Science

Programme of study for key stage 3 and attainment targets

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Curriculum aims

Learning and undertaking activities in science contribute to achievement of the curriculum aims for all young people to become:

- successful learners who enjoy learning, make progress and achieve
- confident individuals who are able to live safe, healthy and fulfilling lives
- responsible citizens who make a positive contribution to society.

The importance of science

The study of science fires pupils' curiosity about phenomena in the world around them and offers opportunities to find explanations. It engages learners at many levels, linking direct practical experience with scientific ideas. Experimentation and modelling are used to develop and evaluate explanations, encouraging critical and creative thought. Pupils learn how knowledge and understanding in science are rooted in evidence. They discover how scientific ideas contribute to technological change – affecting industry, business and medicine and improving quality of life. They trace the development of science worldwide and recognise its cultural significance. They learn to question and discuss issues that may affect their own lives, the directions of societies and the future of the world.

1 Key concepts

There are a number of key concepts that underpin the study of science and how science works. Pupils need to understand these concepts in order to deepen and broaden their knowledge, skills and understanding.

1.1 Scientific thinking

a Using scientific ideas and models to explain phenomena and developing them creatively to generate and test theories.
b Critically analysing and evaluating evidence from observations and experiments.

1.2 Applications and implications of science

a Exploring how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave.
b Examining the ethical and moral implications of using and applying science.

1.3 Cultural understanding

a Recognising that modern science has its roots in many different societies and cultures, and draws on a variety of valid approaches to scientific practice.

1.4 Collaboration

a Sharing developments and common understanding across disciplines and boundaries.

EXPLANATORY NOTES

Explain phenomena: Science is not yet able to explain all phenomena but the process of developing scientific understanding constantly generates new and sometimes conflicting evidence. This in turn gives rise to new explanations and ideas.

Theories: Scientific theories are consistent, comprehensive, coherent and extensively evidenced explanations of aspects of the natural world. They can, at least in principle, be tested by observations and/or experiments.

Ethical and moral implications: Scientists, individuals and society need to think about the balance between the advantages and disadvantages of new developments before making decisions (eg examining issues relating to selective breeding and genetic engineering of plants and animals, to the production of potentially hazardous chemicals, and to the use of nuclear energy). The way scientific developments are achieved can also raise ethical and moral issues, for example experiments on animals to produce drugs that may prolong human life.

Sharing developments and common understanding: Scientists of all disciplines and nationalities communicate scientific ideas and understanding using mathematics and internationally recognised conventions and terminology. Scientific investigation is predominantly undertaken by groups of scientists with different specialisms working in collaboration with each other.

2 Key processes

These are the essential skills and processes in science that pupils need to learn to make progress.

2.1 Practical and enquiry skills

Pupils should be able to:

a use a range of scientific methods and techniques to develop and test ideas and explanations
b assess risk and work safely in the laboratory, field and workplace
c plan and carry out practical and investigative activities, both individually and in groups.

2.2 Critical understanding of evidence

Pupils should be able to:

a obtain, record and analyse data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations
b evaluate scientific evidence and working methods.

2.3 Communication

Pupils should be able to:

a use appropriate methods, including ICT, to communicate scientific information and contribute to presentations and discussions about scientific issues.

EXPLANATORY NOTES

Wide range of primary and secondary sources: Primary sources such as data logging and secondary sources such as the internet are essential aspects of pupils' experience of science.

Use appropriate methods, including ICT, to communicate scientific information: For example, digital photography, video or podcasting as alternatives to text-based approaches.

3 Range and content

This section outlines the breadth of the subject on which teachers should draw when teaching the key concepts and key processes.

The study of science should include:

3.1 Energy, electricity and forces

a energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed
b forces are interactions between objects and can affect their shape and motion
c electric current in circuits can produce a variety of effects.

3.2 Chemical and material behaviour

a the particle model provides explanations for the different physical properties and behaviour of matter
b elements consist of atoms that combine together in chemical reactions to form compounds
c elements and compounds show characteristic chemical properties and patterns in their behaviour.

EXPLANATORY NOTES

Energy: This includes the properties and behaviour of light and sound, renewable energy resources and emerging technologies such as fuel cells.

Shape and motion: This includes pressure effects, linear motion and turning moments.

Circuits: This includes current and voltage in series and parallel circuits.

Variety of effects: Electrical devices are designed to make use of a variety of effects caused by electric currents, including heating, chemical changes and magnetic effects.

Elements: This includes the development and organisation of elements in the Periodic Table.

