

Macmillan Science

Teacher's Book

4

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EDUCATION

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John Stringer


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Contents

Introduction	3	<i>Matter and heat</i>	73
How science works	7	4 Heat and its effects	74
1 What is science?	7	5 Temperature and thermometers	76
2 Observing and investigating	9	6 How heat travels	78
3 Safety in the laboratory	11	7 Heat conductors and insulators	81
Unit 1 Living things	13	8 Solids, liquids and gases	83
<i>Life processes</i>	13	9 Changing state	85
1 Living and non-living things	14	Unit 3 Our Earth	88
2 The characteristics of life	16	<i>Rocks and minerals</i>	88
3 Nutrition	18	1 The Earth	89
4 Respiration – how do plants and animals breathe?	20	2 Investigating rocks	91
5 Movement and growth	22	3 Types of rock	93
6 Sensing and responding	24	4 Minerals and their properties	95
<i>Plants</i>	27	5 Using minerals	97
7 Plant parts and characteristics	28	6 Weathering and erosion	99
8 The variety of plants	30	<i>Oceans</i>	101
9 Investigating leaves	32	7 Oceans, seas, rivers and lakes	102
10 Investigating roots	34	8 Under the surface	104
11 Flowers, fruits and seeds	36	9 Waves and tides	105
12 How non-flowering plants reproduce	39	10 Pollution at sea	107
13 Useful plants	41	Unit 4 Forces and energy	110
<i>Animals</i>	44	<i>Energy</i>	110
14 Animal life	45	1 Energy forms and changes	111
15 Vertebrates	47	2 Using energy	113
16 Invertebrates	49	3 Solar energy	115
17 Animal behaviour	52	<i>Sound</i>	118
18 Useful and harmful animals	54	4 Sound	119
<i>The environment</i>	57	5 Hearing sounds	121
19 Habitats and adaptations	58	6 Sounds: good and bad	123
20 Deserts, rivers and reefs	60	Unit 5 Astronomy	126
21 People and the environment	63	1 The solar system	127
Unit 2 Matter and materials	65	2 Looking at the planets	128
<i>Materials</i>	65	3 Asteroids, comets and meteors	130
1 Different materials	66	CD-ROM answers	133
2 Choosing materials	68	End-of-unit test answers	140
3 Marvellous metals	70		



Introduction

Preface

The Macmillan Science series is a comprehensive science course for all students in primary schools. Building on practical experience and investigation, the books follow current best practice in science education.

Through engaging content and carefully graded activities and exercises, students are guided to develop a sound framework of scientific knowledge, understanding and skills.

Discussing ideas with partners and then with the whole class is central to the approach used throughout. In this way, the children acquire and improve their spoken English, but are also active learners throughout each science lesson.

There are six full-colour Pupil's Books from level 1 to the final year of primary school. The main strands of living things (plants, animals and humans), materials, and the physical world are repeated at each grade, reinforcing ideas learnt earlier and developing these to a higher level.

Science teaching, especially when it is 'hands-on', can be highly enjoyable and rewarding for teachers and students alike. We hope that Macmillan Science will contribute both to the effectiveness of your teaching and to the pleasure that you and your class gain from studying science.

David and Penny Glover

Components

For each level there is a Pupil's Book, a Workbook and a CD-ROM, accompanied by a Teacher's Book which gives clear instructions on how to plan lessons.

- The Pupil's Book contains clear illustrations and instructions for carrying out practical investigations, discussion activities and sections for the assessment of learning.
- The Workbook contains a range of different activities that enable children to review and consolidate their learning.
- The CD-ROM packaged with each Pupil's Book, provides further reinforcement and assessment of skills and concepts developed in each unit through interactive activities.

The scope and sequence is displayed at the beginning of the Pupil's Book, together with the objectives for each unit. Each of the five main areas of science is colour coded for easy reference from one book to another.

Teacher's Book structure

Each topic is divided into three sections: Lesson preparation, Lesson plan and After the lesson.

