Science

The National Curriculum for England www.nc.uk.net

Excellence in schools

About science in the National Curriculum

The structure of the National Curriculum

The programmes of study[1] set out what pupils should be taught, and the attainment targets set out the expected standards of pupils' performance. It is for schools to choose how they organise their school curriculum to include the programmes of study for science.

The programmes of study

The programmes of study set out what pupils should be taught in science at key stages 1, 2, 3 and 4 and provide the basis for planning schemes of work. When planning, schools should also consider the general teaching requirements for inclusion, use of language, use of information and communication technology, and health and safety that apply across the programmes of study.

The **Knowledge, skills and understanding** in each programme of study identify the four areas of science that pupils study:

- scientific enquiry
- life processes and living things
- materials and their properties
- physical processes.

Teaching should ensure that scientific enquiry is taught through contexts taken from the sections on life processes and living things, materials and their properties and physical processes.

The **Breadth of study** identifies contexts in which science should be taught, makes clear that technological applications should be studied, and identifies what should be taught about communication and health and safety in science.

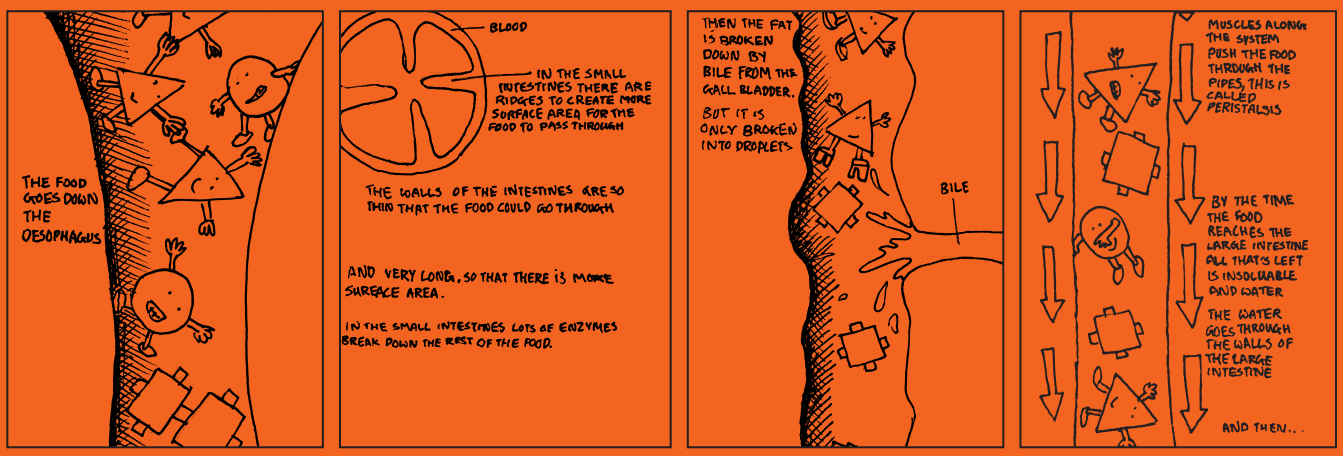
Schools may find the DfEE/QCA exemplar schemes of work at key stages 1, 2 and 3 helpful to show how the programmes of study and attainment targets can be translated into practical, manageable teaching plans.

Science at key stage 4

There are two programmes of study at key stage 4 – single science and double science. Pupils may be taught either the single or the double science programme of study. The requirements of either option would also be met by pupils taking GCSE courses in all three of the separate sciences of biology, chemistry and physics. The Government firmly believes that double science or the three separate sciences should be taken by the great majority of pupils. Single science is intended for a minority of pupils who have good reason to spend more time on other subjects.

[1] The Education Act 1996, section 353b, defines a programme of study as the 'matters, skills and processes' that should be taught to pupils of different abilities and maturities during the key stage.

The programmes of study for science



Science does not tell us everything that we want to know about life, or all we need to know. But it does provide us with the most robust information about the way the universe works that has so far become available to us.

Colin Tudge, Science Writer

Science is valuable because it meshes with all our lives and allows us to channel and use our spontaneous curiosity.

