The Framework for secondary science: overview and learning objectives

Overview of strands

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Strands	Substrands	Sub-substrands
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How science works learning objectives

1 *How science works*

1.1 Explanations, argument and decisions

1.1a1 Scientific thinking: developing explanations using ideas and models

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
● use an existing model or analogy to explain a phenomenon	● describe more than one model to explain the same phenomenon and discuss the strengths and weaknesses of each model	● describe the strengths and weaknesses of a range of available models and select the most appropriate	● justify the selection of a particular model as the most appropriate	● evaluate the effectiveness of using models and analogies in their explanations	● recognise that it is possible to have and to use different, and sometimes conflicting, models in their explanation
● recognise and explain the value of using models and analogies to clarify explanations	● describe how the use of a particular model or analogy supports an explanation	● explain why the manipulation of a model or analogy might be needed to clarify an explanation	● devise own simple models or analogies to explain observations, data or scientific ideas	● evaluate the strengths and weaknesses of their own models and analogies	● explain how devising and using alternative models could help to make a 'creative leap' in an explanation

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1.1a2 Scientific thinking: challenge and collaboration in the development of explanations

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
● recognise that scientists of all disciplines and nationalities often work together to develop explanations	● recognise that science is a communal, and therefore fallible, human activity and that different explanations can arise from individual bias	● describe how bias, a lack of evidence or misconceptions can give rise to inappropriate theories and the role of scientists in questioning these	● describe the process of validating the work of other scientists and explain how this influences the acceptance or rejection of a theory	● explain why it is important for the scientific community to have a process for validating the work of other scientists and how this has influenced the acceptance of current theories	● explain and justify why a 'scientific claim' should be accepted or rejected by the application of the key components of validation to the evidence
● recognise that science cannot yet explain everything	● recognise questions that the scientific process cannot yet answer	● identify some questions that the scientific process cannot yet completely answer but can contribute to	● identify some questions that the scientific process cannot yet completely answer but can contribute to, and explain the reasons for this	● explain why scientific proof is only ever provisional	● explore the implications of the provisional nature of scientific proof

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1.1a3 Scientific thinking: developing argument

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
● identify a range of scientific data and other evidence to back an argument and the counterclaim in less complex and/or familiar contexts, e.g. establishing a wind farm	● identify a range of scientific data and other evidence to back an argument and the counterclaim in more complex and/or less familiar contexts, e.g. use of antibiotics	● use criteria to select relevant scientific data and other sources of evidence to support or negate an argument	● explain how the use of criteria improves the effectiveness of selecting scientific data and other sources of evidence to support or negate an argument	● devise criteria to select relevant scientific data and other sources of evidence to support or negate an argument in familiar contexts	● devise criteria to select relevant scientific data and other sources of evidence to support or negate an argument in less familiar contexts
● recognise that scientific evidence can be used to support or disprove theories	● describe how scientific evidence from different sources carries different weight in supporting or disproving theories	● explain how scientific evidence from a range of sources can be used to support or disprove theories	● describe examples of where scientific theories, applications and models have been changed by new evidence or societal norms	● explain how scientific theories, applications and models have been changed or modified by scientists as a result of new evidence	● explain how scientific theories, applications and models have been changed by the strength of new evidence, changes in societal norms or values

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1.1b Applications, implications and cultural understanding

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe some benefits and drawbacks of scientific developments with which they are familiar	• explain some issues, benefits and drawbacks of scientific developments with which they are familiar	• evaluate the issues, benefits and drawbacks of scientific developments with which they are familiar	• evaluate the relevant issues, benefits and drawbacks of scientific developments with which they are familiar and draw conclusions about which would be more appropriate	• describe and evaluate examples of perceived and actual risk arising from the application of scientific or technological developments	• evaluate and analyse the potential impact of the application of new scientific and technological developments
• recognise that decisions about the use and application of science and technology are influenced by society and individuals	• recognise that decisions about the use and application of science and technology are influenced by society and individuals, and how these could impact on people and the environment	• recognise that different decisions on the use and application of scientific and technological developments may be made in different economic, cultural and social contexts	• explain that scientific evidence could be shaped by a number of factors and used to influence decisions taken on the application of scientific and technological developments	• describe the power and limitations of science in addressing a range of moral or ethical issues, and how this could influence the impact of decisions taken on the application of scientific and technological developments	• explain how scientific evidence can be shaped by bias, scientific status, political or economic factors, and how this could influence the impact of decisions taken on the application of scientific and technological developments

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1.1c Communication for audience and with purpose