Compounds: This includes the different properties of compounds due to the number and type of atoms and their arrangement.

Characteristic chemical properties and patterns: This can be exemplified by the reactions of metals and non-metals, and acids and bases.

3.3 Organisms, behaviour and health

a life processes are supported by the organisation of cells into tissues, organs and body systems
b the human reproductive cycle includes adolescence, fertilisation and foetal development
c conception, growth, development, behaviour and health can be affected by diet, drugs and disease
d all living things show variation, can be classified and are interdependent, interacting with each other and their environment
e behaviour is influenced by internal and external factors and can be investigated and measured.

3.4 The environment, Earth and universe

a geological activity is caused by chemical and physical processes
b astronomy and space science provide insight into the nature and observed motions of the sun, moon, stars, planets and other celestial bodies
c human activity and natural processes can lead to changes in the environment.

EXPLANATORY NOTES

Diet, drugs and disease: This includes the importance of healthy eating complemented by regular exercise, and the effect of drugs such as alcohol, tobacco and cannabis on mental and physical health. It also includes the effects of bacteria and viruses, such as those associated with sexually transmitted infections.

Variation: This includes inherited and environmental variation and variation through genetic engineering and selective breeding.

Behaviour: This includes human and animal behaviour (psychology and ethology).

Geological activity: This includes the rock cycle processes, rock formation and weathering.

4 Curriculum opportunities

During the key stage pupils should be offered the following opportunities that are integral to their learning and enhance their engagement with the concepts, processes and content of the subject.

The curriculum should provide opportunities for pupils to:

a research, experiment, discuss and develop arguments
b pursue an independent enquiry into an aspect of science of personal interest
c use real-life examples as a basis for finding out about science
d study science in local, national and global contexts, and appreciate the connections between these
e experience science outside the school environment, including in the workplace, where possible
f use creativity and innovation in science, and appreciate their importance in enterprise
g recognise the importance of sustainability in scientific and technological developments
h explore contemporary and historical scientific developments and how they have been communicated

EXPLANATORY NOTES

Independent enquiry: This could include using primary sources from experimental work or using secondary sources from desk-based research.

Creativity and innovation: Creativity is an important part of the scientific process. Scientific experimentation can generate new ideas that may not otherwise have been considered, leading to novel discoveries and applications.

Sustainability: This relates to the continuity of economic, social and environmental aspects of human society, as well as the non-human environment. It also incorporates sustainable development: meeting the needs of the present generation without compromising the ability of future generations to meet their needs. It could include examining issues surrounding the availability of finite resources, waste reduction and recycling, energy conservation and renewable energy resources, and environmental pollution.

Contemporary and historical: Pupils should learn about the global and diverse cultural nature of science, and the contributions made by men and women.

Communicated: This should include an appreciation of how science is represented and sometimes misrepresented in the media and by scientists themselves.

i prepare to specialise in a range of science subjects at key stage 4 and consider career opportunities both within science and in other areas that are provided by science qualifications

j consider how knowledge and understanding of science informs personal and collective decisions, including those on substance abuse and sexual health

k make links between science and other subjects and areas of the curriculum.

Experimentation and modelling are used to develop and evaluate explanations, encouraging critical and creative thought. Pupils learn how knowledge and understanding in science are rooted in evidence

EXPLANATORY NOTES

Career opportunities: The knowledge, skills and understanding developed through the study of science are highly regarded by employers. Many career pathways require qualifications in science, but science qualifications do not necessarily lead to laboratory-based occupations.

Substance abuse: This includes the abuse of alcohol, tobacco, cannabis and other drugs, and solvent and volatile substance abuse (see explanatory note for diet, drugs and disease in the 'Range and content' section).

Sexual health: This includes issues related to contraception, pregnancy and sexually transmitted infections (see explanatory note for diet, drugs and disease in the 'Range and content' section).

Attainment targets

Attainment target 1: How science works

Level 4

Pupils decide on an appropriate approach, including using a fair test to answer a question, and select suitable equipment and information from that provided. They select and use methods that are adequate for the task. Following instructions, they take action to control obvious risks to themselves. They make a series of observations and measurements and vary one factor while keeping others the same. They record their observations, comparisons and measurements using tables and bar charts and begin to plot points to form simple graphs. They interpret data containing positive and negative numbers. They begin to relate their conclusions to patterns in data, including graphs, and to scientific knowledge and understanding. They communicate their conclusions using appropriate scientific language. They suggest improvements in their work, giving reasons.

