used them to pull loads, act as a moon buggy or fairground whirl rider, lift loads and move boats. Pp.42, 43: Jets. If other arrangements than the nylon line and plastic straw are tried the idea of friction will arise. P.44: These observations and ideas could be put to practical use through the work on pp.30, 31, 32, 38, which could be extended by trying to control flight direction.

Section Six, p.45. Children should have a lot to add to any discussion arising from the notes on helicopters and hovercraft. Helicopters are often in the news, and examples of their versatility and uses could be collected. P.46: A teacher who first carried out trial work on the paper helicopters reported, 'It has all been a great success, I am knee deep in the things!' There is a fairly obvious link with nature, and the fruits of the sycamore (p.59). The paper variety could be compared with the natural spinners in wind speeds and direction. P.47: Ensure that children understand the template. The propeller must rest very loosely on the two guiding nails. From the emphasis given to the question 'Does it matter which way the blades are twisted?', this is a vital point. The propeller should fly to a height of 3m to 6m. P.48: Once again it is necessary to bear in mind the dangers inherent in using some glues.



The teacher asks another leading question: 'Can you make your helicopter spin the other way round'?

Section Seven, p.49. The bird table described proved a very successful little project. The group visited the local wood merchant, selected, measured, and priced their wood and between them wrote and illustrated a delightful booklet that told about the tools and techniques they used. Pp.50, 51, 52: During trials there was quite a thrill at the response to the challenge, 'Can you weigh a sparrow?'. The photograph gives a clear idea of how one school achieved this, although it was a blue tit that obliged! Children enjoy the broad challenges of large-size art; the chance to draw some fine detailed observations is also a challenge. Detailed drawing of natural specimens, such as feathers, is often equally enjoyed.



The problem: to weigh a sparrow. It was a blue tit that obliged. But does it matter where it lands on the 'spring balance'?

Section Eight, p.55. The issues raised on this page can lead to wide-ranging discussion on pollution and environmental problems. Pp.56 and 57: The insect searches suggested will probably gather in a great variety of 'mini-beasts', not all of them insects. This will prove a valuable 'jumping-offpoint for sorting, grouping and identifying. For further guidance see: *Learning through Science* pack *Which and What*, Macdonald Educational, 356 07559 1; also *Science 5/13*, Macdonald Educational, *Mini-Beasts*, 356 04106 9. Pp.58, 59: There are other aspects of seed dispersal that are worth following up; see *Science 5/13, Using the Environment 3, Tackling Problems*, Part 1, Macdonald Educational, 356 04356 8. Pp.60, 61: This study could be extended and go more deeply into ideas of photosynthesis and the work of leaves of plants. P.62: Further work in connection with pollution can be found in *Moving on Land*, pp.46–47. P.63: Air—The Future. It is now important to include the part that plant life plays in the balance of the atmosphere, and in particular to discuss the implications of the preservation or destruction of the world's forests.

Equipment and Materials

*denotes equipment to be made

Section One: empty bottles, bowl of water, funnel, plasticine, jug, pea, large plastic container, pump and valve, sensitive scales; large sheets of card; wind vane apparatus*; tin with holes drilled, plastic beakers, straw, shallow dish, cork, large plastic bottle; 'suckers', force meters, barometer to examine.

Section Two: wind-measuring apparatus*, see p.14; plastic bottle, peg, 'J' cloth, sand, a 'puddle' and tape measure; flask, cork, plastic bag; humidity-measurer*; cloud reflector*.

Section Three: plastic bottle, bung and tube, bowl of water, balloon, tape measure, bubble-blowing liquid, spinner; hot air apparatus*; for hot air balloon: tissue paper, newspaper, paste, source of hot air: hair dryer.

Section Four: parachute material—thin plastic, e.g., dry cleaners' bags, cotton, nylon, paper tissue, thread, paper clip hook, load—e.g., washers; kite-making materials; for balsa wood glider: balsa wood 1·5mm sheet, glue, sharp knife, cutting board; for paper planes: typing paper A4.

Section Five: stiff paper and card; paper strips, books, funnel, table tennis ball, sticky tape, thin card 25×5cm, cotton reel, plastic tubing, candle, card 5×5cm pin; balsa wood for plane and wing-making, soft board, tissue paper, paste, sharp knife, cutting board; ceiling tile, suitable adhesive; plastic squeezy bottle, wire coat hanger, rubber band, nail, polystyrene pieces; 'sausage' balloon, plastic straw, nylon line, bulldog clip, cork; balsa wood strip, card, pin and bead.

Section Six: typing paper A4, 20cm×6cm; piece of broom handle 10cm, **wooden** cotton reel (not plastic), 6cm piece of 6mm dowel rod, 1m string, 3 small nails, thin aluminium sheet or tin; polystyrene ceiling tile, thin card, suitable glue, fan or hair dryer.

Section Seven: bird table, suggested size of wood—post: 1·5m×4crn×4cm; table: 30cm×30cm; supports: four, each 13cm×4cm×4cm, plus edging for table and dowel rod for perches.

Section Eight: insect collecting—large sheet, greased board; seed dispersal collection; shallow dish, water, tube, pond weed; teacher demonstration: pyrex tube, potassium permanganate, glowing splint; damp steel wool, tube, beaker, water; filter paper, funnel, container.

MOVING ON LAND

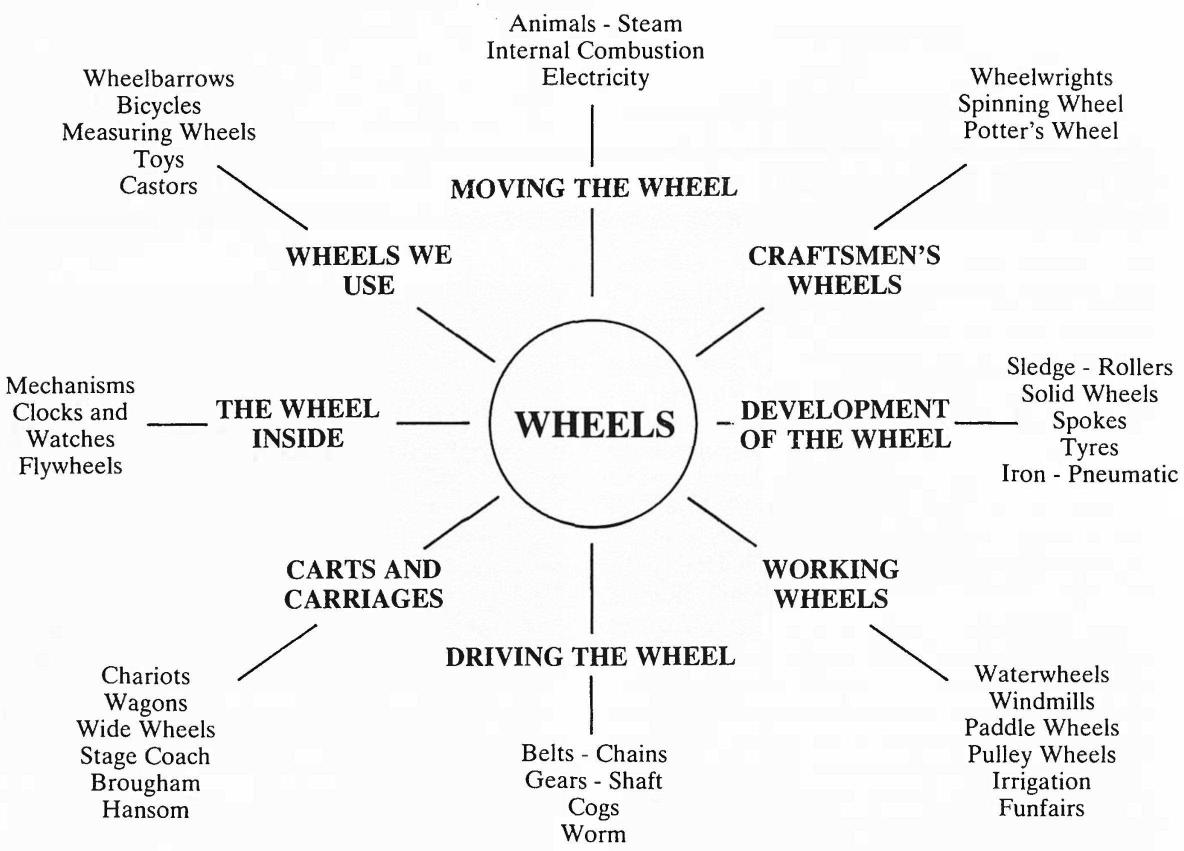
Section One, p.5. Transport is a popular theme for schools to take, but perhaps it is too large, so within the series there is the opportunity to break it down into 'On Land', 'At Sea' (*Ships*) and 'In the Air'. Preparation of work in history, geography, language and mathematics will reduce the organisational problems of 'doing science' with large groups. P.7 suggests the lines on which some historical research could be based. Children could produce their own booklets that tell the story of land transport: 'The First Tracks', 'Early Civilisations', 'Roman Roads', 'The Decay of the Dark Ages', 'Stage Coaches and Sedan Chairs', 'Turnpike and Toll', McAdam and Telford', 'The Coming of Steam and the Internal Combustion Engine'. Prepared and duplicated guide study sheets can help.

Timetables, speed and distance, census counts and charts can provide linked mathematical studies. When the class is thoroughly prepared and organised to take part in studies, small-group science activities become possible, as the teacher is free from the demands of a large number of children.

Section Two, p.9. The concept of energy is an abstract one. Junior and middle school children are almost without exception at the 'concrete operational stage'. They will need lots of experiences involving energy before they will begin to make that abstraction, which will come later. Pp.10 and 11 begin to provide this experience by suggesting activities that involve *forces*; moving things by *pushing, pulling* and *twisting*, and such forces should be measured in *newtons*. It would reinforce a wrong concept to allow children to measure these pushes and pulls in grams and kilograms. Those are the units for measuring mass (heaviness). They are not the units for measuring forces. If you have no force meters you may have imperial measure spring balances which could be converted. Those who are unfamiliar with the S.I. unit 'newton' may need to know that if 1kg is hung on a spring balance it will pull down with a force of 10N. Pp.12 and 13: The idea that 'something' must provide the force is discussed. Pp.14 and 15: Preliminary discussion will probably be needed before children can tackle the energy chain and drawing assignment. P.16 deals with the wider issues of energy, and could be extended to finding out more about coal, oil, gas, hydro-electricity and nuclear power. These industries provide excellent educational material, and it is worth contacting them for help.

Section Three, p.17. Wheels could be a topic on their own, as the chart on the next page shows.