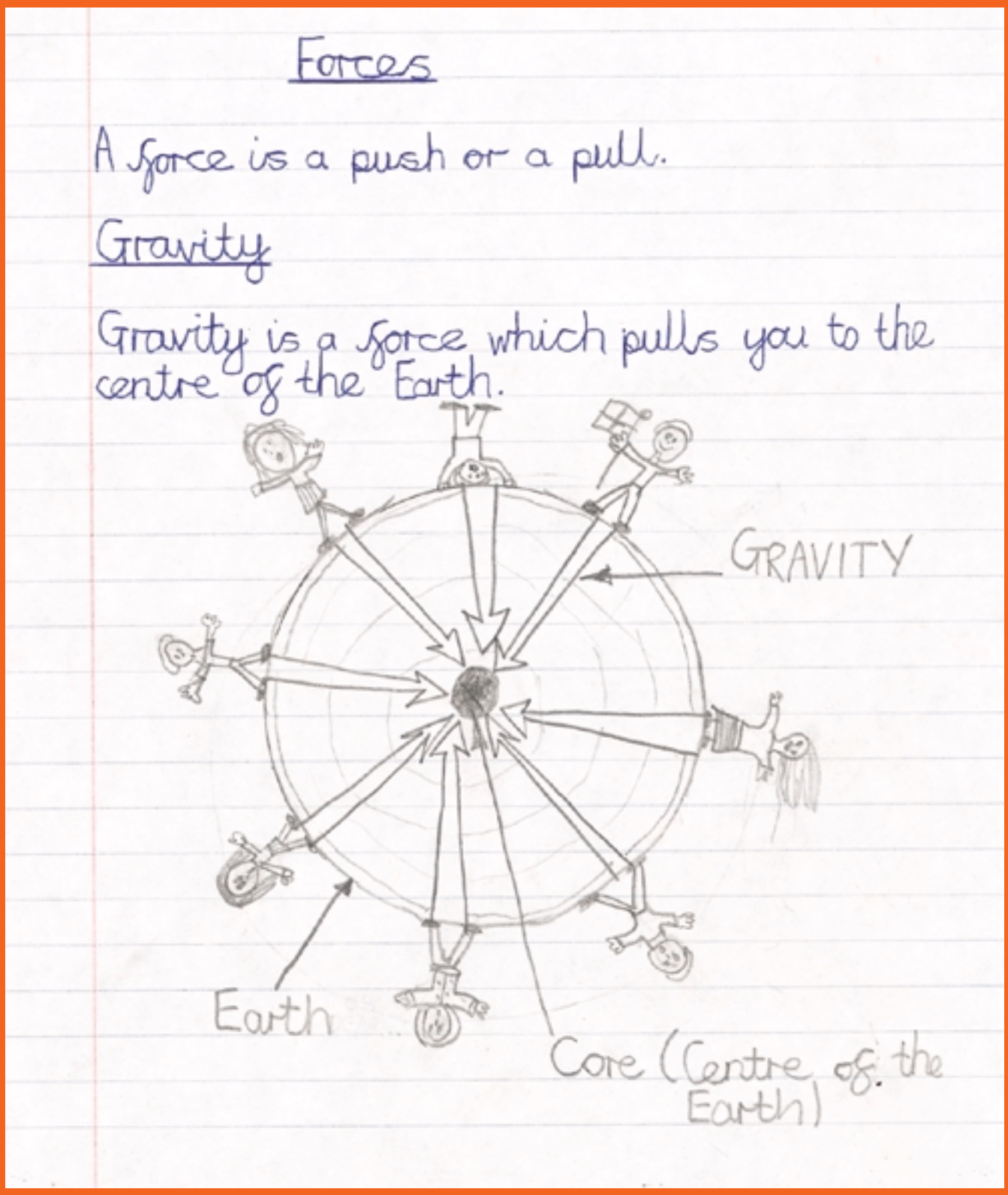
Professor Susan Greenfield, Director, Royal Institution

Studying science teaches us to be good at analysis and helps us to make complex things simple. It trains minds in a way that industry prizes.

Brendan O'Neill, Chief Executive, Imperial Chemical Industries PLC

Science is an integral part of modern culture. It stretches the imagination and creativity of young people. Its challenges are quite enormous.

Professor Malcolm Longair, Institute of Physics Fellow in Public Understanding of Physics, Head of Cavendish Laboratory, University of Cambridge



The importance of science

Science stimulates and excites pupils' curiosity about phenomena and events in the world around them. It also satisfies this curiosity with knowledge. Because science links direct practical experience with ideas, it can engage learners at many levels. Scientific method is about developing and evaluating explanations through experimental evidence and modelling. This is a spur to critical and creative thought. Through science, pupils understand how major scientific ideas contribute to technological change – impacting on industry, business and medicine and improving quality of life. Pupils recognise the cultural significance of science and trace its worldwide development. They learn to question and discuss science-based issues that may affect their own lives, the direction of society and the future of the world.

Programme of study: science

Key stage 1

During key stage 1 pupils observe, explore and ask questions about living things, materials and phenomena. They begin to work together to collect evidence to help them answer questions and to link this to simple scientific ideas. They evaluate evidence and consider whether tests or comparisons are fair. They use reference materials to find out more about scientific ideas. They share their ideas and communicate them using scientific language, drawings, charts and tables.

Knowledge, skills and understanding

Teaching should ensure that **scientific enquiry** is taught through contexts taken from the sections on **life processes and living things, materials and their properties** and **physical processes.**

Sc1 Scientific enquiry

Ideas and evidence in science

1 Pupils should be taught that it is important to collect evidence by making observations and measurements when trying to answer a question.

Investigative skills

2 Pupils should be taught to:

Planning

a ask questions [for example, 'How?', 'Why?', 'What will happen if … ?'] and decide how they might find answers to them

b use first-hand experience and simple information sources to answer questions

c think about what might happen before deciding what to do

d recognise when a test or comparison is unfair

Obtaining and presenting evidence

e follow simple instructions to control the risks to themselves and to others

f explore, using the senses of sight, hearing, smell, touch and taste as appropriate, and make and record observations and measurements

g communicate what happened in a variety of ways, including using ICT [for example, in speech and writing, by drawings, tables, block graphs and pictograms]

Considering evidence and evaluating

h make simple comparisons [for example, hand span, shoe size] and identify simple patterns or associations

i compare what happened with what they expected would happen, and try to explain it, drawing on their knowledge and understanding

j review their work and explain what they did to others.

Note
The general teaching requirement for health and safety applies in this subject.

2 → links to other subjects
These requirements build on En1/10.

2b → links to other subjects
This requirement builds on En2/7a, 7b.

2f → links to other subjects
This requirement builds on Ma3/4a, 4c.

Note for 2f
In the international system of units, kilogram (kg) is the unit of mass. In practice, mass is measured by weighing; scales measure or compare a force (a push or a pull). At key stage 1 it is acceptable to treat weight as synonymous with mass. At key stage 2 pupils will learn that the unit of weight (a type of force) is the newton.

In science, the term volume is preferred to capacity. The preferred unit is cubic centimetres, but at key stage 1 the unit litre (= 1000 cubic centimetres) is acceptable.

2g → links to other subjects
This requirement builds on Ma2/5a, 5b and ICT/3.