Lesson preparation: outlines the topic objectives, equipment needed, key words with definitions and teaching ideas and background information, linking theory with practice.

Lesson plan: detailed lesson plans including ideas for warm-up and extension activities.

After the lesson: Workbook answers. CD-ROM and End-of-unit test answers are given at the back of the book.



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Why teach science in the primary school?

Today, the case for teaching primary science hardly needs to be stated. Science, alongside numeracy and literacy, is a core component of the primary school curriculum in schools around the world.

The reasons for teaching science at the primary level may be summarised as follows:

- Investigation-based science learning develops children's curiosity, problem-solving, practical and communication skills.
- Basic scientific knowledge of the human body, diet, living things, the environment, materials, forces and energy contributes to children's developing awareness of themselves and their relationship to their surroundings; this knowledge will help them to make healthy choices, to keep safe and to solve problems as they move through life.
- Scientific values and attitudes such as respect for evidence, questioning, flexible thinking and the willingness to share knowledge and ideas are relevant in all areas of children's learning, not just science.
- Through science, children become aware of environmental issues and the impact that they, as individuals, can have on their surroundings; they develop respect for living things and their environment and become aware of the harm that simple actions such as littering, wasting energy or contaminating water supplies can cause.
- In the majority of countries, science is an examination subject at the end of the final year of primary school. Children may need to perform well in science to gain a place at the secondary school of their choice.
- A good knowledge of science gained in the primary school prepares children to do well in their more formal science education at secondary school. Good results in secondary school science examinations open up a wide range of career opportunities.

Successful teaching and learning with Macmillan Science

Effective science teaching should involve:

- Planning well-resourced lessons that engage all pupils, so each one is able to participate in the discussion and the practical tasks. Most of the equipment needed for the lessons is easy to obtain, but specific measuring equipment and an assortment of containers are essential for scientific investigations.
- Allowing children to reflect on their prior knowledge, articulating their views about scientific ideas. Sometimes these ideas may be quite different from accepted scientific ones but are often valid from a child's point of view. They provide a key to developing scientific concepts.
- Encouraging children to discuss their ideas with their partners and the rest of the class so that they learn to be active learners, articulating their own ideas and listening to those of others.
- Introducing the key words shown in each unit, developing a shared understanding of these and encouraging children to use them when they express their ideas. Developing working definitions for new vocabulary and using the glossary can help children to clarify meanings of scientific terms.
- Asking 'open questions' so that children are encouraged to think through their ideas in depth rather than just recalling information. Often, inserting 'do you think' into a question can elicit a more meaningful response.
- Teaching scientific recording, using charts and graphic organisers. These enable comparisons to be made and reduce the amount of writing required, leaving more time for discussion and practical work.



- Using the school grounds and the neighbourhood as an extension of the classroom, encouraging children to observe things that they may otherwise walk past each day.
- Encouraging the children to think of themselves as scientists so that they develop a wonder of the natural world and an excitement for exploring the world around them. Science is a way of thinking, not just a body of knowledge.

Teaching a lesson

- 1 Look through the learning objectives and key words to decide how the children can be supported during the topic. The language boxes give additional ideas for how children's language needs can be addressed.
- 2 Check the resources list and ensure that there is enough equipment for all the children to participate in the practical work. Resources can be put out on each table or placed nearby so that it does not cause a distraction during the introduction to the lesson. Ideally, children should work in pairs or small groups so that each person can play an active part.
- 3 Arrange the classroom to ensure easy movement, making sure that bags and clothing are not trailing from chairs.
- 4 If an interactive white board is available, look for visual materials and video sequences that will help to reinforce vocabulary and aid concentration.
- 5 Let the children decide on their own working definitions for new vocabulary and try to develop these during the lesson, referring to the glossary for more precise meanings. Write new vocabulary and summarise children's ideas on the board to reinforce learning, especially for visual learners.
- 7 Encourage children to be active listeners, responding to the ideas of others, saying if they agree or disagree and giving reasons why. Try to develop a sense that the children are talking to each other. Get children to give reasons for their thinking rather than giving short answers to questions.
- 8 At the end of the lesson, encourage the children to reflect on their learning, saying what they found particularly interesting or perhaps difficult. Look at the objectives again and ask the class to assess whether they managed to achieve these. Invite questions about any difficulties or puzzles they may still have. Close the lesson with Check your progress.
- 9 Set the children the Workbook and CD-ROM activities as homework to consolidate their learning.