Pp.18 and 19: One child, when asked how the Egyptians could have moved the great blocks of stone, replied after a thoughtful pause, 'Big whips I expect!' The six following tests represent the stages of the development of the wheel as the science of moving is investigated and compared. P.20: It would be useful if children could find examples of mechanisms such as old clocks, kitchen tools, bicycles, car parts and constructional toys and then search for examples of the five basic mechanisms shown. P.21: The idea of the drive wheel, the followers, coupled with direction of turn and speed is an important mechanical idea. (How many car drivers know what the gear lever alters, as gears are changed or reverse is selected?) P.22: Tractor-making has proved to be a winner. All children have enjoyed it and responded to challenges such as, 'Whose can climb the steepest slope?', 'Whose is the most powerful in a push-of-war?'. Larger models can be devised from plastic squeezy bottles. See *In the Air*, p.40. P.23 is good fun, but *note the last sentence.* Pp.24, 25: technology, designing, making and modifying is a valuable science-linked activity. Here are four models to try. Remember, do not let it stop at the satisfaction of *making* the model; the science begins when questions are asked and then probed. P.26: Since the book was published, Scottish colleagues have informed us that Robert William Thomson of Stonehaven was the first inventor of the pneumatic tyre in 1847, but never received due credit. A plaque now adorns his birthplace in Market Square, Stonehaven. An interesting piece of historical information! Some children may be interested to find out about the work of the wheelwright, and how iron tyres are fitted to wheels by using expansion and contraction. The advantage of pneumatic tyres is that they rely on the elasticity of air. Many children will have had experience of punctures, and so know the advantages of 'riding on air' rather than riding on a solid wheel rim.



Section Four, p.27. Children like to bring their bicycles into school for some of the work suggested. Actual bicycles will be needed for the measurements and enquiries that follow on pp.29, 30.

Section Five, p.33. Change is a vast and all-embracing idea. Several instances in the series draw attention to this idea in a variety of ways. The idea of *change*, for good and for bad, is pursued here. Pp.34, 35: Changes in car design are shown here, and particularly the development of streamlined shaping. Two tests are suggested. (Further ideas appear in *In the Air*, p.40.) P.37: Friction could already have arisen from such experiences as those on pp.10, 11, 18, 19, 21. This page now explores the idea of trying to reduce friction, and proceeds to a study of viscosity. Further work on friction appears later in this book on pp.40, 60 and 61 and in *Ships*, p.32, *Clothes and Costume*, p.40. Pp.38 and 39: Some basic electrical circuit work could well precede these pages. See *Houses and Homes*, pp.48, 49. P.40: Friction experiments rarely seem to obey text book rules. The truth of children's own observations *is* the right answer. P.41 looks at hydraulics. The set-up devised was quite simple, but proved most effective. P.42: An important part of any study of cars and transport is the safety factor. Consider bringing in the human factor, e.g., reaction time, as set out in the *Highway Code.* (Work on this 'thinking time' is suggested in *Sports and Games*, pp.19, 20.) The safety idea featured on pp.43, 44, 45 also gives valuable science experiences: *potential energy, kinetic energy, momentum* and *speed* which are not spelt out in the text, but valuable because they will be built on later. Pp.46, 47 deal with four very useful environmental enquiries into pollution. Note the reminders; always think about *scientific method* (in children's language, a 'fair' test). P.48: Model cars are popular with many children. They enjoy these observations and tests and are usually very competent in devising this particular 'fair' test as personal claims are involved.

Section Six, p.49. Visits to museums and preservation societies have proved to be most worth while. There is often misunderstanding about the story of the development of the steam engine and the railways. A survey of one hundred college students at a teacher training college showed that over 95 per cent thought that James Watt invented *the* steam engine! Research on the pioneers' names given on this page will enable children to unfold the true sequence of the contributions made. Pp.50, 51: At first sight there may seem to be a wholly historical approach. However, do encourage the making of the small models suggested and discuss the scientific approach needed for any fair trials and tests, as outlined for the Rainhill Trials. P.52: A teacher used this illustration to produce an effective teaching aid for an overhead projector. It had a moveable overlay that showed the action of the beam and the steam. A further overlay showed Watt's condenser and the improvement it brought. P.55: The electric motor shown is a commercial kit and is really effective, easily assembled and works well. All children enjoy this activity. Do not make the mistake of thinking trains and cars interest only boys. If you have no such kit,

Girls, too, are thrilled to build and get working a model electric motor.

your local secondary school may be pleased to lend you one. P.56: The small electric model motors are very cheap. Once such a motor is provided the challenge is there. What can you make it *do*? P.57: These home-made electric motors are fun, but very 'fiddly' to get working. We recommend using the commercial kit first, if possible. P.59: When children study famous polar explorers they could list the ways of travelling: dogs, ponies, human muscle, tractors, snowmobiles, ships, aircraft, snowshoes, skis and sledges. Pp.60, 61: Friction is investigated in some depth. This can be a continuation of work on pp.10, 11, 18. There is a further extension in *Sports and Games*, p.58. P.63: It is interesting to find what happens when a loaded wire is hung over a block of ice.

Equipment and Materials

*denotes equipment to be made

Section One: opportunities for research.

Section Two: force meters (newtons), a load (brick) metre rule.

Section Three: load (brick), sledge (piece of flat wood), sledge with runners, rollers (pencils, dowel rod), trolley with wheels (obtained from hobby shops, e.g., aeroplane wheels); mechanisms to examine, mechanisms to make*: base boards, cotton reels, tin lids, rubber bands; cog wheels (construction kits); for tractor: cotton reels, rubber bands, candle, rods, small nail; squeezy plastic bottle, pump and valve; for models to make: balsa wood, strip and sheet, plastic model propellers, electric motor from model shops; rubber bands; tin, Meccano strip, a mass (block of metal), rubber bands, small nails; pumps and valves.

Section Four: bicycles, hoops, coins, spinners.

Section Five: base board, candle, tin, card; ball-firer, shapes from polystyrene; steel ball-bearing, tube, container, hot water, magnet, container, and oils. Teacher demonstration: dilute sulphuric acid, lead plates, glass container, battery, bulb; base boards, drawing pins, steel strip, bulbs in bulb-holders, wire; base board with surfaces—lino, carpet, rubber, metal, sandpaper, polished wood, rough wood; blocks meter; disposable syringes, plastic tubing, model electric motor with driven wheel; car trolley to make electric motor with driven wheel; car trolley to make (wood, wheels and axles) plus seat and 'driver', adjustable slope; model lorry; toy cars (varied colours); box with dimming arrangement; tray, white blotting paper, plastic bags, leaf specimens, detergent, funnel container, noise-meter (if possible to borrow); toy cars—various, slope.

Section Six: model steam engine; electric motor kit to assemble (possibly borrowed from a secondary school), cheap model electric motors, 'odds' for making model electric motors (see p.57); model electric railways and engines.

Section Seven: base board, blocks plus strips, waxes and polishes; skateboards and skates; ice, items to press on to ice.

ROADS, BRIDGES AND TUNNELS

Section One, pp.5–8. This general introductory look at roads, bridges and tunnels is designed to stimulate some discussion. For all questions regarding record holders consult *The Guinness Book of Records* and *The Guinness Book of Structures.*

Section Two, p.9. A picture display of roads through the ages, with their traffic and people, could be based on this section title page. Pp. 10, 11, 12: Looks at road-building and involves the children in four simple tests, but introduces four specialised terms: *compressibility, cohesion, permeability* and *shrinkage.* These results should make children realise that a road is a major engineering achievement which needs careful planning. P. 13 deals with surveying. Some simple woodwork is required to make the groma. Parents could do this, if the children find it too difficult. P. 15: Cat's eyes are used as a starting point to study, test and sort ideas of reflection. A wide-ranging collection is needed; if every child brings something that he or she thinks will reflect and something that will not, the collection can build up quite quickly. P16: The investigation of ways to obtain more grip could be extended by the children making their own model tractors (see *Moving on Land*, p.22). They could then be challenged to see whose tractor could climb the steepest slope. Girls and boys have been most inventive: rubber bands wound round the reel, notches made, edges ringed with sandpaper, the tractor studded with nail spikes are some of the ideas they devised.

Section Three, p. 17. The assignment on the section title p. 17, is a demanding one. It underlines the fundamental problem confronting professional bridge engineers. If children can solve it, their ingenuity will have been well tested. Pp. 18, 19, 20 and 21: Some pre-thinking and prediction should be encouraged. 'What can they do to make that 60×15cm thin card stronger?' As with other tests, some children have preferred the more realistic idea of using toy cars as the load.

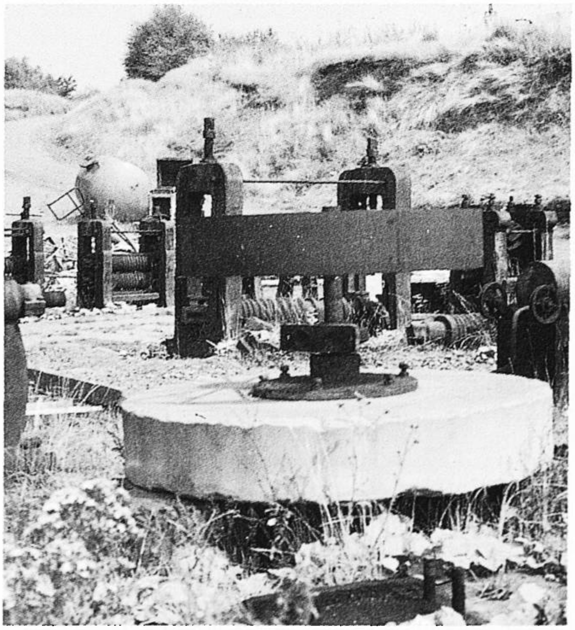
Section Four, p.27: The beam lattice construction can be made from balsa wood strip, using model aircraft building techniques (see *Houses and Homes*, p.29). It is difficult to hold the frame in the upright position for testing; slots in two blocks will help, with a platform devised to take the load.

Pp.28, 29, 30, 31, 32: Arches are introduced and tested. Note that in some suggested tests children will need to have clear in their minds which factors remain *constant* and which one is being *varied.* P.32: Note that polystyrene cutting needs care. It is best to use a sharp knife or a hot wire cutter (in a well ventilated area). The falsework is left deliberately as a challenge; it can be built from straight pieces of balsa wood strip, but has to be designed to hold the bridge blocks cut. The lower photograph gives an idea of a good size to tackle. P.32: If the research work suggested on p.29 has been covered, the important keystone will have been identified. If not, this will need to be done as it is a 'key' part of the model. P.33: This page shows four suspension bridges. There is great variety in the location, place and type of bridge, and children should collect pictures of as many of them as possible. P.34: Children enjoyed working on this large scale. It was not completely successful, but they learned a good deal from the difficulties encountered. Sometimes there was difficulty in keeping the poles upright. P.35: This gives an insight into the design work of the structural engineer. P.36: It is possible to build a working model of the travelling mechanism for cable-spinning, using a construction kit. The mathematical patterns could be extended to look at square and triangular numbers. P.37: A film loop showing the collapse of the Tacoma Narrows Bridge is available. This is very dramatic, as it is evident that only a light wind is blowing, yet the huge construction of steel and concrete twists itself to destruction quite rapidly. (Enquiries may be made to the Library of the Institution of Civil Engineers, Great George Street, London SW1.) The model with a hair dryer or fan wind, shows differences quite dramatically. Pp.38, 39, 40: The forces at work in a cantilever bridge are quite complex. It is an example of opposing forces at work, which result, in this case, in a stable situation. A physicist would call this 'moments about a point'. These practical activities will, however, give children a feel for what is happening, and provide a foundation for future work. P.40: Children may need a little help with the template idea for cutting and constructing the cantilever models.