2i, 2j → links to other subjects
These requirements build on En1/1c, 3c and En3/1d, 1e.

Sc2 Life processes and living things

Life processes

1 Pupils should be taught:
- a the differences between things that are living and things that have never been alive
- b that animals, including humans, move, feed, grow, use their senses and reproduce
- c to relate life processes to animals and plants found in the local environment.

Humans and other animals

2 Pupils should be taught:
- a to recognise and compare the main external parts of the bodies of humans and other animals
- b that humans and other animals need food and water to stay alive
- c that taking exercise and eating the right types and amounts of food help humans to keep healthy
- d about the role of drugs as medicines
- e how to treat animals with care and sensitivity
- f that humans and other animals can produce offspring and that these offspring grow into adults
- g about the senses that enable humans and other animals to be aware of the world around them.

Green plants

3 Pupils should be taught:
- a to recognise that plants need light and water to grow
- b to recognise and name the leaf, flower, stem and root of flowering plants
- c that seeds grow into flowering plants.

Variation and classification

4 Pupils should be taught to:
- a recognise similarities and differences between themselves and others, and to treat others with sensitivity
- b group living things according to observable similarities and differences.

Living things in their environment

5 Pupils should be taught to:
- a find out about the different kinds of plants and animals in the local environment
- b identify similarities and differences between local environments and ways in which these affect animals and plants that are found there
- c care for the environment.

2a → ICT opportunity
Pupils could use multimedia sources to make comparisons.

4 → ICT opportunity
Pupils could use data collected to compile a class database.

1b → ICT opportunity
Pupils could use a software package to combine words and pictures about materials and objects.

Sc3 Materials and their properties

Grouping materials

1 Pupils should be taught to:
- a use their senses to explore and recognise the similarities and differences between materials
- b sort objects into groups on the basis of simple material properties [for example, roughness, hardness, shininess, ability to float, transparency and whether they are magnetic or non-magnetic]
- c recognise and name common types of material [for example, metal, plastic, wood, paper, rock] and recognise that some of them are found naturally
- d find out about the uses of a variety of materials [for example, glass, wood, wool] and how these are chosen for specific uses on the basis of their simple properties.

Changing materials

2 Pupils should be taught to:
- a find out how the shapes of objects made from some materials can be changed by some processes, including squashing, bending, twisting and stretching
- b explore and describe the way some everyday materials [for example, water, chocolate, bread, clay] change when they are heated or cooled.

Sc4 Physical processes

Electricity

1 Pupils should be taught:

a about everyday appliances that use electricity

b about simple series circuits involving batteries, wires, bulbs and other components [for example, buzzers, motors]

c how a switch can be used to break a circuit.

Forces and motion

2 Pupils should be taught:

a to find out about, and describe the movement of, familiar things [for example, cars going faster, slowing down, changing direction]

b that both pushes and pulls are examples of forces

c to recognise that when things speed up, slow down or change direction, there is a cause [for example, a push or a pull].

Light and sound

3 Pupils should be taught:

Light and dark

a to identify different light sources, including the Sun

b that darkness is the absence of light

Making and detecting sounds

c that there are many kinds of sound and sources of sound

d that sounds travel away from sources, getting fainter as they do so, and that they are heard when they enter the ear.

2a → links to other subjects
This requirement builds on Ma3/3a, 3b.

3c → ICT opportunity
Pupils could use sensors to detect and compare sounds.

2a → links to other subjects
This requirement builds on En1/1b, 8c, 10c and En3/9a, 9d.

Breadth of study

1 During the key stage, pupils should be taught the **Knowledge, skills and understanding** through:

- a a range of domestic and environmental contexts that are familiar and of interest to them
- b looking at the part science has played in the development of many useful things
- c using a range of sources of information and data, including ICT-based sources
- d using first-hand and secondary data to carry out a range of scientific investigations, including complete investigations.

2 During the key stage, pupils should be taught to:

Communication

- a use simple scientific language to communicate ideas and to name and describe living things, materials, phenomena and processes

Health and safety

- b recognise that there are hazards in living things, materials and physical processes, and assess risks and take action to reduce risks to themselves and others.

Programme of study: science

Key stage 2

Knowledge, skills and understanding

Teaching should ensure that **scientific enquiry** is taught through contexts taken from the sections on **life processes and living things**, **materials and their properties** and **physical processes**.

Sc1 Scientific enquiry

Ideas and evidence in science

1 Pupils should be taught:

a that science is about thinking creatively to try to explain how living and non-living things work, and to establish links between causes and effects [for example, Jenner's vaccination work]

b that it is important to test ideas using evidence from observation and measurement.

Investigative skills

2 Pupils should be taught to:

Planning

a ask questions that can be investigated scientifically and decide how to find answers

b consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

c think about what might happen or try things out when deciding what to do, what kind of evidence to collect, and what equipment and materials to use

d make a fair test or comparison by changing one factor and observing or measuring the effect while keeping other factors the same

Obtaining and presenting evidence

e use simple equipment and materials appropriately and take action to control risks

f make systematic observations and measurements, including the use of ICT for datalogging

g check observations and measurements by repeating them where appropriate

h use a wide range of methods, including diagrams, drawings, tables, bar charts, line graphs and ICT, to communicate data in an appropriate and systematic manner

During key stage 2 pupils learn about a wider range of living things, materials and phenomena. They begin to make links between ideas and to explain things using simple models and theories. They apply their knowledge and understanding of scientific ideas to familiar phenomena, everyday things and their personal health. They begin to think about the positive and negative effects of scientific and technological developments on the environment and in other contexts. They carry out more systematic investigations, working on their own and with others. They use a range of reference sources in their work. They talk about their work and its significance, and communicate ideas using a wide range of scientific language, conventional diagrams, charts and graphs.