Developing children's scientific vocabulary

To become scientifically literate, children must acquire the vocabulary they need to describe their observations and ideas. To aid with this aspect of their learning, new key words are identified in every lesson. Simple definitions for all the key words are given in the glossary at the back of the Pupil's Book, and the Teacher's Guide offers suggestions for helping children to learn these new words.

During the lesson, you could write the key words on the board as they are introduced. Children could copy the key words into their notebooks. If you print the key words on individual cards, they can be used as flashcards for reading practice. Key word cards can also be used to label displays and to play word games.



General safety rules for students

Hazardous laboratory chemicals such as strong acids and alkalis should not be used in the primary school, but common household chemicals such as cleaners and paints are often introduced for various activities. These must be treated as potentially hazardous, and any safety instructions on the container followed. In general, anything which is irritating, toxic or corrosive (bleach, for example) should be handled only by the teacher.

Particular care should be taken with matches, candles and other naked flames and heat sources. In lower primary, children should not use heat sources themselves; these should only be demonstrated by the teacher. We advise against the use of spirit burners by pupils in the primary school because of the fire risk posed by fuel spills.

Safety equipment

There is some basic safety equipment that you should have when you do an experiment. Make sure you have the following nearby:

- First Aid box. Keep your First Aid box complete at all times – if you use something up, replace it. The most important things to have in your First Aid box are First Aid instructions, plasters, small bandages, large bandages and safety pins.
- Bucket of water (with cup). Burns or chemical poisoning (either swallowed, on the skin, or in the eyes) need water. Near the water, keep a cup with which to pour the water more effectively.
- Fire blanket. A blanket should be kept for smothering fires. If someone's clothes catch fire, quickly lay the person on the floor and smother the flames with the blanket.
- Fire bucket. Fill a metal bucket with clean, dry sand and keep a long-handled scoop or ladle in it. Sand is very good for putting out fires. NEVER put out a spirit or kerosene fire with water – ALWAYS use sand.

Field work and visits

Nothing is as effective as first-hand experience in promoting curiosity and developing understanding of the natural world. As with any learning experience, preparation is the key to a successful field trip.

- Visit the site yourself in advance to explore what it has to offer.
- If there is a warden or an education officer, discuss what he or she will show the children on the day of the visit. Brief them about the topics the children have been studying in recent lessons.
- It is often helpful to prepare worksheets for the trip. These should prompt the children to find and answer questions about the important specimens/features you want them to see and understand.
- Make a safety assessment before committing yourself to the trip. How many adults will you need to accompany the class? Are there any particular hazards at the site?
- Follow up the trip with a lesson in which children talk and write about their experiences.



Lesson 1: What is science?

Lesson preparation

Objectives

- ☞ explain what science is
- ☞ describe some of the different things scientists do
- ☞ list some of the branches of science

Equipment

Extension: research facilities

Key words

discoveries: new findings; things that were not known previously

experiments: practical tests or investigations carried out by scientists

observations: scientific facts noted and recorded by a scientist who is watching or measuring something

theories: ideas that explain observations using scientific principles

Background information

Students may imagine scientists as either trying to find a cure for cancer or planning new ways of destroying the world. Students seldom think of women or those from ethnic minorities as scientists, but this may be because of the idea of the mad male scientist shown in the media.