Level 5

Pupils decide appropriate approaches to a range of tasks, including selecting sources of information and apparatus. They select and use methods to obtain data systematically. They recognise hazard symbols and make, and act on, simple suggestions to control obvious risks to themselves and others. They use line graphs to present data, interpret numerical data and draw conclusions from them. They analyse findings to draw scientific conclusions that are consistent with the evidence. They communicate these using scientific and mathematical conventions and terminology. They evaluate their working methods to make practical suggestions for improvements.

Level 7

Pupils plan appropriate approaches and procedures, by synthesising information from a range of sources and identifying key factors in complex contexts and in which variables cannot readily be controlled. They select and use methods to obtain reliable data, including making systematic observations and measurements with precision, using a range of apparatus. They recognise the need for a risk assessment and consult appropriate sources of information, which they follow. They record data in graphs, using lines of best fit. They analyse findings to draw conclusions that are consistent with the evidence and use scientific knowledge and understanding to explain these conclusions and identify possible limitations in primary and secondary data. They use quantitative relationships between variables. They communicate effectively, using a wide range of scientific and technical conventions and terminology, including symbols and flow diagrams. They begin to consider whether the data they have collected are sufficient for the conclusions they have drawn.

Level 8

Pupils recognise that different strategies are required to investigate different kinds of scientific questions, and use scientific knowledge and understanding to select an appropriate strategy. In consultation with their teacher they adapt their approach to practical work to control risk. They record data that are relevant and sufficiently detailed, and choose methods that will obtain these data with the precision and reliability needed. They analyse data and begin to explain, and allow for, anomalies. They carry out multi-step calculations and use compound measures, such as speed, appropriately. They communicate findings and arguments, showing awareness of a range of views. They evaluate evidence critically and suggest how inadequacies can be remedied.

Level 6

Pupils identify an appropriate approach in investigatory work, selecting and using sources of information, scientific knowledge and understanding. They select and use methods to collect adequate data for the task, measuring with precision, using instruments with fine-scale divisions, and identify the need to repeat measurements and observations. They recognise a range of familiar risks and take action to control them. They record data and features effectively, choosing scales for graphs and diagrams. They analyse findings to draw conclusions that are consistent with the evidence and use scientific knowledge and understanding to explain them and account for any inconsistencies in the evidence. They manipulate numerical data to make valid comparisons and draw valid conclusions. They communicate qualitative and quantitative data effectively, using scientific conventions and terminology. They evaluate evidence, making reasoned suggestions about how their working methods could be improved.

Exceptional performance

Pupils recognise that different approaches are required to investigate different kinds of scientific questions, and use scientific knowledge and understanding to select appropriate strategies. They readily identify hazards, seek appropriate risk assessment information and advice, select that which is relevant and, in consultation with their teacher, adjust practice as required. They make records of relevant observations and comparisons, clearly identifying points of particular significance. They decide the level of precision needed for measurements and collect data that satisfy these requirements. They analyse findings to interpret trends and patterns and draw conclusions from their evidence. They make effective use of a range of quantitative relationships between variables in calculations or when using data to support evidence. They communicate findings and arguments, showing their awareness of the degree of uncertainty and a range of alternative views. They evaluate evidence critically and give reasoned accounts of how they could collect additional evidence.

Attainment target 2: Organisms, their behaviour and the environment

Level 4

Pupils describe some processes and phenomena related to organisms, their behaviour and the environment, drawing on scientific knowledge and understanding and using appropriate terminology, for example using food chains to describe feeding relationships between plants and animals in a habitat. They recognise that evidence can support or refute scientific ideas, such as in the identification and grouping of living things. They recognise some applications and implications of science, such as the use of predators to control pest populations.

Level 5

Pupils describe processes and phenomena related to organisms, their behaviour and the environment, drawing on abstract ideas and using appropriate terminology, for example the main functions of plant and animal organs and how these functions are essential. They explain processes and phenomena, in more than one step or using a model, such as the main stages of the life cycles of humans and flowering plants. They apply and use knowledge and understanding in familiar contexts, such as different organisms being found in different habitats because of differences in environmental factors. They recognise that both evidence and creative thinking contribute to the development of scientific ideas, such as the classification of living things. They describe applications and implications of science, such as solving some of the health problems that arise when organ damage occurs.

Attainment target 3: Materials, their properties and the Earth

Level 4

Pupils describe some processes and phenomena related to materials, their properties and the Earth, drawing on scientific knowledge and understanding and using appropriate technology, for example separation methods. They recognise that evidence can support or refute scientific ideas, such as the classification of reactions as reversible and irreversible. They recognise some applications and implications of science, such as the safe use of acids and alkalis.