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• use key scientific vocabulary and terminology in discussions and written work	• use a range of scientific vocabulary and terminology consistently in discussions and written work	• communicate effectively and use appropriate scientific terminology and conventions in discussion and written work	• communicate effectively using a wide range of scientific terminology and conventions in discussion and written work	• communicate qualitative and quantitative evidence effectively using scientific terminology and conventions, drawing on abstract ideas and models as appropriate to the audience and purpose	• use a wide range of technical vocabulary and techniques with fluency, demonstrating communication and numerical skills as appropriate for a range of audiences and purposes
• identify and use the conventions of various genres for different audiences and purposes in scientific writing	• adapt the stylistic conventions of a range of genres for different audiences and purposes in scientific writing	• adapt the stylistic conventions of a wider range of genres for different audiences and purposes in scientific writing	• use simple criteria to judge the appropriateness of a piece of scientific writing for a particular audience	• devise criteria to judge the appropriateness of a piece of scientific writing for a particular audience	• critically evaluate criteria used to judge the appropriateness of a piece of scientific writing for a particular audience

1.2 Practical and enquiry skills

1.2a Using investigative approaches: planning an approach

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe an appropriate approach to answer a scientific question using a limited range of information and making relevant observations or measurements	• describe an appropriate approach to answer a scientific question using sources of evidence and, where appropriate, making relevant observations or measurements using appropriate apparatus	• explain how the planned approach to answer a scientific question was informed by scientific knowledge, understanding or other sources of evidence	• explain how the planned approach was informed by a range of scientific knowledge, understanding and evidence and, where appropriate, how this influenced the method of data collection	• explain how to plan appropriate approaches to investigatory work by synthesising information from a range of sources in complex contexts and where variables are less easily controlled	• explain why different approaches are required to investigate different kinds of scientific questions and how scientific knowledge, understanding and sources of evidence are used in the different approaches

1.2b Using investigative approaches: selecting and managing variables

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• recognise the range of variables involved in an investigation and decide which to control	• describe and identify key variables in an investigation and assign appropriate values to these	• use and apply independent and dependent variables in an investigation by choosing an appropriate range, number and value for each one	• identify key factors in complex contexts where variables are less easily controlled	• use and apply key variables in complex contexts, including ones in which variables are less easily controlled	• identify and manage a range of variables in complex contexts including ones in which variables are less easily controlled

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1.2c Using investigative approaches: assessing risk and working safely

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• explain how action has been taken to control obvious risk and how methods are adequate for the task	• explain how to take action to control the risks to themselves and others, and demonstrate competence in their practical techniques	• explain how approaches to practical work were adapted to control risk	• use and apply risk assessment in carrying out practical procedures	• explain why the chosen approach to practical work needed to be adapted to control risk	• explain how hazards are identified and risks managed to collect data in a safe and skilful manner

1.2d Using investigative approaches: obtaining and presenting primary evidence

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
● describe and record observations and evidence systematically	● explain how the observation and recording methods are appropriate to the task	● use and apply qualitative and quantitative methods to obtain and record sufficient data systematically	● explain how inherent variation, e.g. from human error, sensitivity and accuracy of instrument, needs to be considered when collecting data	● use and apply systematic observation and precise measuring with a range of apparatus, whilst taking account of inherent variation, to obtain and record reliable data	● use and apply systematic observation and precise measuring with a range of apparatus, while taking account of inherent variation, to obtain and record reliable data in a more demanding context
● recognise that the presentation of experimental results through the routine use of tables, bar charts and simple graphs makes it easier to see patterns and trends	● describe ways in which the presentation of experimental results through the routine use of tables, charts and line graphs makes it easier to see patterns and trends	● explain how the presentation of experimental results through the routine use of tables, charts and line graphs makes it easier to see patterns and trends	● apply and use appropriate ways of recording relevant observations and comparisons, clearly identifying points of particular significance	● explain how the chosen presentation of data has been used to support a valid conclusion	● explain how the chosen presentation of data takes account of uncertainty or alternative conclusions

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1.2e Working critically with primary evidence

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe patterns and trends in results and link this evidence to any prediction made	• describe how the patterns and trends in the results link to the conclusions drawn and whether the evidence is sufficient	• explain how patterns and trends in results can be manipulated to be consistent with the evidence gathered and the predictions made	• explain how the numerical data have been manipulated to make valid comparisons and conclusions linked to the original scientific question	• synthesise and manipulate data, analyse findings and draw valid and reliable conclusions consistent with the evidence and linked to the original scientific question • recognise that correlation does not always imply causation	• synthesise and manipulate data, analyse findings, draw valid and reliable conclusions consistent with the evidence, and explain how strongly the evidence relates to the original scientific question • explain why correlation does not always imply causation
• describe and suggest how planning and implementation could be improved	• describe and suggest, with reasons, how planning and implementation could be improved	• explain how improvements to the planning and implementation would have led to the collection of more valid and reliable evidence and a more secure conclusion	• evaluate the planning and implementation, and explain how this could account for errors and anomalies and how inadequacies could be remedied	• evaluate the planning and implementation, and explain how this could account for errors and anomalies and the subsequent impact on the conclusion in simple contexts	• evaluate the planning and implementation, and explain how this could account for errors and anomalies and the subsequent impact on the conclusion in more complex contexts