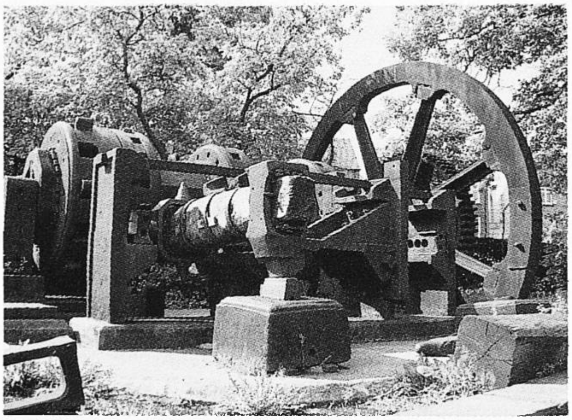
Section Five, p.41. The books listed on the back cover will again help in looking up record-holders. P.42: Children can here become aware of different construction methods, as they usually only think of the driven tunnel. P.44: This page aims to get children thinking about other factors in engineering design beyond the obvious 'digging the hole'. Pp.45, 46, 47: Here is an area of science (geology) that interests many children but which is seldom tackled in primary school. A good resource is the collection of stones, rocks and pebbles from children's trips and holidays. They will probably want them named, but often naming them implies that we now know all about them. Encourage children to examine, observe and test their specimens, and find out and list all they can from their own observations. There is more help with geological studies in the *Learning through Science* pack, *Earth*, Macdonald Educational, 356 07557 5.

Section Six, p.49. This section title page introduces building materials used in construction. Tests follow, but bricks and concrete have not been included, as these are covered in *Houses and Homes*, pp.21, 22, 23, 36. Pp.50 and 51 deal with testing wood for strength and bending. Some supervision is recommended. Watch that the load is placed in the container gently, rather than thrown or dropped in. This is good science, for there is a sudden greater force applied from the falling energy. It is also more controlled and safer. P.52: This is a straightforward test, but careful and clear rules are needed about using the varnishes and wood preservatives. P.55: The Ironbridge Gorge Museum at Coalbrookdale, Shropshire, and the nearby Blist Hill Open Air Museum are well worth while visiting. This work could really link with a study of the Industrial Revolution. Pp.54 and 55: Two pieces of apparatus need to be constructed. A parent may be pleased to help. This home-made rig for testing bending can be used quite effectively by the children. The traditional science apparatus shown at the top of p.55 would need to be teacher-demonstrated.

Section Seven, p.57. This section title page has stimulated a whole 'mini-topic' of 'fasteners'. Children have made a collection that finally consisted of well over a hundred items. This led to sorting and classifying in a variety of ways: by the materials they fasten, the materials they are made of, what tools are used and where the fasteners are used. It also produced some excellent language work. P.58: The stand shown bottom right is a very useful piece of home-made apparatus. It can also be used for pendulum studies and swinging patterns, as well as breaking and stretching experiments. It consists of three separate lengths of wood and can be set up anywhere with the aid of six small screw clamps. Pp.59, 60: More breaking-strain tests are shown. These are popular with children, who particularly like taking the test to destruction. However, there is opportunity within the book for different children or groups to do this, but not to repeat identical experiences in exactly the same context. Note the variety of fasteners collected just relating to wood. P.61: This links with p.57. P.62: This glue test provides an excellent chance to discuss variables and working in a scientific way. It could also be used to highlight again the dangers of glues in general. They are important and useful everyday materials, *but can be dangerous*.



Blist Hill Open Air Museum at Coalbrookdale, which has many relics of the Industrial Revolution.



Above: Abbeydale Industrial Hamlet, in Sheffield, lets the visitor see preserved machinery such as this.

Right: 'Does it matter how the load is placed on the bridge?' Teachers' questions are fundamental to sound progress. Here this boy is being helped to look more critically at what he is doing.

Equipment and Materials

**denotes equipment to be made*

Section One: opportunities for research.

Section Two: soil auger, soil samples, tin, measuring cylinder, funnel, container, clay; groma*; (wood to make) slope, paper, dropper; paper, markers (Highway Code); reflection collection, torch; slope, surfaces (smooth plastic, sandpaper) funnel, container, salt, ice cubes, thermometer.

Section Three: for bridge-building: newspaper rolls, wood strips, straws; thin card 60×15cm, blocks or books; materials for comparison 60×15cm (sugar paper, card, wood, paper, hardboard, plastic), thin card varied widths 60cm long; tube-making, (newspaper, sugar paper, thin card, thin dowel, cane, broom handle); for making pillars and piers: card 31×10cm, card varied heights, thick card square, small bucket, load (sand, gravel masses); two identical scales, 1m length polystyrene or balsa wood, model lorry.

Section Four: balsa wood strip, test apparatus*, card, blocks or books, loads, thick polystyrene, balsa wood strip, glue; poles; ropes; straws, counters or coins; block balsa wood to make bridge sections, fan or hair dryer; sheet balsa wood, blocks or books.

Section Five: card, tubes, toy cars, wood strips: collection of rocks, stones and pebbles, scratch test materials (p.47); measuring cylinders, stick of chalk, funnels, samples of sand, chalk, gravel, clay.

Section Six: strip wood specimens (lolly sticks, balsa wood), thin wood strips for bending tests; wood varnishes and preservatives, wood block, scales, bucket of water, paint brush (rules and provision for clean using); metal bending apparatus*; metal expansion apparatus*; Teacher demonstration apparatus: expansion apparatus plus heat source, concrete (cement, sand and stones) reinforcing rods, (florist's wire) mould, test apparatus (see Houses and Homes, p.36).

Section Seven: breaking-strain apparatus*; wires (fuse wire, thin copper wire, 26–34swg, constantan wire 26–34swg, nickel chrome 26–34swg, plus samples for comparison of cotton, nylon, fishing line, silk and wool). SAFETY: use safety gloves and goggles; threads; straws, plant stems, strips of balsa wood, load, force meter; construction kit strips; glues (**glues can be dangerous**), lolly sticks or hardboard strips, loads.

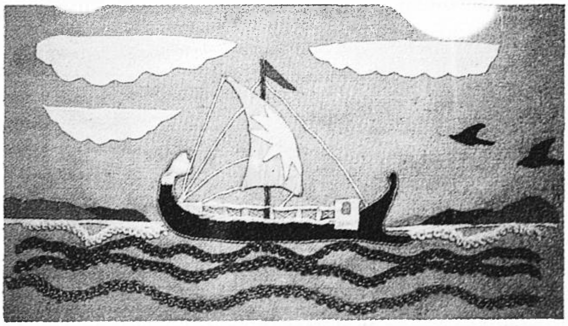
SHIPS

Section One, pp.5, 6, 7. Discussion material is provided as a preliminary to work on floating and sinking. It draws on children's observations and experience that 'wood floats' and a probable vague puzzlement as to why a great mass of iron will also float. Pp. 8, 9: Gathering a wide range of materials is invaluable; this resource will extend beyond the direct use for the floating experiences. It will be needed for investigations involving a study of materials, and for practical mathematics and set work. It is important to try to provide wood samples that will sink, e.g., lignum vitae, pitch pine and metals that will float, such as aluminium foil. Pp. 10, 11: The floating/sinking work should be extended beyond the initial observations. Questions 1 to 8 provide a more challenging approach; to make floaters sink, sinkers float and to devise ways of floating the heaviest load. P. 11 demands thought about the practical activities, to eliminate factors that have no relevance to floating. Discussion will be needed to unravel any misconceptions children may have.

Pp. 12, 13: Some advanced work. Children may not all fully grasp the significance of the measurements, but will begin to realise that there are forces acting on objects when in water. The practical experience is worth while, as it will begin to give a feel for a later and fuller understanding. This 'spiral' of learning is important. Concepts are only built by having wide experiences to which one refers again and again and builds upon. P. 14: An advanced investigation for faster/older children. It is a first look at Archimedes' Principle in terms of the forces involved.

Section Two, p. 15. The intention here is to focus attention on the differences between salt water and fresh water. One difference, density, is visually indicated. Other questions could be posed:

Where do we find fresh water?
Where do we find salt water?
Why is the sea salty?
Are some seas more salty than others?



Above: As part of the topic 'Ships', this collage work, using fabrics and stitching, depicts 'Ships through the Ages'.

Left: Using the 'gutter' test tank.

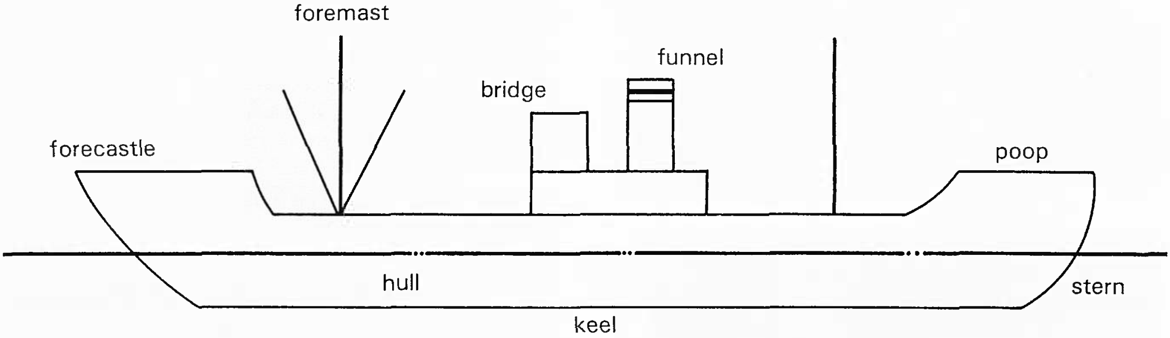
The letters on the Plimsoll mark stand for:

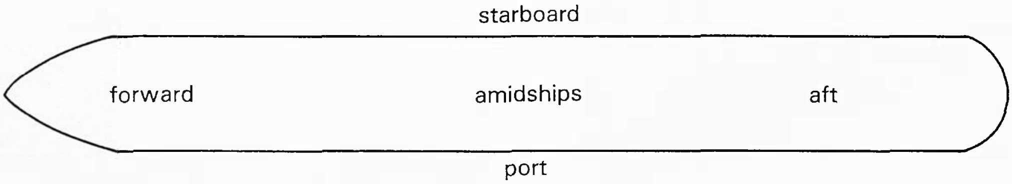
LR	Lloyd's Register
TF	Tropical Fresh
F	Fresh
T	Tropical
S	Summer
W	Winter
WNA	Winter North Atlantic.