Note
The general teaching requirement for health and safety applies in this subject.

2 → links to other subjects
These requirements build on En1/10.

2b → links to other subjects
This requirement builds on En2/3.

2c, 2e, 2f → links to other subjects
These requirements build on Ma3/4a, 4b.

Note for 2c, 2e, 2f
In the international system of units, kilogram (kg) is the unit of mass. In practice mass is measured by weighing; scales measure or compare a force (a push or a pull). At key stage 2 pupils learn that the unit of weight (a type of force) is the newton.

In science the term volume is preferred to capacity. The preferred unit is cubic centimetres.

2f → links to other subjects
This requirement builds on ICT/2b.

2h → links to other subjects
This requirement builds on ICT/3.

2i, 2j → links to other subjects
These requirements build on Ma2/2i, 4a, 4d.

2i–2k → links to other subjects
These requirements build on Ma4/2.

Considering evidence and evaluating

i make comparisons and identify simple patterns or associations in their own observations and measurements or other data

j use observations, measurements or other data to draw conclusions

k decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made

l use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions

m review their work and the work of others and describe its significance and limitations.

Sc2 Life processes and living things

Life processes

1 Pupils should be taught:

a that the life processes common to humans and other animals include nutrition, movement, growth and reproduction

b that the life processes common to plants include growth, nutrition and reproduction

c to make links between life processes in familiar animals and plants and the environments in which they are found.

Humans and other animals

2 Pupils should be taught:

Nutrition

a about the functions and care of teeth

b about the need for food for activity and growth, and about the importance of an adequate and varied diet for health

Circulation

c that the heart acts as a pump to circulate the blood through vessels around the body, including through the lungs

d about the effect of exercise and rest on pulse rate

Movement

e that humans and some other animals have skeletons and muscles to support and protect their bodies and to help them to move

Growth and reproduction

f about the main stages of the human life cycle

Health

g about the effects on the human body of tobacco, alcohol and other drugs, and how these relate to their personal health

h about the importance of exercise for good health.

Green plants

3 Pupils should be taught:

Growth and nutrition

a the effect of light, air, water and temperature on plant growth

b the role of the leaf in producing new material for growth

c that the root anchors the plant, and that water and minerals are taken in through the root and transported through the stem to other parts of the plant

2b → ICT opportunity
Pupils could use a database or spreadsheet to analyse data about types of food in school lunches.

Note for 2c
Details of structure do not need to be taught.

2c, 2e, 2f → ICT opportunity
Pupils could use video or CD-ROM to see things that cannot be directly observed.

4a → ICT opportunity
Pupils could use a branching database to develop and use keys.

5b → ICT opportunity
Pupils could use video or CD-ROM to compare non-local habitats.

5f → ICT opportunity
Pupils could use simulation software to show changes in the populations of micro-organisms in different conditions.

Reproduction

d about the parts of the flower [for example, stigma, stamen, petal, sepal] and their role in the life cycle of flowering plants, including pollination, seed formation, seed dispersal and germination.

Variation and classification

4 Pupils should be taught:

a to make and use keys

b how locally occurring animals and plants can be identified and assigned to groups

c that the variety of plants and animals makes it important to identify them and assign them to groups.

Living things in their environment

5 Pupils should be taught:

a about ways in which living things and the environment need protection

Adaptation

b about the different plants and animals found in different habitats

c how animals and plants in two different habitats are suited to their environment

Feeding relationships

d to use food chains to show feeding relationships in a habitat

e about how nearly all food chains start with a green plant

Micro-organisms

f that micro-organisms are living organisms that are often too small to be seen, and that they may be beneficial [for example, in the breakdown of waste, in making bread] or harmful [for example, in causing disease, in causing food to go mouldy].

Sc3 Materials and their properties

Grouping and classifying materials

1 Pupils should be taught:

a to compare everyday materials and objects on the basis of their material properties, including hardness, strength, flexibility and magnetic behaviour, and to relate these properties to everyday uses of the materials

b that some materials are better thermal insulators than others

c that some materials are better electrical conductors than others

d to describe and group rocks and soils on the basis of their characteristics, including appearance, texture and permeability

e to recognise differences between solids, liquids and gases, in terms of ease of flow and maintenance of shape and volume.

Note for 1e
Particle theory does not need to be taught.

2b → ICT opportunity
Pupils could use sensors to record temperature changes.

2e → ICT opportunity
Pupils could use CD-ROM or the internet to research water supplies in a range of localities.

Changing materials

2 Pupils should be taught:

a to describe changes that occur when materials are mixed [for example, adding salt to water]

b to describe changes that occur when materials [for example, water, clay, dough] are heated or cooled

c that temperature is a measure of how hot or cold things are

d about reversible changes, including dissolving, melting, boiling, condensing, freezing and evaporating

e the part played by evaporation and condensation in the water cycle

f that non-reversible changes [for example, vinegar reacting with bicarbonate of soda, plaster of Paris with water] result in the formation of new materials that may be useful

g that burning materials [for example, wood, wax, natural gas] results in the formation of new materials and that this change is not usually reversible.

Separating mixtures of materials

3 Pupils should be taught:

a how to separate solid particles of different sizes by sieving [for example, those in soil]

b that some solids [for example, salt, sugar] dissolve in water to give solutions but some [for example, sand, chalk] do not

c how to separate insoluble solids from liquids by filtering

d how to recover dissolved solids by evaporating the liquid from the solution

e to use knowledge of solids, liquids and gases to decide how mixtures might be separated.

1a → ICT opportunity
Pupils could use simulation software to extend an investigation of components in a series circuit.