1.2f Working critically with secondary evidence

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe patterns and trends in secondary evidence and link these to the prediction or conclusion drawn	• describe what needs to be considered in the collection and manipulation of simple secondary evidence to evaluate the conclusion or interpretation made	• explain whether the collection and manipulation of secondary evidence is sufficient or insufficient to support the conclusion or interpretation made	• explain, using scientific knowledge and understanding, how some of the limitations in the collection and manipulation of secondary evidence can distort the conclusion drawn	• evaluate the conclusions drawn by others, including scientists, in familiar or less complex contexts and consider how strongly the evidence supports these conclusions or claims	• evaluate the conclusions drawn by others, including scientists, in less familiar or more complex contexts, and consider how strongly the evidence supports these conclusions or claims
• recognise that different conclusions may be drawn from secondary data	• recognise that the selection, ordering or rejection of secondary data could lead to different conclusions	• explain how secondary numerical data have been manipulated to support a particular conclusion or viewpoint	• recognise that scientific controversies can arise from different interpretations of the same evidence	• describe a range of issues that can affect the credibility of data	• explain how scientific controversies can arise from different ways of interpreting evidence

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Range and content learning objectives

2 Organisms, behaviour and health

2.1 Life processes

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe the role of organ systems in plants and animals that can contribute to the seven life processes	• explain how the organs and tissues in plants and animals function to support the seven life processes in a healthy organism	• explain how the specialisation of cells in plants and animals support the seven life processes in a healthy organism • explain how chemical, physical and biological factors can disrupt the seven life processes	• explain how individual intracellular and extracellular processes and structures in plants and animals support the seven life processes • explain why certain chemical, physical and biological factors can disrupt the seven life processes	• explain how the different intracellular and extracellular processes work together to support life in familiar contexts • evaluate the impact of chemical, physical and biological factors and explain their effects on the life processes	• use and apply their understanding of how life processes in organisms work together in unfamiliar contexts • critically evaluate the relative impact of chemical, physical and biological factors and their effect on life processes in unfamiliar contexts

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2.2 Variation and interdependence

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe how organisms can vary and how this may lead to their survival in changing environments • describe how the major taxonomic groups are classified • use a combination of food chains within a habitat to produce food webs	• explain how variation has benefits and limitations for the survival of organisms in specific habitats • describe some examples of variation arising from inherited and environmental factors • explain energy transfer in food chains and webs and relate this to the abundance of organisms	• explain how variation in organisms can be artificially induced and the effect of these organisms on the environment • explain how internal and external factors can affect energy transfer in food chains and webs	• explain how the combined effects of changes to genes and environmental change can lead to variation in a species • explain the fluctuations in distribution and population size using: – energy flow – pyramids of number and biomass – predator/prey relationships	• apply and use their knowledge of variation and interdependence to explain: – natural selection – the applications and implications of artificial selection – evolutionary and ecological relationships	• apply and use their extensive knowledge of variation and interdependence to explain and critically evaluate the impact of human activity on evolutionary and ecological relationships

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2.3 Behaviour

Year 7	Year 8	Year 9	Year 11	Year 11	Extension
• describe simple learned and innate behaviours in response to internal and external stimuli and how these aid survival	• explain how changes in learned behaviour due to internal and external stimuli are of benefit to the organism	• make links between observed social behaviours and the benefit to the survival of the species	• explain how chemical and electrical signals enable body systems to respond to internal and external changes and the effect of this on behaviour	• explain the effects of natural and artificial substances on chemical and electrical signals within the body, and possible effects on behaviour	• evaluate evidence from different sources about the impact of natural and artificial substances on behaviour

3 Chemical and material behaviour

3.1 Particle models

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
● describe matter using a simple model and use it to explain changes of state ● recognise the link between heating and cooling and changes of state ● use the simple particle model to explain the physical characteristics of solids, liquids and gases	● apply and use the particle model to describe a range of physical observations ● apply and use the particle model to describe a range of separation techniques	● evaluate and refine the particle model to explain a range of physical observations ● evaluate and refine the particle model to explain a range of separation techniques	● refine the particle model to explore the structure of atoms, including protons, neutrons and electrons ● apply particle models in unfamiliar contexts, and begin to evaluate the strengths and weaknesses of the model	● use the particle model and ideas from science and across disciplines to explain phenomena and evaluate the use of the model	● use the particle model and ideas from science and across disciplines to explain complex phenomena and make critical evaluations to justify the use of a 'good enough' model