This information is asked for on p. 18, but it also implies another factor affecting density—temperature. Pp. 16, 17 provide practical investigations in measuring the density differences of salty water and the effect upon flotation. Density is not named as such. This term could be introduced if appropriate. The use of coloured water may prove a distractor, and needs careful explanation, so that there is no confusion. P. 18: Here is one way in which the book research has been recorded.

tank, for example, by using chairs on the table, or devising a pulley arrangement (see *Science 5/13, Science from Toys*, Macdonald Educational, 356 04006 2, pp.41–43). WARNING: do not try to move the tank when it is full. Use a syphon to empty it.

Section Four, p. 23. This section title outlines a study which could be widened to look at the ship-building industry and its geographical aspects. Pp.24, 25, 26, 27: We are indebted to Mr. Manistre, Head Teacher of Lovat County Middle School, Newport Pagnell for the plans of these models, on the inside front and back covers. The models look very effective when set in 'the sea'. A good medium is one part Polyfilla, one part sawdust, which is then painted. P. 28: There are further tests on fixing and fastening in *Roads, Bridges and Tunnels*, p. 57 ff. P. 29: Before making the electromagnetic crane the children will probably need to study magnetism, electric circuits and electromag-





Section Three, p. 19. This section title and the following page look at the shapes of ships and so set the context for the practical investigations that follow. P. 21: The test tank suggested is a very useful investment. The 2 m length of wide guttering will have to be bought or 'acquired'. Two stop ends will also be needed. A sealing compound may be necessary as well. The test tank will have to be placed on a table or desk top. Note that a *drop of at least as long as the tank* is needed for the falling weight to move the 'boat' the length of the tank. This means either raising the

netism. Such experiences are provided in *Communication*, pp.44, 45, 46, 47, and *Houses and Homes*, pp.47, 48, 49. Pp.30, 31: A discussion on the problems of rusting and corrosion, and known ways of preventing them will be a valuable prelude to the practical work. The investigations outlined provide a good opportunity for devising tests, dealing with variables and the need for controls. Each test will need a control to compare with, for instance, a painted nail to compare with an unpainted nail under the same test conditions. Extension work on rotting wood and preserving techniques appears in *Roads, Bridges and Tunnels*, p.52. P.32: Here is a practical look at factors involving *friction*. Sometimes we wish to *increase* friction as much as possible as with brakes (see *Moving on Land*, pp.40, 41). Here we are concerned with the *reduction* of friction. The ideas suggested are: the surfaces in contact, the area in contact and the use of lubricants. Carefully controlled tests will be needed, varying only one factor at a time.

Section Five, p.33. The title page introduces the idea of top-heaviness, and toppling over could be discussed. Double decker buses and the London Transport test are suitable examples. Another line of enquiry is the stability of bottles and containers. The Swedish warship *Vasa* toppled over when she was launched. Pp.34, 35, 36: These pages let children explore the idea of the centre of gravity in general terms, and then apply that idea to a ship-shaped model. P.37: Four investigations relate to the centre of gravity and toppling. Emphasis is given to the placing of the centre of gravity as low as possible, thus making for greater stability. Pp.38, 39, 40: The stability problem is studied as it affects ships. Variation of mast height, and also keel and centre-board size and heaviness are shown to be factors in counter-balancing.

Section Six, pp.41 and 42. Here is material for discussion. 'How many ways can be thought of for moving a boat or ship through water?' The page suggests, wind, paddle and oar, paddle wheel and propeller. What would be the motive force for each? Pp.48, 49, 50: This work is an extension of the foregoing ideas. Further study could deal with yacht rigs, types of sailing ship and sail shapes and their names. Museum visits would be helpful. Here are some suggestions:

St Katharine Dock, London
National Maritime Museum, Greenwich
Exeter Maritime Museum
Hartlepool Maritime Museum
Buckler's Hard Maritime Museum, Hants.

Pp.43, 44: This investigation into levers starts with the direct link through the oar and widens the study to other types of lever. Few junior children are ready for a formal approach to a study of levers. Consider this an experience to be built upon later. P.45: Pieces of apparatus like the 'sail test rig' cannot be purchased, and this one was devised by a school to fulfil a need, and can be made fairly easily. Making and modifying are a useful part of any science work. P.46: Children enjoy the making and shaping of the balsa wood boats and the chance to combine model-making with a practical investigation. P.47: The advance in propulsion brought about by steam is now considered. Research into the pioneers and their vessels (listed at the foot of the page) will give the historical background. The making of the steam turbine will need help and supervision. Any work involving heat sources should be supervised, and preferably done outside. *Note:* the hole in the can needs to be *directly* under the blades of the turbine. P.48: The print shows the famous 'duel' between the *Rattler* and the *Alecto*. Discuss a 'fair' test. What things would make the test unfair? Consider such factors as the tide; different engines; one starting before the other; the size and heaviness of the ships. Pp.48, 49, 50: the series of models, and various ways of moving model boats, will provide ideas for making models, and could encourage children to try some ideas of their own:

How could they improve performance?
Which method of moving would be best for their model?
Whose will go the fastest? ... furthest?
Can the course be controlled?

Section Seven, p.51: How were sails raised and lowered? How were anchors raised? There are two clues: the pulleys and the capstan. P.52: This draws attention to anchor shapes and parts. 'A' is the stock, weighted to ensure that it lies on the sea bed and so makes the fluke 'B' dig in. This is the *Vasa's* anchor. The capstan model is simple to construct once a large round reel is obtained, for instance, the core of a wire reel. P.53: Here is a fairly detailed construction, using an electric motor as a device for raising loads. This one uses Meccano, but other construction kits could well be used. If other 'engines' can be brought in or borrowed—children's own models for example —there could be the challenge of using these for a similar load-raising activity, and making comparisons. The gears available in construction kits would be a useful aid. Pp.54, 55: The pulley apparatus depicted is very useful, not only for pulley experiments but also pendulum studies and stretching-and-breaking strain tests. A parent could make this equipment. Encourage the careful measurement of the factors involved, that is, the pull force, the distance pulled, the downward pull of load, and the distance that the load is moved; then the search for a pattern. The point of Question 4 is that eventually the friction within the pulley system could overcome any mechanical advantage. Mechanical advantage is the *ratio of the actual load raised to the force required to raise it*. P.56: The word 'work' is studied in its scientific sense. Extension work can be found in *Moving on Land*, pp. 10, 11, 15.

Section Eight, p.57: Discuss what the children know about submarines. This may include *Twenty Thousand Leagues under the Sea*, and the voyage of the USS submarine *Nautilus* under the North Pole on 23rd August 1958. P.58: Further help with experimental work on air and breathing will be found by reference to 'Other Routes Through'. Pp.59, 60 use mirrors to investigate a periscope. Junior children are not ready for studies involving such terms as *angles of incidence*, *angles of reflection* and *apparent distances*. However, this is what these activities are about and they offer valuable basic experience.

Section Nine, Pp.61, 62. A link is made between the idea of pulleys to change direction of a pull, as opposed to the forces encountered on pp.54, 55. We return to the principle of the lever in the idea of pushing on a rudder, and so steering the vessel.

Equipment and Materials

*denotes equipment to be made

Section One: collections of woods, metals, stones, pebbles and rocks, glass, plastics (pp. 8 – 9 give details); tank or bowl of water, aluminium foil, plasticine, 'cargo' of washers and coins; tin can, spring balance, brick, wooden block, masses, bucket of water; overflow bucket.

Section Two: hydrometers to make, using tubes, plasticine, lead shot, straws, balsa wood; jars, card, salt water, colouring.

Section Three: test tank*; wood pieces for boat shape making, tools for shaping.

Section Four: for model-making (see inside front and back covers); paper fasteners, hardboard strips, wood glue; electromagnetic crane to make (see p.29); for rusting experiments: tubes, steel wool (free of grease), iron nails, boiled water, oil, tinplate, galvanised nail, painted nail, greased nail, copper-plated nail, TCP, magnesium ribbon; for friction experiment: base board and blocks; surfaces: plastic, oil grease, talc, graphite, force meter.

Section Five: card shapes, pencil, thread, washer; for balancing and toppling test: blocks of wood, plumb line, selection of differently shaped bottles, plastic ball, ping-pong ball, clay, paper; p.38: stability model to investigate*.

Section Six: oar model* to show forces; sail investigation apparatus*; hair dryer or fan; for boat models: balsa wood; for steam turbine model: tin and press-on lid, washers, Meccano strips, aluminium sheet or tin, insulating tape, tin snips; for model boats with various propulsion methods: balsa, tacks, rubber band, angle bracket, hook, bead, sheet tin or aluminium, screws, plastic mouthpiece, bought propeller, balloon, clock-work motor, cigar tube, tobacco tin, cork, candle stubs, wire, cotton wool soaked in meths, crocodile clips, SP11 battery.

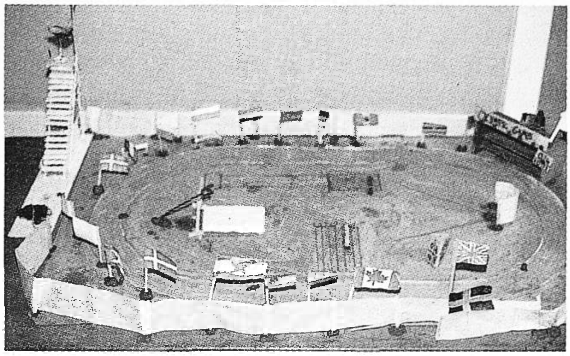
Section Seven: model capstan to make*; for model 'test bed' for anchor-raising*: (Meccano parts) pulleys, double angle strip, wood base, 4·5V battery, collars, bush wheel, driving band, axle rod, crocodile clips, rope, wire hook, plastic bucket with load; for test-rig*: wood frame, pulleys, cord, load, force meter.

Section Eight: bottle, bucket of water, two-hole bung, plastic tubing; for periscope experiment: softwood 55×7·5×1·5cm and 55×12×1·5cm, two mirrors 10×7·5cm; for periscope model*: balsa wood or card, mirrors, glue.

Section Nine: For adding rudders to model boats previously made: sheet tin.

SPORTS AND GAMES

Section One, p.5. The ABC of games gives a link with mathematics through sets and sorting of sports. Schools have done this as a corporate effort and also tried to illustrate each. Pp. 6, 7, 8 are designed to help in organising science activities; they provide suggestions for research. One school used a time-scale and a large blank wall map to unify a display of their findings. The survey work needs some specific teaching on how to conduct, record and analyse research: e.g., how to question people, how to make answer charts and then to compare and contrast findings.