Note for 1b
Resistance does not need to be taught.

Note for 2b
Distinction between mass and weight need not be taught.

3f → ICT opportunity
Pupils could use sensors to detect and compare sounds made under different conditions.

Sc4 Physical processes

Electricity

1 Pupils should be taught:

Simple circuits

a to construct circuits, incorporating a battery or power supply and a range of switches, to make electrical devices work [for example, buzzers, motors]

b how changing the number or type of components [for example, batteries, bulbs, wires] in a series circuit can make bulbs brighter or dimmer

c how to represent series circuits by drawings and conventional symbols, and how to construct series circuits on the basis of drawings and diagrams using conventional symbols.

Forces and motion

2 Pupils should be taught:

Types of force

a about the forces of attraction and repulsion between magnets, and about the forces of attraction between magnets and magnetic materials

b that objects are pulled downwards because of the gravitational attraction between them and the Earth

c about friction, including air resistance, as a force that slows moving objects and may prevent objects from starting to move

d that when objects [for example, a spring, a table] are pushed or pulled, an opposing pull or push can be felt

e how to measure forces and identify the direction in which they act.

Light and sound

3 Pupils should be taught:

Everyday effects of light

a that light travels from a source

b that light cannot pass through some materials, and how this leads to the formation of shadows

c that light is reflected from surfaces [for example, mirrors, polished metals]

Seeing

d that we see things only when light from them enters our eyes

Vibration and sound

e that sounds are made when objects [for example, strings on musical instruments] vibrate but that vibrations are not always directly visible

f how to change the pitch and loudness of sounds produced by some vibrating objects [for example, a drum skin, a plucked string]

g that vibrations from sound sources require a medium [for example, metal, wood, glass, air] through which to travel to the ear.

The Earth and beyond

4 Pupils should be taught:

The Sun, Earth and Moon

a that the Sun, Earth and Moon are approximately spherical

Periodic changes

b how the position of the Sun appears to change during the day, and how shadows change as this happens

c how day and night are related to the spin of the Earth on its own axis

d that the Earth orbits the Sun once each year, and that the Moon takes approximately 28 days to orbit the Earth.

4b–4d → ICT opportunity
Pupils could use video or CD-ROM to study models of the Sun, Earth and Moon system.

2a → links to other subjects
This requirement builds on En1/10a–10c and En3/9b–9d and Ma3/1a.

Breadth of study

1 During the key stage, pupils should be taught the **Knowledge, skills and understanding** through:

a a range of domestic and environmental contexts that are familiar and of interest to them

b looking at the part science has played in the development of many useful things

c using a range of sources of information and data, including ICT-based sources

d using first-hand and secondary data to carry out a range of scientific investigations, including complete investigations.

2 During the key stage, pupils should be taught to:

Communication

a use appropriate scientific language and terms, including SI units of measurement [for example, metre, newton], to communicate ideas and explain the behaviour of living things, materials, phenomena and processes

Health and safety

b recognise that there are hazards in living things, materials and physical processes, and assess risks and take action to reduce risks to themselves and others.

The attainment targets for science

About the attainment targets

An attainment target sets out the 'knowledge, skills and understanding that pupils of different abilities and maturities are expected to have by the end of each key stage'[1]. Except in the case of citizenship[2], attainment targets consist of eight level descriptions of increasing difficulty, plus a description for exceptional performance above level 8. Each level description describes the types and range of performance that pupils working at that level should characteristically demonstrate.

The level descriptions provide the basis for making judgements about pupils' performance at the end of key stages 1, 2 and 3. At key stage 4, national qualifications are the main means of assessing attainment in science.

Range of levels within which the great majority of pupils are expected to work		Expected attainment for the majority of pupils at the end of the key stage	
Key stage 1	**1–3**	at age 7	**2**
Key stage 2	**2–5**	at age 11	**4**
Key stage 3	**3–7**	at age 14	**5/6**[3]

Assessing attainment at the end of a key stage

In deciding on a pupil's level of attainment at the end of a key stage, teachers should judge which description best fits the pupil's performance. When doing so, each description should be considered alongside descriptions for adjacent levels.

Arrangements for statutory assessment at the end of each key stage are set out in detail in QCA's annual booklets about assessment and reporting arrangements.

Examples in the level descriptions

The examples in grey type are not statutory.

[1] As defined by the Education Act 1996, section 353a.
[2] In citizenship, expected performance for the majority of pupils at the end of key stages 3 and 4 is set out in end of key stage descriptions.
[3] Including modern foreign languages.

Attainment target 1: scientific enquiry

Level 1

Pupils describe or respond appropriately to simple features of objects, living things and events they observe, communicating their findings in simple ways [for example, talking about their work, through drawings, simple charts].

Level 2

Pupils respond to suggestions about how to find things out and, with help, make their own suggestions about how to collect data to answer questions. They use simple texts, with help, to find information. They use simple equipment provided and make observations related to their task. They observe and compare objects, living things and events. They describe their observations using scientific vocabulary and record them, using simple tables when appropriate. They say whether what happened was what they expected.

Level 3

Pupils respond to suggestions and put forward their own ideas about how to find the answer to a question. They recognise why it is important to collect data to answer questions. They use simple texts to find information. They make relevant observations and measure quantities, such as length or mass, using a range of simple equipment. Where appropriate, they carry out a fair test with some help, recognising and explaining why it is fair. They record their observations in a variety of ways. They provide explanations for observations and for simple patterns in recorded measurements. They communicate in a scientific way what they have found out and suggest improvements in their work.