Einstein said that 'science favours the prepared mind' and the example in this unit shows how Alexander Fleming was able to recognise the significance of his observations because of his scientific knowledge.

An important characteristic of good science is that it is always changing. Students may believe that the laws of science are permanent. The truth is very different: understanding of the world is constantly being challenged, and that is how knowledge advances.

Lesson plan

Warm up

Ask the students to draw a scientist. Their pictures may match the stereotype described above. But remember that you are asking them to draw something as foreign to them as a dragon, and with similar stereotypical characteristics. *Tell me about your scientist. Tell me what scientists do. Tell me what they do when they are not working.*

Ask the students to compare their scientists and talk to each other about them. *Are all scientists like this? How important is luck in scientific discovery?*

Work with the students to explain to them how observations and measurements are used by scientists to come up with their theories. Explain that scientific theories must be tested with experiments.

Ask the students to work in groups to name some scientists and to explain what was important about their discoveries. Work with the students to group the scientists they have named into one of the branches of science: biology, chemistry, physics, or possibly geology or even microbiology.



Lesson 1: What is science?

Activity 1 p4

Answers

- 1 The bacteria did not grow near the mould.
- 2 A substance made by the mould killed bacteria.
- 3 He made a broth from the mould to see if it killed bacteria.
- 4 Penicillin
- 5 It has saved millions of lives.

Activity 2 p5

Answers

- 1 biology 2 chemistry 3 physics 4 geology

Extension

Ask students to research one or more famous scientists. Ensure that they have a spread of both living and dead scientists, both genders and different ethnic backgrounds. Ask the students to make a brief presentation about their personal choice.

Introduce a scientist of your own choice. Ideally, pick someone who is from the same background and community as the students themselves. They may not be famous, but their contribution to society will have been important. For example, you might choose a nurse, a pharmacist, an environmentalist or someone concerned with any of the services to the students' homes. If at all possible, arrange for this person to visit the school and to talk about their work.

Concluding the lesson p5

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What you have learnt answers

A scientist makes observations to try and understand the world. He develops theories to explain his observations, and performs experiments to test his theories. Scientists make discoveries that help society and the environment.

Check your progress answers

- 1 a practical way of understanding the world and everything in it
- 2 example answer: Fleming observed that bacteria did not grow near mould. This led to the discovery of penicillin.
- 3 Biology, chemistry, physics and geology. Living things, matter, forces and energy, substances and reactions and soil and rocks.



Lesson 2: Observing and investigating

Lesson preparation

Objectives

- ☞ describe how scientists make observations and measurements
- ☞ explain how a scientist uses an experiment to test a hypothesis
- ☞ understand that a scientific experiment must be a fair test

Science skills

identifying a fair test
structuring a fair test

Equipment

Warm up: white and brown sugar, 2 glasses, hot and cold water, a spoon

Key words

fair test: an experiment in which everything apart from the thing being tested is kept the same –an experiment must be fair in order to check a theory

hypothesis: an explanation or theory that has yet to be proved

instruments: devices, inventions or machines used for measuring, handling and observing scientific specimens

measurements: observations made with a numbered scale such as a ruler or a thermometer

predictions: forecasts about the outcome of events or tests

records: a scientist's written notes of his observations and measurements

senses: sight, hearing, smell, taste and touch

Background information

Many science ideas are subject to fair tests. A fair test controls the factors that might affect the outcome, leaving just one factor to be investigated. In a fair test, everything, apart from the factor you're testing, is kept the same.

Lesson plan

Warm up

Present a simple test as unfairly as possible. For example, you might tell the students that you want to find out whether brown sugar or white sugar dissolves faster. For a fair test, you should use the same amounts of sugar, in the same amounts of water, at the same temperature, and with the same amount of stirring.