This detailed model of an athletics field was made by a group involved in the topic 'Sports and Games'. The mathematics of scale and the distances related to 'the staggers' proved quite a challenge.

Section Two, p.9. A new activity is initiated: collecting sports balls of many types. A whole range of language and mathematical studies can result from this. P. 10: Note the instruction: 'Guess before you start your tests.' Prediction before tests is something to encourage. It is a good science process, and it gives an 'edge' to the tests to see 'If what we *thought* was right. If not, why?'. P. 12: This throwing and catching activity could well take place as part of a P.E./Games lesson, incorporating some recording into skills that are being practised anyway. P. 13: The measuring of area, volume and strength of hands is useful work. Children's hands will probably not show much difference, but measurements of adult hands may be more significant. P. 15: A school which tried this rolling experiment complained, 'We can't do it—the ball won't roll straight'. This should be regarded as a challenge, and a problem to solve: 'How can we measure a curved path?' 'Can we make the ball run straight? P. 16 can link with more work with compressed air. See also *In the Air*, pp. 11, 12.

A teacher at work with children discovering the Pythagoras ratios for a right-angled triangle.

Section Three, p. 17; The large scale 3–4–5 triangle to make a right angle, proved fascinating to the children, and was followed up with more mathematics on angles and triangles. As sports day was approaching a group became involved in helping to set out the athletics field, with all the problems of the staggers for the relay races. They became so interested that they made a model athletics field to scale. P. 18: This test was a success, because those who were not very good at football thought out, organised and applied the test. They achieved a new status. Pp. 19, 20: The reaction time test is very useful. It can so often arise as a variable in science experiments. 'Is thinking time affecting the results?'. It is worth keeping in mind and using in other testing situations. P. 22. This is a search for links and patterns from collected data. If there is no correlation, that *in itself* is a result, and children need help with this idea. Pp. 23, 24: A practical look at those problems such as always 'kicking about in the goal mouth' and 'cutting across grass instead of using pathways'.

Section Four, p.25. Mathematical methods of showing links could be used. Note: golf, cricket, squash (fast, medium and slow), tennis and table tennis balls (tournament and cheap) will be needed for the tests that follow. P.26: This simple piece of apparatus needs to be specially made. P.27: The experiment with the tube needs a really good, sharp, strong tug. The rotation of the tube (as with the ball) causes an air flow around it and consequently high and low pressure areas. This causes the swerve. This phenomenon is called the Bernoulli effect. Pp.28, 29: These two pages are the result of the story outlined in the introduction to this guide. P.30: The teacher presented these children with two table tennis balls, saying, 'This one cost 35p and this one 5p. Is there any difference in performance?'. The four tests are their ideas, after discussion on the desirable features of a table tennis ball:

1. It should be perfectly round.
2. It should bounce consistently.
3. It should fly straight through the air.
4. It should stand up to hard wear.

Other children may respond with different ideas. P.32: As with squash balls, shuttlecocks are made to have different speeds—another possibility for investigation.

Section Five, p.33. More children now go on ski trips, and spectacular ski and skating events have great appeal. Swimming instruction is also a part of nearly every school's programme. Pp.34, 35: These experiments could be tried during swimming lessons. P.36: This deals with wind direction and course direction. One class started from a history picture which showed the English and Spanish fleets bearing down upon each other and the puzzled comment 'How can they do that when the same wind is for both of them?'. (More studies on boats, ships, shapes, moving, and means of propulsion appear in *Ships*). P.37: The force meter will need to be a sensitive one (0–1N) as differences will be small. P.38: One group became very interested in working out how far up the slope to release the ball, to make it reach a particular pot.

Section Six, p.39. As a result of these questions one school produced a superb display showing jumps and distances in relation to the size of buses and buildings. Pp.40, 41: Children are apt to 'cheat' (in the nicest way) when doing such tests. They tend to want to be best and distort results by lengthening their stride beyond normal and disobeying the walking rules. It is worth discussing this and *trying* to help them be objective. Pp.42, 43: This, again, is a search for links and relationships from collected data. Measuring and graphical work will provide meaningful mathematics. P.44: Children have had great fun making and using this piece of electrical apparatus. P.45: They also like the whole idea of being noisy to put others off. A secluded corner will be needed! P.46: Any test must be supervised to make sure the child does not hyperventilate.

Section Seven, p.47. These are lesser-known events. See how many pieces of the throwing and gymnastic apparatus pupils can name. P.48: The idea of a path of a missile is a basic one. There could be links with historical work, involving such siege machines as mangonels and ballista. (See *Learning through Science, Moving Around: Siege Machines*. Macdonald Educational, 356 07556 7.) Pp.50, 51: This is a good introduction to measuring force, as it straightforwardly deals with pulls and pushes, which must not be confused with mass. P.52: Children enjoy making balancing models. A very good project that involves art, craft and science is to make a mobile. This is a 'concrete operational stage' activity about 'moments' in physics.

Section Eight, p.53. Answers to the research questions posed throughout the book can be found within the books listed on the end papers. (For this particular page *Motor Racing* by G. Nicholson is best.) P.54: We have not seen this particular experiment anywhere else; it was entirely devised and developed by a school. Children wondered why cyclists used this slipstreaming. Pp.55, 56 suggests four tests that can be developed from the toy models that many children already have. P.57: This type of challenge is useful for a Science Club/Science Fair type activity. P.58: These tests involve the ideas of reducing friction. Possible extension work appears in *Moving on Land*, pp.18, 19, 60 and 61.

Section Nine, p.59. Some children who are just not interested in sport have tackled this section with interest. There is something for them too. Some of the games like Nine Man's Morris, De Bono's 'L' game are simple to make; perhaps a chess club could be started also. Pp.60, 61: A quite sustained study of probability can be developed. Pp.62, 63: The work here developed from the straightforward word count resulting from a Scrabble game. It is interesting to see if children can connect that discovery with the other aspects shown.


Catching tests: these involve the variables of different balls, different distances and the use of right, left and both hands.

Equipment and Materials

*denotes equipment to be made

Section One: survey work; no special equipment needed.

Section Two: collection of balls, metre measure, board and chalk; container for volume measuring, squared paper; 'Newton's cradle'*; adjustable ramp/slope, pump and valves.

Section Three: long length of rope or metre tape; football; stumps; stop clock or watch; flat stick for making reaction timer; rugby ball, stools and boxes; for investigating grassed areas: soil samples, watering can and detergent, pegs, string.

Section Four: golf club apparatus*; golf ball; card tube, 1m of tape; squash balls (fast, medium and slow), ball-firing apparatus*, hot water, thermometer, metre rule; table tennis balls (expensive and cheap), slope, tin and load, ball-firer; box, rubber bands, tennis racquet, shuttlecocks bought and home-made.

Section Five: tin foil, tank of water; balsa wood sheet, tank of water; balsa wood, knitting needle and hook, tray of salt or sand, force meter, ski jump apparatus*.

Section Six: stop clock or watch, personal scales (newtons), tape measure or rule; P.E. skittles and cane; 'steady hand apparatus'*; for Kim's Game: assorted small objects; for puffing and blowing: large plastic container, sweet jar, half brick, large bowl of water, plastic tubing.

Section Seven: for missile launcher toy: rubber-nosed rocket; for model arm: card, rubber bands, personal scales, force meters, large sheet of paper and marker; for balancing toy: cork, knitting needles.

Section Eight: fan or hair dryer, card 7·5×6cm, cotton reel; streamlining test apparatus*, slope, toy bus or lorry; aerofoils*; model dragster*; for moving experiment: load (brick), force meter, tin lid with marbles.

Section Nine: dice, apparatus for beetle test*; coin, books for letter counts.

SKILLS, METHODS AND PROCESSES OF SCIENCE

In developing *Science in a Topic* it has been a paramount concern that the activities suggested should involve children in practical, first-hand experiences in scientific skills, methods and ways of working.

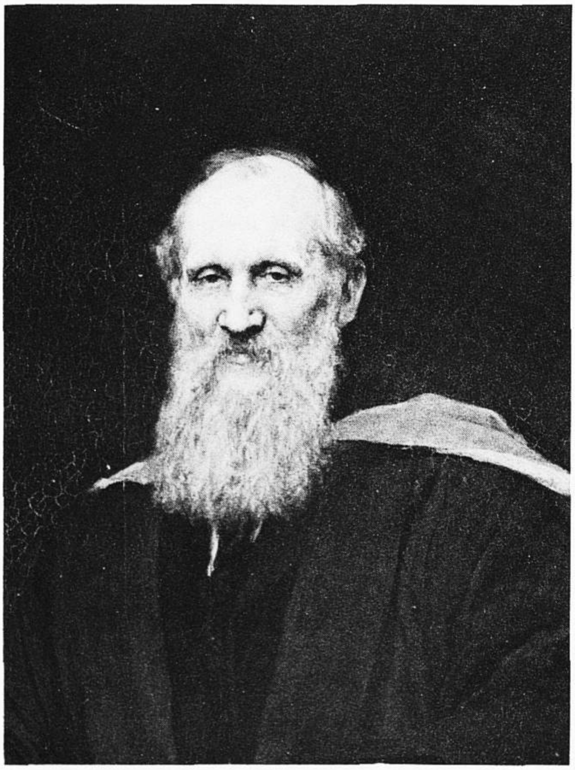
The Times Educational Supplement of 2 May, 1980 carried a survey ('The Monday Report') on the views of 3000 primary pupils on their schools. In respect of science teaching, the following comments were made. 'It was impossible to exaggerate the enthusiasm for science where it happened, and the strength of demand for it where it did not.' On the other hand, 'a few children disliked science, and they knew why. "Science is very boring because we don't do any experiments ... Science wouldn't be so boring if we could do the experiments ourselves." '

On the following pages we analyse and show in chart form the pages where particular science processes/methods and skills are dealt with.

The importance of *recording* must be constantly recognised, and it is implicit in the charts 'The Skills of Science' and 'The Methods of Science'. Throughout the series, children are encouraged to record their findings—immediately, in a clear and orderly manner, and with relevant facts and observations.

In the charts the use of a dash following a page number indicates that the subject in question continues for at least the next page and possibly more.

Lord Kelvin once observed, 'You have not done science unless you have made measurements'. The children are encouraged to use the whole range of the tools of *measurement* as shown in 'The Skills of Science' chart. However there are many opportunities to widen their concept of measurement—for example, measuring the brightness of a bulb; their reaction time; the strength of dough; tiredness; the hardness of water. Such activity comes under the heading 'Measurement, Unusual'.



This famous scientist, Lord Kelvin, once said: 'When you can measure what you are speaking about and express it in numbers, you know something about it.'