Level 4

Pupils recognise that scientific ideas are based on evidence. In their own investigative work, they decide on an appropriate approach [for example, using a fair test] to answer a question. Where appropriate, they describe, or show in the way they perform their task, how to vary one factor while keeping others the same. Where appropriate, they make predictions. They select information from sources provided for them. They select suitable equipment and make a series of observations and measurements that are adequate for the task. They record their observations, comparisons and measurements using tables and bar charts. They begin to plot points to form simple graphs, and use these graphs to point out and interpret patterns in their data. They begin to relate their conclusions to these patterns and to scientific knowledge and understanding, and to communicate them with appropriate scientific language. They suggest improvements in their work, giving reasons.

Level 5

Pupils describe how experimental evidence and creative thinking have been combined to provide a scientific explanation [for example, Jenner's work on vaccination at key stage 2, Lavoisier's work on burning at key stage 3]. When they try to answer a scientific question, they identify an appropriate approach. They select from a range of sources of information. When the investigation involves a fair test, they identify key factors to be considered. Where appropriate, they make predictions based on their scientific knowledge and understanding. They select apparatus for a range of tasks and plan to use it effectively. They make a series of observations, comparisons or measurements with precision appropriate to the task. They begin to repeat observations and measurements and to offer simple explanations for any differences they encounter. They record observations and measurements systematically and, where appropriate, present data as line graphs. They draw conclusions that are consistent with the evidence and begin to relate these to scientific knowledge and understanding. They make practical suggestions about how their working methods could be improved. They use appropriate scientific language and conventions to communicate quantitative and qualitative data.

Level 6

Pupils describe evidence for some accepted scientific ideas and explain how the interpretation of evidence by scientists leads to the development and acceptance of new ideas. In their own investigative work, they use scientific knowledge and understanding to identify an appropriate approach. They select and use sources of information effectively. They make enough measurements, comparisons and observations for the task. They measure a variety of quantities with precision, using instruments with fine-scale divisions. They choose scales for graphs and diagrams that enable them to show data and features effectively. They identify measurements and observations that do not fit the main pattern shown. They draw conclusions that are consistent with the evidence and use scientific knowledge and understanding to explain them. They make reasoned suggestions about how their working methods could be improved. They select and use appropriate methods for communicating qualitative and quantitative data using scientific language and conventions.

Level 7

Pupils describe some predictions based on scientific theories and give examples of the evidence collected to test these predictions. In their own work, they use scientific knowledge and understanding to decide on appropriate approaches to questions. They identify the key factors in complex contexts and in contexts in which variables cannot readily be controlled, and plan appropriate procedures. They synthesise information from a range of sources, and identify possible limitations in secondary data. They make systematic observations and measurements with precision, using a wide range of apparatus. They identify when they need to repeat measurements, comparisons and observations in order to obtain reliable data. Where appropriate, they represent data in graphs, using lines of best fit. They draw conclusions that are consistent with the evidence and explain these using scientific knowledge and understanding. They begin to consider whether the data they have collected are sufficient for the conclusions they have drawn. They communicate what they have done using a wide range of scientific and technical language and conventions, including symbols and flow diagrams.

Level 8

Pupils give examples of scientific explanations or models that have had to be changed in the light of additional scientific evidence. They evaluate and synthesise data from a range of sources. They recognise that investigating different kinds of scientific questions requires different strategies, and use scientific knowledge and understanding to select an appropriate strategy in their own work. They decide which observations are relevant in qualitative work and include suitable detail in their records. They decide the level of precision needed in comparisons or measurements, and collect data enabling them to test relationships between variables. They identify and begin to explain anomalous observations and measurements and allow for these when they draw graphs. They use scientific knowledge and understanding to draw conclusions from their evidence. They consider graphs and tables of results critically. They communicate findings and arguments using appropriate scientific language and conventions, showing awareness of a range of views.

Exceptional performance

Pupils give examples of scientific explanations and models that have been challenged by subsequent experiments and explain the significance of the evidence in modifying scientific theories. They evaluate and synthesise data from a range of sources. They recognise that investigating different kinds of scientific questions requires different strategies, and use scientific knowledge and understanding to select an appropriate strategy in their own work. They make records of relevant observations and comparisons, clearly identifying points of particular significance. They decide the level of precision needed in measurements and collect data that satisfy these requirements. They use their data to test relationships between variables. They identify and explain anomalous observations and measurements, allowing for these when they draw graphs. They use scientific knowledge and understanding to interpret trends and patterns and to draw conclusions from their evidence. They consider graphs and tables of results critically and give reasoned accounts of how they could collect additional evidence. They communicate findings and arguments using appropriate scientific language and conventions, showing their awareness of the degree of uncertainty and a range of alternative views.

Attainment target 2: life processes and living things

Level 1

Pupils recognise and name external parts of the body [for example, head, arm] and of plants [for example, leaf, flower]. They communicate observations of a range of animals and plants in terms of features [for example, colour of coat, size of leaf]. They recognise and identify a range of common animals [for example, fly, goldfish, robin].

Level 2

Pupils use their knowledge about living things to describe the basic conditions [for example, a supply of food, water, air, light] that animals and plants need in order to survive. They recognise that living things grow and reproduce. They sort living things into groups, using simple features. They describe the basis for their groupings [for example, number of legs, shape of leaf]. They recognise that different living things are found in different places [for example, ponds, woods].

Level 3

Pupils use their knowledge and understanding of basic life processes [for example, growth, reproduction] when they describe differences between living and non-living things. They provide simple explanations for changes in living things [for example, diet affecting the health of humans or other animals, lack of light or water altering plant growth]. They identify ways in which an animal is suited to its environment [for example, a fish having fins to help it swim].