Aim to be very unfair, using very different amounts and even favouring one sugar over another. *Why is that unfair? What should I do to be fair? Why would that give me better results?*

Ask the students to plan the test for you. Remind them that what you're interested in is whether brown sugar or white sugar dissolves faster. *So what should I change?* (The colour of the sugar.) *So what must I keep the same?* (Everything else.) *So why is that a fair test?*



Lesson 2: Observing and investigating

Activity 1 p8

Students can work on a blank sheet of paper, recording what they hear. They could make a little sketch. The further away the sound, the further the picture from the centre of the paper. The louder the sound, the larger the picture.

Answers

1–3 students' own answers

Extension

Ask the students to plan a fair test for a simple hypothesis that you can easily test in the classroom. Get them to answer three key questions: *what are we going to change?*; *what are we going to keep the same?*; *what are we going to observe or measure?*

Concluding the lesson p8

What you have learnt answers

A scientist uses his senses and scientific instruments to make observations. He uses measuring instruments such as clocks and rulers to make measurements. He records all his observations. Observations lead to questions. A good theory makes predictions. A scientist plans an experiment to test a hypothesis. The experiment must be a fair test.

Check your progress answers

- 1 by using their senses and scientific instruments
- 2 so they are not forgotten and can be checked by others
- 3 a theory that has not been proved
- 4 by designing an experiment
- 5 A fair test is an experiment in which everything apart from the thing being tested is kept the same.

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Lesson 3: Safety in the laboratory

Lesson preparation

Objectives

- ☞ identify dangers in the science laboratory
- ☞ state the safety rules for working in the laboratory

Science skills

plannings

Equipment

none

Key words

dangers: hazards or risks

laboratory: a room fitted out for performing scientific experiments

laboratory rules: safety rules that must be obeyed in the laboratory

safety: protection from danger

Background information

It is important to remember that science in schools is an extremely safe activity. There are far fewer accidents than students might experience doing sport, in workshops, or simply moving about the school. Nevertheless, it is important that they follow basic science safety rules and begin to recognise ways in which they can keep themselves and others safe.

Lesson plan

Warm up

Explain to the students that life is full of risks, and that some careful risk-taking (for example some exciting sports) are part of living life to the full, but a risk should never become a hazard. *Here we are in the science laboratory. Tell me some risks that you can see around you. By silly behaviour, you can turn a risk into a hazard. Tell me some things you could do that would put you or others in danger. Tell me some precautions you can take that would reduce the risks in the science laboratory.*

Activity 1 p10

Answers

1–2 students' own answers



Lesson 3: Safety in the laboratory

Extension

The students could make a pocket guide for other students new to the laboratory to tell them about safe behaviour. A list of positive ideas is preferable to a list of don'ts.

Ask the students to act out a piece of drama in which somebody new to the laboratory behaves wrongly, and the consequences that follow.

Concluding the lesson p10

What you have learnt answers

Scientists carry out experiments in the science laboratory. There are potential dangers when performing experiments. When working in the laboratory you must follow the laboratory rules. The rules are designed for the safety of everyone in the laboratory.

Check your progress answers

- 1 electricity, sharp blades, heat, heavy objects, loose clothing (or any others from the list on p9 of the Pupil's Book)
- 2 false – never taste anything unless you know that it is safe.
- 3 example answers: If long hair isn't tied back it could catch fire. Shoes protect your feet better than sandals. Goggles protect your eyes from splashes or heat.

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Living things: Life processes

The classification of living and non-living things is not quite as straightforward as you might imagine. There are lists of the characteristics of living things, but not all living things show all these, for example, many plants do not move at a speed that we can observe. You only have to think of two everyday objects like an apple and a hen's egg to realise that it's very hard to recognise whether these are alive or not. (A recently picked apple will still be alive although not capable of independent life. It contains seeds of course, which have the potential for life. The hen's egg may or may not be alive; it may or may not have been fertilised.)

We take in and use food for energy. Some of this food is used for growth – wanted and unwanted – and some for repair and maintenance. We move. Even those animals that don't move have to make the most of passing opportunities: sea anemones grab passing plankton, and barnacles were famously described as 'lying on their backs and kicking their food into their mouths'.