THE SKILLS OF SCIENCE	MEASURING FORCE	MEASURING MASS	MEASURING VOLUME	MEASURING AREA	MEASURING LENGTH HEIGHT THICKNESS	MEASURING TEMPERATURE	MEASURING TIME	MEASURING 'UNUSUAL'	CHEMISTRY SKILLS	USING THE TOOLS-AIDS
CLOTHES AND COSTUME	10,14,19, 38	38		27,28	10,14,19, 32,39,40	24,25,26	24	20,21,22, 25,28,31, 36,48,49, 58	47,49,50, 54,55	18,21,32–, 43,44,60
COMMUNI-CATION	17,53,54				38	27	52	6–,15,16, 41,44,46, 50	31,32	31,22, 31,32, 33,36–
FOOD	11,50		28,54	13,28,48, 49,54	14	11,52,53	11,52,53	15,19,42	15,16,18, 19,20,26, 28–,32,38–, 40–,60–62	13,32,36, 55,63
HOUSES AND HOMES	21,29,36, 46,58,62, 63	20,35,42	12	12,13,20, 21,26	10,18,20, 30,34,36, 38,39,42, 44	18,25,30		11,12,15, 22,23,34, 52	16,57,58, 60	10,14,15, 17,24
IN THE AIR	7,22,30–, 38–,42,46, 58	7,26		50	9	21	7,26,40–, 46,59	12,14–,16–, 20–,62	60,61,62	10,11,14–, 56
MOVING ON LAND	15,29,24	60			10–,15,19, 40,60–	39	37,46–48, 58	30,35,43, 44,45,47		10–,15,19
ROADS, BRIDGES AND TUNNELS	11,12,13, 18–,30–,35, 43,52,56, 58	48,52	12,48	24	18–23,26–32, 39,43,50– 52,54,56, 58,60	16	16,48	37,47		10,46,55
SHIPS	22,24–,55	32	14	12–,16	14,28, 32,43, 44,53, 55,56		22	16,34, 36–,45	30–31	12–,16, 32,5, 54
SPORTS AND GAMES	10–,15,17, 22,26,28, 29,40–43, 46,48	13,23,24	13,46	15,38,43	10,37,41, 50,58	29	32,35,40–, 44	18,19–,21 30,36,37, 38,44,54, 55–,60–		40–,45,50, 58

THE METHODS OF SCIENCE	OBSERVATION (USING ALL THE SENSES PLUS AIDS)	COLLECTING DATA AND INFORMATION	SORTING AND COMPARING	WONDERING WHY RAISING QUESTIONS AND PROBLEMS	LOOKING FOR LINKS RELATION-SHIPS PATTERN	TESTING AND COMPARING	EXPERIMENTAL TECHNIQUE 'FAIR TESTS' 'CONTROLS'	DEALING WITH VARIABLES	MAKING AND TESTING	DESIGNING AND MAKING APPARATUS
CLOTHES AND COSTUME	12,13,18, 21,26,42–,	11,31,38, 54,59,62	13,18,27,	5–21,30, 32–,34–45, 52,57	19,24,38,	10,14,18,20, 22,25,27,28, 31,36,39, 42–,50–58	19,24,26, 40,46,47, 48,49,54–, 60	24,26,46, 51	33,36,51, 56,63	19,20,22, 27,39,48
COMMUNI-CATION	6–,14,26–, 29,33,36–, 60–	5,9,10–13, 19,24,34, 35,39,45	14,20,31–, 45	6–,16,38,51	21,26–,33, 47,54	6–,14–,20, 21–,26–,31–, 33,37,41, 44,46–56	15,16,38, 50,62	6	8,14–,16, 20–,23,30, 34,40,42, 46–,49,58	21,53,57,
FOOD	11,13,15, 16,24,26, 29–32,34–, 58,59,60–	8,21,22, 23,27,46, 60–	10,29,33, 43,45,46, 54–,57	5–,12,17, 24,44	11,29,60–	13,16,18–, 24,26, 28–,34–,38–, 40–,48–,58	11,14,15, 34,36–,52–	14,15,42 52	32,50,62, 63	11,19,63
HOUSES AND HOMES	5–,10,15, 32,54,62–	14,19,27, 31,32,52, 55,62	12,34,50, 62	5–,9,12,16, 18,21,22, 24,37,45, 47,59–	22,44,46	10,11,12, 13,15,18, 20,26,38–, 42,57–	22,25,30, 34,58,63	44,59	14,22,23, 29,36,46, 48–51,54	11,22,30, 36,44
IN THE AIR	7,8,15, 18,36–49, 50–53,56	5,11,15, 19,33–,50–, 54,57,60	53,56–58	13,17,36, 46,47,63	20–,26–	6,8,9, 20–,35,36–, 40–,58–	7,16,26–, 60–,62	16,26–,46	12,14,16, 17,18,21, 22–,28–,30–, 38–,40–48	7,47
MOVING ON LAND	10,20–,37, 43,45	5–,12,26, 33–,36,42	14,27,48	16,29,37, 56	29,30,40, 63	10–15,18, 24–,32,35, 37,39,42, 45,48,60–	35,40,44, 46–62	22,37,44–, 48,56,60	21,22–,24–, 39,41,43, 50,55,56–	19,41,43, 45
ROADS, BRIDGES AND TUNNELS	10–,16,45	6,14,32, 41,57,61	15,45,46–	17,20–,23, 50–	24,36,54, 60	10–,14,16 24,26–,28, 30–,37,39, 42–,47–,50–	18,20–,23, 58,62	20–,23,30–, 31,62	13,18–,23, 27,28–,32, 34–,37,40, 56	54,55
SHIPS	59	8,9,18, 42	8,9	7,10,11, 20,42,46, 58	10,14	10,12–,16–, 22,28,32, 34–,41–,53–	30–	30–	22,29,32, 36,38,45, 48–,52,59–, 62	21,43,44, 45,47
SPORTS AND GAMES	10–,20,61	5–,9,25, 39,53,60–, 63	9,59,60–, 63	10–,18,21, 23,26,29, 40–,46,50	12–,22,40–, 46,48,54	12–,15,18, 21–,26,27, 28,30–,34–, 40–,55–58	10–,19,20, 23–,24,29, 38,44,48	26,29,36, 38,45	28,32,36, 37,44,49, 52,57	20,26,30, 38,54,55–

THE CONTENT: CONCEPTS COVERED

Scientific methods, processes and ways of working are the main thrust of the series. If these aims are paramount in the teacher's mind, then the 'knowledge content' is bound to be dealt with, because the processes cannot be practised in a vacuum. But if the 'knowledge/fact content' is the first aim, there is a distinct possibility that only this will be covered, so that the essential and unique quality of a science study is then lost. However, we must not conclude that the actual content is unimportant. The series does, in fact, feature a sound basis of fundamental science topics. They are listed below, and for ease of reference have been broken down into the following ten broad areas:

1. **LIVING THINGS: PLANTS AND ANIMALS**
Food chains; Independence; Adaptation; Variation; Life processes; Needs of living things; Growing and development; Life cycles.

2. **HUMAN BIOLOGY**
Sensory perception; Life needs; Variation; Behaviour.

3. **CLASSIFICATION**
The sorting and grouping of plants, animals and materials to varied criteria. Searching for patterns and relationships in collected data.

4. **ENVIRONMENT**
The interaction of any place with living things—plants, animals or man. The weather, seasons and the associated land structure—rocks, soil, water.

5. **FORCES AT WORK**
Pushes, pulls, twists to move things; Opposing forces to movement; Making movement easier; Balance and stability; Ideas of friction; Laws of motion; Machines; Change of shape.

6. **THE PROPERTIES OF MATTER**
(Particularly relating to AIR, WATER, AND SOLID MATERIALS)
The Atmosphere; Water vapour; Ice; States of matter; Water level; Floating and sinking; Capillarity; Pressure; Surface tension; Hardness; Solubility; Density.
MATERIALS AND THEIR PROPERTIES.

7. **ENERGY SOURCES**
Coal; Oil; Gas; Chemicals; Food; Wind; Air; Sun; Atomic; Finite supplies; Potential, Kinetic.

8. **ENERGY FORMS**
Heat; Light; Sound; Electrical; Magnetic; Radio; Motion; Gravity.

9. **CHEMICAL CHANGE**
Dissolving; Acids and alkalis; Fermentation; Crystals; Change of state; Rusting.

10. **MATHEMATICAL AND MEASUREMENT**
Area; Volume; Distance; Mass; Weight; Temperature; Time; Speed.

For ease of reference the 'spread' is shown on the chart overleaf.

THE FUNDAMENTAL IDEAS

Figures refer to Sections in individual books.

		LIVING THINGS PLANTS AND ANIMALS	HUMAN BIOLOGY	CLASSIFI-CATION	ENVIRON-MENT	FORCES AT WORK	PROPERTIES OF MATTER	ENERGY SOURCES	ENERGY FORMS	CHEMICAL CHANGE	MATHS AND MEASURE-MENT
CLOTHES AND COSTUME				3		3	2 3 4				3
			5			6 8	5 7 8		7	8	
		10		11			10			9 10	
COMMUNI-CATION			1 3	2 4					3 4	1	
			5			7	6		7 8		
		12		9					9 10 11	10	
FOOD		2	4	1 4	4	2		1		2 3 4	
		8	5	5 8			5			5 6	
		9	11			11	10			10 11	
HOUSES AND HOMES				2		3 4	2 3			2	2
						6 7	5	8	8	5	
		10			10		9			9	
IN THE AIR					2	1 4	1 2 3	2			
		7 8	8		8	5 6		5	5		
MOVING ON LAND				4		2 3 4		2	2		2 4
					5	5 7		6	5 6		
ROADS, BRIDGES AND TUNNELS				1	2	3 4	2 3 4		2		2 3 4
					5	5 6 7	5 6 7				5 6
SHIPS				1		3 4	1 2 4			4	1
			8			5 6 7	8	6	6		
						9					
SPORTS AND GAMES		3	2 3	1	3	2 4	2 4				2
			6 7			5 7 8			8		6
				9							9

These fundamental ideas arise in different ways within the individual topics and so reinforce and develop basic concepts. To take one example, pupils can become familiar with a wide range of forces and ways in which they are put to use:

air at work	Air	p. 12
crossing the bridge	RBT	p.24
dough strength	F	p. 14
experiments with pulleys	SS	pp.54–55
leg power	SG	p.41
levers	HH	p.46
magnetic attraction	Com	p.44
pushes, pulls and twists	ML	p. 10
soles and slipping	CC	p.40


Does magnetism pass through water? Having learned that it can, this boy is applying his new knowledge of magnetic forces.

OTHER ROUTES THROUGH *THE SCIENCE IN A TOPIC* SERIES

Teachers and children may wish to follow topics other than those specifically featured in this series. Some teachers may prefer more conventional science topic titles. In fact the series is a useful basis for planning these types of science curriculum, and it can also serve as an enrichment for work schemes derived from other sources. Here, therefore, are some suggested alternative *outline* 'routes', with references to the appropriate titles. For fuller details see Index.