Level 5

Pupils describe processes and phenomena related to materials, their properties and the Earth, drawing on abstract ideas and using appropriate terminology, for example the weathering of rocks. They explain processes and phenomena, in more than one step or using a model, such as the deposition of sediments and their formation into rocks. They apply and use knowledge and understanding in familiar contexts, such as identifying changes of state. They recognise that both evidence and creative thinking contribute to the development of scientific ideas, such as basing separation methods for mixtures on physical and chemical properties. They describe applications and implications of science, such as the uses of metals based on their specific properties or the benefits and drawbacks of the use of fossil fuels.

Attainment target 4: Energy, forces and space

Level 4

Pupils describe some processes and phenomena related to energy, forces and space, drawing on scientific knowledge and understanding and using appropriate terminology, for example the observed position of the sun in the sky over the course of a day. They recognise that evidence can support or refute scientific ideas, such as sounds being heard through a variety of materials. They recognise some applications and implications of science, such as the use of electrical components to make electrical devices.

Level 5

Pupils describe processes and phenomena related to energy, forces and space, drawing on abstract ideas and using appropriate terminology, for example 'balanced forces'. They explain processes and phenomena, in more than one step or using a model, such as the length of a day or a year. They apply and use knowledge and understanding in familiar contexts. They recognise that both evidence and creative thinking contribute to the development of scientific ideas, such as objects being seen when light from them enters the eye. They describe applications and implications of science, such as the ways sound can be produced and controlled, for example in musical instruments.

Level 6

Pupils describe processes and phenomena related to organisms, their behaviour and the environment, using abstract ideas and appropriate terminology, for example simple cell structure and function. They take account of a number of factors or use abstract ideas or models in their explanations of processes and phenomena, such as environmental factors affecting the distribution of organisms in habitats. They apply and use knowledge and understanding in unfamiliar contexts, such as a food web in a habitat. They describe some evidence for some accepted scientific ideas, such as the causes of variation between living things. They explain the importance of some applications and implications of science, such as the use of selective breeding.

Level 6

Pupils describe processes and phenomena related to materials, their properties and the Earth, using abstract ideas and appropriate terminology, for example the particle model applied to solids, liquids and gases. They take account of a number of factors or use abstract ideas or models in their explanations of processes and phenomena, such as word equations. They apply and use knowledge and understanding in unfamiliar contexts, such as relating changes of state to energy transfers in a range of contexts such as the formation of igneous rocks. They describe some evidence for some accepted scientific ideas, such as the patterns in the reactions of acids with metals and the reactions of a variety of substances with oxygen. They explain the importance of some applications and implications of science, such as the production of new materials with specific desirable properties.

Level 6

Pupils describe processes and phenomena related to energy, forces and space, using abstract ideas and appropriate terminology, for example electric current as a way of transferring energy. They take account of a number of factors in their explanations of processes and phenomena, for example in the relative brightness of stars and planets. They also use abstract ideas or models, for example sustainable energy sources and the refraction of light. They apply and use knowledge and understanding in unfamiliar contexts. They describe some evidence for some accepted scientific ideas, such as the transfer of energy by light, sound or electricity, and the refraction and dispersion of light. They explain the importance of some applications and implications of science, such as the responsible use of unsustainable sources of energy.

Level 7

Pupils describe a wide range of processes and phenomena related to organisms, their behaviour and the environment, using abstract ideas and appropriate terminology and sequencing a number of points, for example respiration and photosynthesis, or pyramids of biomass. They make links between different areas of science in their explanations. They apply and use more abstract knowledge and understanding, in a range of contexts, such as inherited and environmental variation. They explain how evidence supports some accepted scientific ideas, such as the structure and function of cells. They explain, using abstract ideas where appropriate, the importance

Level 7

Pupils describe a wide range of processes and phenomena related to materials, their properties and the Earth, using abstract ideas and appropriate terminology and sequencing a number of points, for example the rock cycle. They make links between different areas of science in their explanations, such as between the nature and behaviour of materials and their particles. They apply and use more abstract knowledge and understanding, in a range of contexts, such as the particle model of matter, and symbols and formulae for elements and compounds. They explain how evidence supports some accepted

Level 7

Pupils describe a wide range of processes and phenomena related to energy, forces and space, using abstract ideas and appropriate terminology and sequencing a number of points, for example how energy is transferred by radiation or by conduction. They make links between different areas of science in their explanations, such as between electricity and magnetism. They apply and use more abstract knowledge and understanding in a range of contexts, such as the appearance of objects in different colours of light. They explain how evidence supports some accepted scientific ideas, such as the role of gravitational attraction in determining the motion

Attainment target 2: Organisms, their behaviour and the environment

Level 7 continued

of some applications and implications of science, such as the uses of cells in stem cell research.