We grow. We are growing, repairing, renewing, all the time. Most living things start off small and get bigger. Things grow by adding to themselves.

This contrasts with balloons and umbrellas which grow by stretching. You can understand students getting the two confused. Most growing plants and animals do not 'swell up' and, indeed, many plants become more complex as they grow, adding roots and branches. We can reproduce. Life is finite and, if living things did not reproduce, then life would quickly die out on Earth. Virtually all living things reproduce and where they are sterile, as in the case of worker ants, they have an important role to play in the reproduction of their colony or society.

We respire. The true process of respiration is the use of food to release energy – a process very similar to burning. It takes place in all our cells. We respond to stimuli. We are aware of what is going on around us and respond accordingly. From the unconscious responses (our pupils growing larger as we walk into the darkened cinema) to the conscious (watching the film) we react to the multiple stimuli that we receive from the world around us.

Finally, we produce waste. Some of it is gaseous – carbon dioxide from our lungs, less pleasant gases from other places – and some is liquid and solid waste. Excretion is the general name for all these waste-ridding activities, and is common to everything that lives.

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Lesson 1: Living things and non-living things

Lesson preparation

Objectives

- ① classify the things around you as living, non-living or once-living
- ② begin to describe the processes of life

Science skills

observing
classifying

Equipment

Warm up: a plastic flower, a pot of soil, water, a real pot plant

Extension: an egg, a bowl

Key words

life processes: things such as feeding (nutrition), breathing (respiration), reproducing and excreting that living things do

living: a living thing shows some or all of the seven characteristics of life

non-living: describes anything that does not have all seven characteristics of life

Background information

Most living things demonstrate most of the recognised life processes but not all. So any list of life processes is always somewhat limited. For example, most plants are unable to move or at least to move quickly. Most bees are unable to reproduce. So it is important to keep an open mind when looking at the processes of life. Do not encourage students to think of any list as definitive. Nevertheless, it is obvious which things around us are living and which are not, although students may have difficulty in believing that a tree, which appears to do nothing, is actually alive.

Lesson plan

Warm up

Bring in a plastic flower. You might plant it in a pot of soil. You could even water it. Compare it with a real pot plant. *Why isn't my plant alive? How can you tell that a real plant is alive? How do you know that that tree/grass/plant is alive?*

Activity 1 p11

Ask the students to work in groups and to complete the activities in the Pupil's Book. The table is a difficult one to complete; for example, the carrot and a mushroom, providing they are fresh, are both alive.

Answers

Living: dog, fish, mosquito, mushroom, carrot; Once-living: leather bag, leather shoe, table, newspaper, bread; Non-living: tin can, car, volcano

Activity 2 p12

Answers

- | | |
|---|--|
| <p>1 fish: moves, grows, feeds, senses, respire, makes waste, reproduces</p> <p>2 insect: moves, grows, feeds, senses, respire, makes waste, reproduces</p> | <p>3 car: moves, makes waste</p> <p>4 fire: moves, grows</p> <p>5 river: moves, grows</p> |
|---|--|

Extension

A hen's egg is a very difficult example which will challenge the most able students. Even if the egg is free range, we cannot be certain that it is fertilised. But you can use it to challenge the students' understanding of living and non-living; for example, get them to draw what they think is inside the egg, before you break it and explain to them the functions of the yolk and white.

Concluding the lesson p12

This is a difficult topic for students who may imagine that science is clear cut and has answers to everything. However it is important to emphasise that scientists cannot, as yet, originate life. All living things came from living origins. But scientists haven't always believed that: only a few hundred years ago many scientists were convinced that mice, for example, originated in the piles of dirt that might collect in the corner of a room. So tell the students that what they have learnt is a step on the way to a better understanding.

What you have learnt answers

Plants and animals are living things. We can tell that they are alive because they move, grow, reproduce and perform other life processes. Stones, water and other non-living things do not have all the characteristics of life.