(Abbreviations: CC, *Clothes and Costume*, Com, *Communication*, F, *Food*, HH, *Houses and Homes*, Air, *In the Air*, ML, *Moving on Land*, RBT, *Roads, Bridges and Tunnels*, SS, *Ships*, SG, *Sports and Games*. S. = Section; B.I.C. = back inside cover; F.I.C. = front inside cover)

AIR

aeroplanes,		
jets	Air	S.5
air and weather	Air	S.2
the air around us		
the atmosphere	Air	S.1
balloons and airships	Air	S.3
breathing	SS	S.8
	Air	S.8
	SG	S.6
helicopters and hovercraft	Air	S.6
parachutes, kites and gliders	Air	S.4
sailing	SG	S.5
	SS	S.6
streamlining	Air	S.5
	ML	S.5
	SG	S.8
rusting	SS	S.4
wind and clothes	CC	S.4

ANIMALS

animals as food	F	S.8
birds	Air	S.7
bones	F	S.8
camouflage	CC	S.5
communication		
pets		
birds		
bees		
colour	CC	S.12
food chains	F	S.3
herring		
- life cycle	F	S.8
insects	Air	S.8
moths		
clothes	CC	S.10
rearing silkworms	CC	S.2
worms	SG	S.3

CHEMISTRY

acids and alkalis		
indicators		
anti-acids	F	S.7
cheese-making	F	S.3
chromatography	Com	S.6
	F	S.7
carbon dioxide	F	S.11
dyeing (mordants)	CC	S.9
flame proofing	CC	S.10
invisible ink	Com	S.1
oxygen	Air	S.8
rotting and rusting	SS	S.4
salt		
purifying		
filtering		
evaporation		
crystals		
dissolving		
density	F	S.5
salting	RBT	S.2
starch test, iodine	F	S.2, 11
soaps, starch, soda		
and bleach	CC	S.8
sugar refining		
crystals	F	S.4
yeast, carbon dioxide	F	S.2

ELECTRICITY

basic circuits	HH	S.8
electric irons	CC	S.8
electric motors	ML	S.6
electrics of the car	ML	S.5
electro-magnetic crane	SS	S.4
electro-magnets	Com	S.9
electroplating	HH	S.2
generating electricity	HH	S.8
pencils		
resistance graphite	Com	S.6
static	CC	S.7
'steady hand' device	SG	S.6
switches		
switch circuits	Com	S.8
resistance	Com	S.9
telephone and telegraph	Com	S.9
volts	HH	S.8
watts	HH	S.8

ENERGY

energy		
chains		
and work		
using and wasting	ML	S.2
engines	ML	S.6
the future	Air	S.8
potential energy	SG	S.2

THE ENVIRONMENT

Natural

farm visit	F	S.3
flour mills	F	S.3
garden animals	HH	S.10
geology	RBT	S.5
grass, trampling	SG	S.3
grasses	F	S.2
soil	RBT	S.2

Urban

building site visit	HH	S.1
doors, windows, walls and roofs	HH	S.3, 4 & 5
road-building	RBT	S.2
shops	F	S.1
pollution	Air	S.8
cars	ML	S.5
traffic and cars	ML	S.6

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THE ROLE OF THE SCIENCE

To be educated implies a knowledge of science, for this allows us to understand and enjoy more about the world we live in. Science is not just for scientists: it is for all of us. As citizens within a democracy, we need science education, because we are affected by the many decisions that are made in that field.

We need to be informed and rational about such issues as:

ENERGY CHAINS
FOSSIL FUELS
THE WORLD'S FINITE RESOURCES
NUCLEAR ENERGY
POLLUTION
CONSERVATION
FOOD PRODUCTION
FOOD CHAINS
HEALTH—PERSONAL AND WORLD
THE MEDIA AND ADVERTISING

Most modern descriptions of the essential curriculum refer to the importance of balance, and list areas of experience rather than subjects. The following list, produced by the Department of Education and Science, has had a fundamental impact on the way schools plan what they do.

AREAS OF EXPERIENCE

Aesthetic and creative
Ethical
Linguistic
Mathematical
Physical
Scientific
Social and political
Spiritual

This list is presented in alphabetical order—no other order of importance is inferred—all areas are equally significant.

It is important that children should be allowed to have a balanced curriculum. This must include science. In primary schools it need not appear as a subject on a timetable; indeed, it is probably better that it should not. But, science must be there and it must be planned.

It is therefore absolutely essential that a school has a strategy to ensure that:

(a) science is included for all children
(b) teachers understand what science is
(c) the work is significant and appropriate to primary children
(d) the science work is planned
(e) there is evaluation of the work done

The headteacher and staff of a school need to devise this strategy, to produce a policy that can provide science experiences. Ways of implementation must be included.

Such a strategy, or 'map', will show where we are, where we have been and where we can go. It will show routes for the journey and obstacles in the way. Without such a 'map' and a compass we are sure to meander aimlessly.

Help in formulating such a policy can be found in: *Learning Through Science*, Formulating a School Policy, Schools Council/Macdonald Educational, 356 06252 X.

BUT—WHAT IS SCIENCE?

The contribution that science makes to the curriculum is unique. It includes an understanding of an area of knowledge, as, indeed, every subject does, and every subject has its own way of working and developing special skills and disciplines.

Science, however, is different, because its essential nature is a process of first-hand enquiry and investigation. It includes planning and carrying out tests and experiments, using controls and recognising patterns. Its unique quality lies in its special way of working, rather than in the list of 'things' that seem 'scientific'.

Professor Sir Hermann Bondi, an eminent scientist, states, 'Science is not a subject in which there is only one answer, usually to be found at the back of the book. The great advances in science have been made by asking the questions differently from the way they were being asked before. Science is first of all a way of thinking. We must teach our most able people to think. Knowledge can come later.'

Judith, aged 10, had this to say,

'English is to help you talk and write,
maths is to help you work things out,
geography is to help you learn about other countries.
But science is to help you find out about *everything.*
You say what you think.
You do experiments to see if what you thought was right.
You feel excited and curious to find if you were right or not.
You feel pleased if you were right.
And if you were wrong you wonder what could be right.'

These are the processes which characterise science:

1. **Observation**	Using all the senses to notice reality and changes that occur.
2. **Comparing and Classifying**	Looking for similarities and differences, links and patterns.
3. **Predicting**	Questioning and guessing what will happen when different parts of the environment affect one another.
4. **Testing and Experimenting**	Trying things out and learning from first-hand experiences; keeping the tests 'fair'; recording the results of such tests and checking these observations by repeating them.
5. **Measuring**	A very important part of observation, comparison and testing.
6. **Conclusions**	These may result from measurement and experiments, but more often than not, new questions will be posed by the observations.

The six elements which characterise science will be translated by those using *Science in a Topic* as:

1. (a) Looking to find out
   (b) Listening to find out
   (c) Smelling to find out
   (d) Touching to find out
   (e) Tasting to find out

2. Sorting out:
   (a) observations
   (b) data
   (c) 'things'
   to make lists and sets and see patterns.

3. Wondering:
   Guessing 'why' and 'what might happen if ...?'

4. Trying out ideas by doing things.
   Devising ways to test these ideas and making these tests 'fair'.

5. Measuring:

length	mass	temperature
area	force	speed
volume	time	energy

This measuring will include less usual factors like the brightness of bulbs and the strength of magnets and muscles, the capacity of lungs and the reaction time of friends.

Observation of any primary school will find extensive use of the 'stuff' of science.

A display resulting from a visit to a wildlife centre may seem to indicate that there has been substantial science learning. It could be asked, 'but is it science or is it art?' Art is important, but painting and collage work is not *science.* An opportunity may have been missed to do some real science. Closer inspection of some science books may reveal that these are English comprehension in 'science education' clothing! Reading and writing are very important but they are not *Science.* A nature walk or town trail could give rise to science learning. It may be, however, that this results in the children's enjoying being out of school; they may press leaves and flowers, engage in more drawing and writing, and possibly good observation. This could be described as excellent geography, history, craft and English. All these are important, but they are not *Science.* Watching television is not science. It can lead to good science if children begin to experiment with real things in a scientific way. Working with a microprocessor can help with the interpretation of observations but this in itself is not *science.*

DOES YOUR CLASSWORK/TOPIC INCLUDE THESE ACTIVITIES?

children collecting facts by all means available—particularly first-hand observation	children classifying facts, ordering and looking for patterns	children posing questions and searching for answers and reasons	children testing possible reasons and beginning to realise the need to work in a scientific way	children perhaps arriving at conclusions, learning new facts—or—asking further questions
Recording and Communicating				
OBSERVATION	**CLASSIFI-CATION**	**HYPOTHESIS**	**TESTING**	**CONCLUSIONS**

Here is an example of such a scientific enquiry:

WHICH IS THE BEST WASHING PRODUCT?

Observation	Classification	Hypothesis	Testing	Conclusions
How many washing powders are there? What are the different types? How 'good' are they? Which works best? Which is best value?	Types: granules liquid solid biological low lather low temperature pre-soaking others …	'X' washes whiter because … What the makers claim, e.g. whiteness, softness, stain removal Opinions of the users	Controlled experiment Water—hard, soft; different temperatures; volume washing time amount of product used effectiveness on different stains	Which claims were justified? Which were not proved? Which product gave the best result? How can we decide which is really best? (a fresh problem)

RECORDING AND COMMUNICATION

Recording

Children must be encouraged to record what they have observed and measured. There is more than one reason for doing this. A vital element of science is comparing, looking for *links, patterns* and *relationships.* Children cannot do this without clear records of their tests and experiments.

Most children will realise the need to make immediate records. They know that they can easily forget, and their observations and measurements cannot be remembered with accuracy.

They also need help to know *what* to record. The set pattern of recording experience, which is often followed within *secondary* education, is not really appropriate at this stage. Primary and middle school children require more freedom to work within a less rigid framework, and to experience a variety of methods of recording. It is tempting for teachers to discourage pupils from recording 'superfluous' information, but sometimes such records can lead to new knowledge, which perhaps the teacher does not expect.

Children will need help to record in a methodical way. It is not easy to interpret a jumble of data. Unaided, children often produce work that is a series of disjointed jottings. The *Science in a Topic* series helps by giving clear pointers towards useful records, for example, *Food:* Colour changes, page 41 and *Sports and Games:* Bouncing balls, page 11.