Level 8

Pupils demonstrate extensive knowledge and understanding related to organisms, their behaviour and the environment. They use and apply this effectively in their descriptions and explanations, identifying links between topics, for example relating cellular structure of organs to their associated life processes. They interpret, evaluate and synthesise data from a range of sources and in a range of contexts, for example environmental data from fieldwork. They show they understand the relationship between evidence and scientific ideas, and why scientific ideas may need to be changed, for example the short-term and long-term effects of environmental change on ecosystems. They describe and explain the importance of a wide range of applications and implications of science, such as relating photosynthesis and respiration to changes in the atmosphere and growth of crops.

Attainment target 3: Materials, their properties and the Earth

Level 7 continued

scientific ideas, such as the reactivity series of metals. They explain, using abstract ideas where appropriate, the importance of some applications and implications of science, such as the need to consider the availability of resources, and environmental effects, in the production of energy and materials.

Level 8

Pupils demonstrate extensive knowledge and understanding related to materials, their properties and the Earth. They use and apply this effectively in their descriptions and explanations, identifying links between topics, for example relating mode of formation of rocks to their texture and mineral content. They represent common compounds by chemical formulae and use these formulae to form balanced symbol equations for reactions. They interpret, evaluate and synthesise data from a range of sources and in a range of contexts, such as describing chemical reactions, classifying them and suggesting how new substances could be made. They show they understand the relationship between evidence and scientific ideas, and why scientific ideas may need to be changed. They describe and explain the importance of a wide range of applications and implications of science.

Attainment target 4: Energy, forces and space

Level 7 continued

of bodies in the solar system. They explain, using abstract ideas where appropriate, the importance of some applications and implications of science, such as the uses of electromagnets.

Level 8

Pupils demonstrate extensive knowledge and understanding related to energy, forces and space, for example the passage of sound waves through a medium. They use and apply this effectively in their descriptions and explanations, identifying links between topics. They interpret, evaluate and synthesise data from a range of sources and in a range of contexts. They show they understand the relationship between evidence and scientific ideas, and why scientific ideas may need to be changed, such as the developing understanding of the structure of the solar system. They describe and explain the importance of a wide range of applications and implications of science, such as 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 organisms, their behaviour and the environment. They apply this effectively in their descriptions and explanations, identifying links and patterns within and between topics, for example linking internal and external cell structures to life processes. They interpret, evaluate and synthesise data, from a range of sources in a range of contexts, and apply their understanding to a wide range of biological systems. They demonstrate an understanding of how scientific knowledge and understanding changes, building on processes such as questioning, investigating and evidence-gathering, for example in the study of global climate change. They describe and explain the importance of a wide range of applications and implications of science in familiar and unfamiliar contexts, such as addressing problems arising from global climate change.

Exceptional performance

Pupils demonstrate both breadth and depth of knowledge and understanding of materials, their properties and the Earth, for example the different timescales over which rock formation and deformation take place. They apply this effectively in their descriptions and explanations, identifying links and patterns within and between topics, for example relating the properties of materials to the nature of their constituent particles. They interpret, evaluate and synthesise data from a range of sources in a range of contexts, and apply their understanding to a wide range of chemical systems, such as explaining chemical behaviours that do not fit expected patterns. They demonstrate an understanding of how scientific knowledge and understanding changes, building on processes such as questioning, investigating and evidence-gathering. They describe and explain the importance of a wide range of applications and implications of science in familiar and unfamiliar contexts.

Exceptional performance

Pupils demonstrate both breadth and depth of knowledge and understanding of energy, forces and space. They apply this effectively in their descriptions and explanations, identifying links and patterns within and between topics, for example understanding how models like the particle model are useful in explaining physical phenomena, such as how sweating causes cooling. They interpret, evaluate and synthesise data from a range of sources in a range of contexts and apply their understanding to a wide range of data on energy-efficient physical systems. They demonstrate an understanding of how scientific knowledge and understanding changes, building on processes such as questioning, investigating and evidence-gathering, for example through the role of artificial satellites and probes in communications and space exploration. They describe and explain the importance of a wide range of applications and implications of science in familiar and unfamiliar contexts, such as alternative methods of electricity generation.

The study of science fires pupils' curiosity about phenomena in the world around them and offers opportunities to find explanations