Level 4

Pupils demonstrate knowledge and understanding of life processes and living things drawn from the key stage 2 or key stage 3 programme of study. They use scientific names for some major organs of body systems [for example, the heart at key stage 2, the stomach at key stage 3] and identify the position of these organs in the human body. They identify organs [for example, stamen at key stage 2, stigma, root hairs at key stage 3] of different plants they observe. They use keys based on observable external features to help them to identify and group living things systematically. They recognise that feeding relationships exist between plants and animals in a habitat, and describe these relationships using food chains and terms [for example, predator and prey].

Level 5

Pupils demonstrate an increasing knowledge and understanding of life processes and living things drawn from the key stage 2 or key stage 3 programme of study. They describe the main functions of organs of the human body [for example, the heart at key stage 2, stomach at key stage 3], and of the plant [for example, the stamen at key stage 2, root hairs at key stage 3]. They explain how these functions are essential to the organism. They describe the main stages of the life cycles of humans and flowering plants and point out similarities. They recognise that there is a great variety of living things and understand the importance of classification. They explain that different organisms are found in different habitats because of differences in environmental factors [for example, the availability of light or water].

Level 6

Pupils use knowledge and understanding drawn from the key stage 3 programme of study to describe and explain life processes and features of living things. They use appropriate scientific terminology when they describe life processes [for example, respiration, photosynthesis] in animals and plants. They distinguish between related processes [for example, pollination, fertilisation]. They describe simple cell structure and identify differences between simple animal and plant cells. They describe some of the causes of variation between living things. They explain that the distribution and abundance of organisms in habitats are affected by environmental factors [for example, the availability of light or water].

Level 7

Pupils use knowledge and understanding of life processes and living things drawn from the key stage 3 programme of study to make links between life processes in animals and plants and the organ systems involved. They explain the processes of respiration and photosynthesis in terms of the main underlying chemical change. They use their knowledge of cell structure to explain how cells [for example, ovum, sperm, root hair] are adapted to their functions. They identify common variations between individuals, including some features [for example, eye colour] that are inherited and others [for example, height] that can also be affected by environmental factors. They construct models [for example, food webs, pyramids of numbers] to show feeding relationships, and explain how these relationships affect population size.

Level 8

Pupils demonstrate an extensive knowledge and understanding of life processes and living things drawn from the key stage 3 programme of study by describing and explaining how biological systems function. They relate the cellular structure of organs to the associated life processes [for example, the absorption of food in the digestive system, gas exchange in the lungs]. They recognise, predict and explain changes in biological systems [for example, the effect of increased carbon dioxide concentration on the growth of greenhouse crops, the consequences of smoking for organ systems]. They explain how characteristics can be inherited by individuals and apply their knowledge [for example, in relation to selective breeding]. They predict the short-term and long-term effects of environmental change on ecosystems and use their understanding of such systems to justify their predictions.

Exceptional performance

Pupils demonstrate both breadth and depth of knowledge and understanding drawn from the key stage 3 programme of study when they describe and explain how biological systems function. They recognise that organisms respond to change, and describe ways in which this is achieved. They relate their understanding of internal and external cellular structures to life processes [for example, the increased surface areas of cells in the digestive system]. They relate their understanding of cellular structure to inheritance and variation and explain how this leads to new varieties [for example, how genetic engineering is a modern form of selective breeding]. They recognise the importance of quantitative data [for example, related to populations in an environment] when they describe and explain patterns of change within an ecosystem.

Attainment target 3: materials and their properties

Level 1

Pupils know about a range of properties [for example, texture, appearance] and communicate observations of materials in terms of these properties.

Level 2

Pupils identify a range of common materials and know about some of their properties. They describe similarities and differences between materials. They sort materials into groups and describe the basis for their groupings in everyday terms [for example, shininess, hardness, smoothness]. They describe ways in which some materials are changed by heating or cooling or by processes such as bending or stretching.

Level 3

Pupils use their knowledge and understanding of materials when they describe a variety of ways of sorting them into groups according to their properties. They explain simply why some materials are particularly suitable for specific purposes [for example, glass for windows, copper for electrical cables]. They recognise that some changes [for example, the freezing of water] can be reversed and some [for example, the baking of clay] cannot, and they classify changes in this way.

Level 4

Pupils demonstrate knowledge and understanding of materials and their properties drawn from the key stage 2 or key stage 3 programme of study. They describe differences between the properties of different materials and explain how these differences are used to classify substances [for example, as solids, liquids, gases at key stage 2, as acids, alkalis at key stage 3]. They describe some methods [for example, filtration, distillation] that are used to separate simple mixtures. They use scientific terms [for example, evaporation, condensation] to describe changes. They use knowledge about some reversible and irreversible changes to make simple predictions about whether other changes are reversible or not.

Level 5

Pupils demonstrate an increasing knowledge and understanding of materials and their properties drawn from the key stage 2 or key stage 3 programme of study. They describe some metallic properties [for example, good electrical conductivity] and use these properties to distinguish metals from other solids. They identify a range of contexts in which changes [for example, evaporation, condensation] take place. They use knowledge about how a specific mixture [for example, salt and water, sand and water] can be separated to suggest ways in which other similar mixtures might be separated.

Level 6

Pupils use knowledge and understanding of the nature and behaviour of materials drawn from the key stage 3 programme of study to describe chemical and physical changes, and how new materials can be made. They recognise that matter is made up of particles, and describe differences between the arrangement and movement of particles in solids, liquids and gases. They identify and describe similarities between some chemical reactions [for example, the reactions of acids with metals, the reactions of a variety of substances with oxygen]. They use word equations to summarise simple reactions. They relate changes of state to energy transfers in a range of contexts [for example, the formation of igneous rocks].