All too often recording is regarded as 'writing about it'. How many children pretend that they do not notice, so that they will not need to 'write about it'? Recording can be much more imaginative. Some alternative ways are shown in *Science in a Topic.* Here is a selection:

1.	Tape recording	ML	p.47
2.	On-site drawings	HH	p.6
3.	Model-making	SS	pp.25–27
4.	Retention of experimental materials	Com	p.31
5.	Chart-directed observations	F	pp.60–61
6.	Photographs: children taking their own of visits and experiments	RBT	p.24
7.	Making working models	ML	pp.21–25
8.	Preserved displays, e.g., feathers, flowers, bones	Air	p.53
9.	Art: paintings, rubbings, collages, sketches	Com	pp. 19–20
10.	Retention and display of devised apparatus	SG	pp.26–28
11.	Light-sensitive paper images	Com	p.52
12.	Display of collections	HH	p.32

COMMUNICATION

The joy of discovery must have an outlet. Children should want to communicate their findings to others, and opportunities should be found for them to do this in varied ways to different audiences. The most familiar one is where children's writing is directed at the teacher, who has the role of a critic. Using imagination, she can also expose her children to other types of audience. Here are some instances.

Above: This group is thrilled to show the headteacher the results of its investigations into shuttlecocks.

Top right: Displays such as this may be used to challenge other children, groups or classes to see what they can do.

Lower right: A school assembly gives the opportunity for children to share their discoveries with others. It can increase motivation and is an interesting alternative way of communicating results to a wider audience.


Sound is measured in Decibels (db)

INTEGRATION

Science at the secondary stage is sometimes divided up into the separate disciplines of physics, chemistry and biology. Primary children are not ready for such specialisation and fragmentation. Neither are they ready to divorce the 'science' way of learning from the other areas of study. Primary children are at the *concrete operational stage*; they learn by doing and working with real things. They need *real experiences before they can move with any meaning into generalisations.* These concrete operations are vital for language-learning and mathematics; science experiences aid development in all other major areas of the curriculum. Isolated science lessons, on the other hand, can lose much of their significance, and vital links between other areas of learning may be weakened.

THE TOPIC APPROACH

Many teachers feel that the theme/topic/project approach through a co-operative development of an integrated study brings an important unifying aspect to school work. For children, the basic skills take on more meaning. Many children have learnt to read, but it can become just a mechanical exercise. Reading is only important to them if what they read is significant in terms of enjoyment or discovery. Writing becomes important when children really need to communicate, rather than just fill pages with words. Many mathematical skills become much more significant when used in a practical context. Science can become a 'fourth R': a *reason* for doing the other three.

The term 'topic' can mean different things to different schools and even to different teachers in one school. It can be 'spare-time' work reflecting a subject interest—for example, writing a little booklet about 'Coffee', 'Rubber', 'The Tudors' or 'Farming'. Such topics are usually limited to second-hand paraphrasing from geographical or historical sources.

It can at its best be an exciting original investigation, involving:

a whole school	a class	one individual
a year group	a group	

Science, which should form an essential and integrated part of the curriculum, must receive at least as much attention as it would have warranted as a separate subject. The teacher must ensure that this is the case, whatever approach is being used.

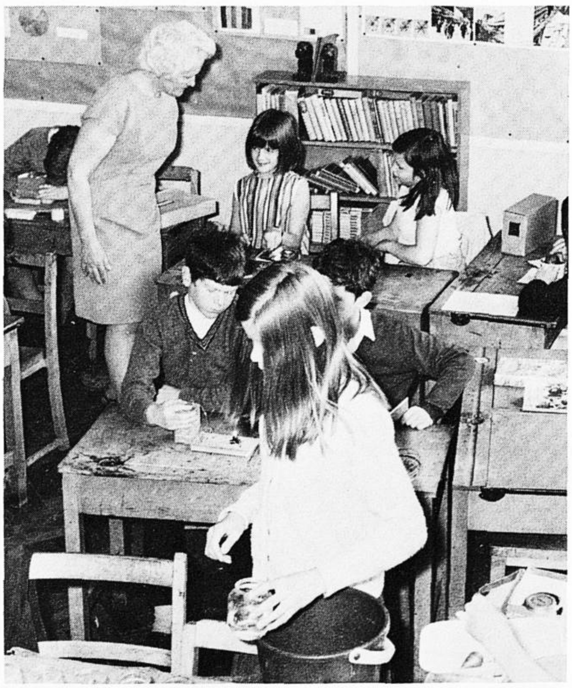
A topic or theme approach is merely one way of organisation, and its advantages and disadvantages are discussed below.

Advantages of the Topic or Theme Approach

1. *Organisation*

Topic study can lead to real investigations which demand active first-hand enquiry. Children need *things* to investigate, and *things* to investigate *with.* Even the most enthusiastic and dedicated teachers could be deterred from tackling science investigations in an ordinary classroom with 30–40 lively youngsters and little or no apparatus. Science teaching attempted in these conditions will be virtually worthless. The values that science is meant to bring to the curriculum will be lost or distorted. A topic approach, on the other hand, *can* mean that the teacher has more scope. Work can be set which is within the topic, but involves no great physical activity. Part of a large group can be 'anchored' in this way. Some children may then be doing: *book research, directed reading; drawing; map work; writing; model-making; art.*

These activities all need careful preparation, but this can be done beforehand. The teacher will thus be free to talk and work with small groups or individuals who are involved in the science investigations within the topic.



An example of how a class topic may be organised. This group is working on the science aspects of 'Communication'.

2. *Links*

Many attempts at integration start by a patching together of several diverse subjects. A *theme* approach, on the other hand, starts from a different concept. The topic has prime importance; it is the central core, and the links are then obvious and natural. The teacher's role is to plan and provide the means for children to participate in each aspect of the topic and experience the different ways of learning and developing skills.

At the end of every book in the series is an *Integrated Study* outlining ideas for follow-up work. In addition, title pages of individual sections offer talking points and ideas for book research—a preliminary to the practical assignments that follow.

There are, for instance, many opportunities to use mathematical skills. Children will likewise learn to use a wide range of apparatus, such as measuring equipment, thermometers, timers, electrical instruments and magnifying aids.

There are many occasions where art, craft and technology will lead on naturally from the science content. In *Clothes and Costume*, investigating dyes and dyeing can lead to batik work and tie dyeing. In *Moving on Land*, the design and construction of wheeled models is simple technology.

3. *Genuine Investigations*

When science has to be a separate part of the curriculum, the danger is that conclusions may be decided *before* experiments are started. 'Artificial' experiments may also be devised to drag in out-of-context science with little relevance to what interests primary pupils. Investigations will mean more to children if kept within a broader area—the principle followed in this series.

Topic work can encourage children to try various extensions, which add to the total learning of the group. Each extension lets children learn similar skills and share experiences, with the bonus that each enquiry is now a *genuine* investigation. For example, *Clothes and Costume*, p.19 suggests testing the strength of threads, but indicates seven possible extensions that different groups could pursue. Similarly, *Sports and Games*, p.9 suggests many enquiries about bouncing balls. Each enquiry will reinforce basic experiences of potential energy and elasticity.

4. *Non-specialists Can Do It*

Some teachers lack confidence in their ability to teach formal 'Science'. However, science *within a topic*, by its nature, can make the non-specialist feel far more at home. 'Topic science' is not the science of laboratories and white coats, but the science of life, with which any enthusiastic primary school teacher can feel at ease, sometimes learning alongside the children. All teachers have the advantage of normal adult experiences and common sense. This common sense, plus their primary philosophy and teaching skills, is all they need, since the science is derived from everyday life. Examples are breadmaking in *Food*, newspapers in *Communication* and washday investigations in *Clothes and Costume.*

Probably the greatest value of this work is that it makes all primary education more significant, through directing it towards the *concrete operational stage.* Topic work, which must include science, encourages children to handle and investigate real objects. Second-hand information under the same headings would normally require much more abstract thought.

Disadvantages of the Topic or Theme Approach

1. *Risk of Exclusion*

Teachers may decide to opt out of tackling important subject areas in which they think they are not fully competent or knowledgeable.

2. *Possible Imbalance*

The curriculum could be loaded by the intrinsic interests of teachers. Without good liaison and planning, work done on previous occasions might be duplicated. There is also a danger that, if topic choice is left entirely to children, 'Football', 'Space', 'Horses' and 'Dinosaurs', may predominate year after year.

There should be a balance within the science content, too, for although the total detailed subject coverage is not so important, it is essential that elements of each of the following are included: *learning about themselves; plants, animals; the immediate environment; the weather and seasons; the properties of materials and ideas of energy.*

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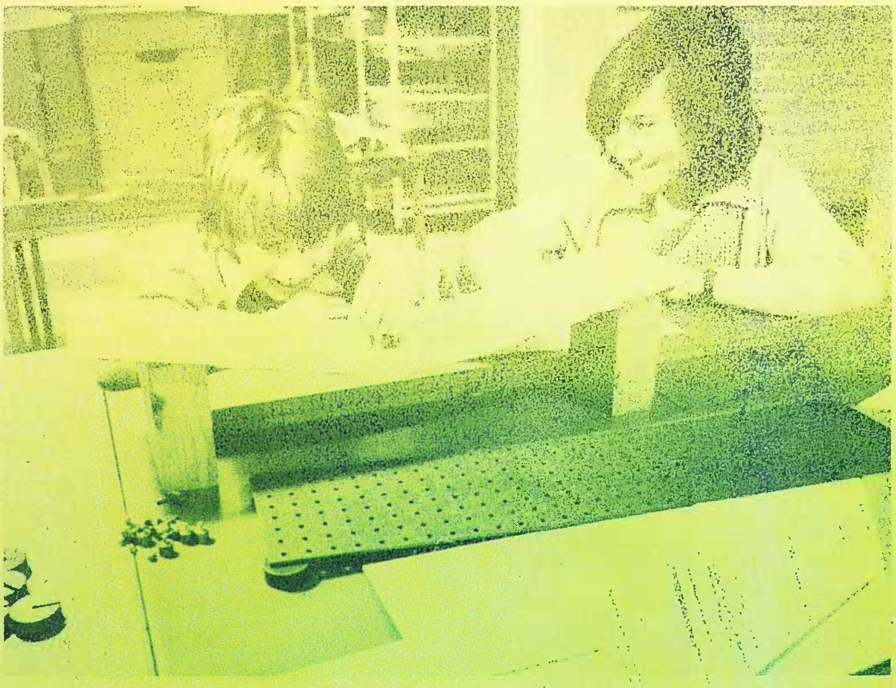
COMMUNICATION	Com	SPORTS AND GAMES	SG
FOOD	F	Page nos. in figures; i.c.= inside cover	

SCIENCE IN A TOPIC

A Teacher's Guide to the Series

This guide to the primary science series SCIENCE IN A TOPIC enables the teacher to realise its full potential as an integrated and flexible scheme. The authors identify the specific learning content and scientific principles inherent in each investigation, and show how topics may be extended and linked from book to book. Many interesting new 'routes' are suggested, through cross-references and a series index. Particularly helpful for the non-specialist is the discussion on skills, aims, methods and processes of modern science teaching in the primary school. There are also detailed notes on the individual books, with fascinating comments on pupils' reactions when the initial experiments were carried out in schools.



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