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Check your progress answers

- 1** example answers: wooden spoon, bone, cotton shirt
- 2** feeds, moves, grows, senses, produces waste, breathes, reproduces
- 3** example answer: It cannot reproduce, breathe or grow.

After the lesson

Workbook p4-5

Answers

- | | |
|---|--|
| <p>1 living things: a b f g h i
non-living things: c j l
once living things: d e k</p> <p>2 reproduces, respire, moves, grows, makes waste, feeds, senses</p> <p>3 a Plants and animals are living things.
b Rocks, metal, sand and water are non-living things.</p> | <p>c Bone, wood, leather and horn were once living things.</p> <p>4 a no
b grow, respire, excrete, feed, reproduce
c by using energy from a battery
d from other living things</p> |
|---|--|



Lesson 2: The characteristics of life

Lesson preparation

Objectives

- 🕒 list the seven characteristics of life
- 🕒 explain why each characteristic is essential for life
- 🕒 discuss how an animal and a plant show life's characteristics

Science skills

using evidence

Equipment

Warm up: a realistic baby doll

Extension: cards with life characteristics, salad plants

Key words

excrete: to get rid of unwanted or dangerous substances from the body

grow: to get bigger

movement: change of position; motion from one place to another

nutrition: obtaining energy and materials for life – by eating food, for example

reproduction: producing offspring similar to the parent(s)

respiration: releasing energy from food (usually by combining it with oxygen)

sensitivity: sensing and reacting to changes in the surroundings

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Background information

The lesson introduces seven characteristics of life. Most living things share these basic seven characteristics, but they are not always easily demonstrated.

Growth is not the same as expansion. Plants and animals grow because they add to their bodies and not because they expand like a balloon.

Green plants are able to make their own food; animals are not, which is why most animals need to move about in order to find the food they need.

The word respiration is commonly used to describe the process of breathing. The correct scientific use is to describe the process by which plants and animals release energy from their food.

Lesson plan

Warm up

Present a baby doll to the class – the more realistic the better. Tell the students that it is so realistic that you believe it is alive. *How do you know it is not alive? What can a real baby do that my doll can't? Could my doll ever be alive? Why not?*

Ask the students to list some of the ways in which a baby is different from a doll. Collect these on the board. Use one colour for statements that are certain and another colour for statements that students may think.



Activity 1 p15

Answers

1 nutrition 2 growth 3 reproduction 4 excretion 5 respiration 6 sensitivity 7 movement

Extension

Ask the students to work in groups to tell a story which includes many of the basic characteristics of life. While most of the group act out the story, one or more of them holds up a card with the name of a life characteristic on it. (For obvious reasons, you may choose to exclude excretion and reproduction!)

Give the cards to other students in the class and ask the group to act the story again. Can the audience hold up the cards at the right moments?

Bring some small plants into school which the students can explore. For example, some small salad plants like mustard, cress or mung beans. Ask them to discuss the ways in which the plants are alive or the simple activities they could do in order to demonstrate the characteristics of life.

Concluding the lesson p15

What you have learnt answers

All living things share the seven characteristics of life. When their bodies grow they increase in size. They eat other organisms, or make their own food for nutrition. They excrete to get rid of waste. During reproduction they produce offspring similar to themselves. They release energy from their food by respiration. They show sensitivity to changes in their surroundings and are capable of movement of their whole body or body parts.

Check your progress answers

- 1 growth, reproduction, sensitivity, movement, nutrition, respiration, excretion
- 2 a to get rid of waste produced by other life processes b to release the energy stored in food
- 3 it releases gases through its leaves and chemicals when the leaves fall
- 4 to find food, choose a mate and react to danger

After the lesson

Workbook p6–7

Answers

- 1 growth, feeding, respiration, sensation, reproduction, movement, excretion
- 2 a grow b reproduce c respire d excrete
- 3 Answers should include all of the characteristics from activity 1
- 4 students' own answers