Level 7

Pupils use knowledge and understanding drawn from the key stage 3 programme of study to make links between the nature and behaviour of materials and the particles of which they are composed. They use the particle model of matter in explanations of phenomena [for example, changes of state]. They explain differences between elements, compounds and mixtures in terms of their constituent particles. They recognise that elements and compounds can be represented by symbols and formulae. They apply their knowledge of physical and chemical processes to explain the behaviour of materials in a variety of contexts [for example, the way in which natural limestone is changed through the action of rainwater, ways in which rocks are weathered]. They use patterns of reactivity [for example, those associated with a reactivity series of metals] to make predictions about other chemical reactions.

Level 8

Pupils demonstrate an extensive knowledge and understanding drawn from the key stage 3 programme of study, which they use to describe and explain the behaviour of, and changes to, materials. They use the particle model in a wide range of contexts. They describe what happens in a range of chemical reactions and classify some [for example, oxidation, neutralisation]. They represent common compounds by chemical formulae and use these formulae to form balanced symbol equations for reactions [for example, those of acids with metals, carbonates or oxides]. They apply their knowledge of patterns in chemical reactions to suggest how substances [for example, salts] could be made.

Exceptional performance

Pupils demonstrate both breadth and depth of knowledge and understanding drawn from the key stage 3 programme of study when they describe and explain the nature and behaviour of materials. They use particle theory in a wider range of contexts, recognising that differences in the properties of materials relate to the nature of the particles within them. They recognise, and give explanations for, examples of chemical behaviour that do not fit expected patterns. They routinely use balanced symbol equations for reactions. They interpret quantitative data about chemical reactions, suggesting explanations for patterns identified.

Attainment target 4: physical processes

Level 1

Pupils communicate observations of changes in light, sound or movement that result from actions [for example, switching on a simple electrical circuit, pushing and pulling objects]. They recognise that sound and light come from a variety of sources and name some of these.

Level 2

Pupils know about a range of physical phenomena and recognise and describe similarities and differences associated with them. They compare the way in which devices [for example, bulbs] work in different electrical circuits. They compare the brightness or colour of lights, and the loudness or pitch of sounds. They compare the movement of different objects in terms of speed or direction.

Level 3

Pupils use their knowledge and understanding of physical phenomena to link cause and effect in simple explanations [for example, a bulb failing to light because of a break in an electrical circuit, the direction or speed of movement of an object changing because of a push or a pull]. They begin to make simple generalisations about physical phenomena [for example, explaining that sounds they hear become fainter the further they are from the source].

Level 4

Pupils demonstrate knowledge and understanding of physical processes drawn from the key stage 2 or key stage 3 programme of study. They describe and explain physical phenomena [for example, how a particular device may be connected to work in an electrical circuit, how the apparent position of the Sun changes over the course of a day]. They make generalisations about physical phenomena [for example, motion is affected by forces, including gravitational attraction, magnetic attraction and friction]. They use physical ideas to explain simple phenomena [for example, the formation of shadows, sounds being heard through a variety of materials].

Level 5

Pupils demonstrate knowledge and understanding of physical processes drawn from the key stage 2 or key stage 3 programme of study. They use ideas to explain how to make a range of changes [for example, altering the current in a circuit, altering the pitch or loudness of a sound]. They use some abstract ideas in descriptions of familiar phenomena [for example, objects are seen when light from them enters the eye at key stage 2, forces are balanced when an object is stationary at key stage 3]. They use simple models to explain effects that are caused by the movement of the Earth [for example, the length of a day
or year].

Level 6

Pupils use and apply knowledge and understanding of physical processes drawn from the key stage 3 programme of study. They use abstract ideas in some descriptions and explanations [for example, electric current as a way of transferring energy, the sum of several forces determining changes in the direction or the speed of movement of an object, wind and waves as energy resources available for use]. They recognise, and can give examples of, the wide application of many physical concepts [for example, the transfer of energy by light, sound or electricity, the refraction and dispersion of light]. They give explanations of phenomena in which a number of factors have to be considered [for example, the relative brightness of planets and stars].

Level 7

Pupils use knowledge and understanding of physical processes drawn from the key stage 3 programme of study to make links between different phenomena. They make connections between electricity and magnetism when explaining phenomena [for example, the strength of electromagnets]. They use some quantitative definitions [for example, speed, pressure] and perform calculations, using the correct units. They apply abstract ideas in explanations of a range of physical phenomena [for example, the appearance of objects in different colours of light, the relationship between the frequency of vibration and the pitch of a sound, the role of gravitational attraction in determining the motion of bodies in the solar system, the dissipation of energy during energy transfers].

Level 8

Pupils demonstrate an extensive knowledge and understanding of the physical processes in the key stage 3 programme of study. They use models to describe and explain phenomena [for example, the magnetic field of an electromagnet, the passage of sound waves through a medium]. They use quantitative relationships between physical quantities in calculations that may involve more than one step. They offer detailed and sometimes quantitative interpretations of graphs [for example, speed–time graphs]. They consider ways of obtaining data [for example, of the solar system] and they use their knowledge of physical processes to explain patterns that they find. They consider physical phenomena from different perspectives [for example, relating the dissipation of energy during energy transfer to the need to conserve limited energy resources].

Exceptional performance

Pupils demonstrate both breadth and depth of knowledge and understanding of the physical processes in the key stage 3 programme of study when they describe and explain physical phenomena. They make effective use of a range of quantitative relationships between physical quantities. They understand how models [for example, the particle model] are useful in explaining physical phenomena [for example, how sweating causes cooling]. They apply their understanding of physical phenomena to a wide range of systems [for example, recognising the role of gravitational attraction in determining the movement of satellites, planets and stars]. They recognise the importance of quantitative data and make effective use of this when they consider questions such as energy efficiency.