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3.2 Chemical reactions

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• sort some reactions into reversible and irreversible • recognise that new materials are made during chemical reactions	• recognise that materials can be made up of one or more kinds of particles • describe the type and arrangement of atoms in elements, compounds and mixtures • describe and develop a particle model to explain the differences between the terms *atoms, elements, compounds* and *mixtures*	• use a particle model to construct predictions for simple chemical reactions and to produce word equations	• use a particle model to construct predictions for chemical reactions and to produce symbol equations • explain the evidence that a chemical reaction has taken place in terms of energy transfer and rearrangements of bonds between atoms	• use a particle model to predict the outcome of chemical reactions and to produce balanced symbol equations • explain the evidence that a chemical reaction has taken place in terms of rearrangements of bonds between atoms, using the model of the differences of electron structure between elements	• use a particle model to predict the outcome of complex chemical reactions and to produce balanced symbol equations and ionic half-equations when appropriate • explain the evidence that a chemical reaction has taken place (in a system at equilibrium) in terms of energy transfer and rearrangements of bonds between atoms

3.3 Patterns in chemical reactions

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe, record and group observations from chemical reactions	• describe patterns in a range of chemical reactions	• link experimental and numerical data to illustrate a range of patterns in chemical reactions	• explain properties and patterns in reactivity in terms of a particle model for atomic structure	• apply knowledge of patterns of reactivity in the periodic table to predict the outcomes of reactions from a range of familiar contexts	• apply knowledge of patterns of reactivity in the periodic table to evaluate critically a range of domestic and industrial processes including systems at equilibrium

4 Energy, electricity and forces

4.1 Energy transfer and electricity

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
● describe how energy can be stored, e.g. food, fuels and electrical cells ● describe how energy is transferred in simple contexts such as heating and cooling, food chains and simple circuits ● recognise that quantitative measures of energy transfer are needed to inform decisions, e.g. about lifestyles ● describe how energy stored in a range of energy resources, e.g. food, biomass, oil, gas, wind and waves, can be usefully transferred	● use a simple model of energy transfer to describe common observations ● explain why quantitative measures of energy transfer should also be considered when making informed decisions, e.g. building wind farms ● explain how electricity is generated using a variety of energy resources	● develop more complex models of energy transfer mechanisms (incorporating ideas about particles or waves) ● use energy-accounting systems, including Sankey diagrams, to track energy transfers ● use quantitative measures of energy transfer to support informed decision-making ● apply the idea of energy conservation and dissipation to simple biological, chemical and physical systems	● apply the concept of conservation of energy to energy efficiency calculations in living and non-living systems ● develop the idea of energy dissipation in a variety of contexts ● evaluate the economic costs and environmental effects of energy use through the measurement of energy transfers and efficiency calculations ● describe the effects of energy transfer to living systems by electromagnetic and nuclear radiation	● use quantitative measures and the concept of energy conservation to evaluate a range of strategies to conserve limited energy resources ● use and apply complex models of energy transfer to a wide range of phenomena ● explain a wide range of complex phenomena using the principle of conservation of energy and appropriate wave or particle models	● apply broader or deeper knowledge and understanding of energy in explanations of observations and phenomena ● use valid and rational argument to offer solutions to problems arising from the applications and implications of energy

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4.2 Forces

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• recognise the forces acting on an object in different situations • distinguish between situations involving balanced and unbalanced forces • recognise that forces can combine or wholly or partly cancel each other out and their size and direction can be represented using arrows • recognise that there are contact forces and forces that act at a distance	• apply ideas about balanced and unbalanced forces to explain the way objects move • investigate situations where forces are applied over large and small areas or have a turning effect • recognise that forces at a distance get weaker as the distance increases	• recognise how simple quantitative relationships can be applied to the way objects move (including balanced and unbalanced forces) • recognise how simple quantitative relationships can be applied to situations where forces are applied over large and small areas or have a turning effect	• use simple quantitative relationships to make predictions in more complex situations • use simple relationships involving more complex quantities to make quantitative predictions in familiar situations	• use relationships involving more complex quantities to make quantitative predictions in more complex and unfamiliar situations	• apply knowledge and understanding of forces in explanations of observations and phenomena to complex and unfamiliar contexts • use valid and rational argument to offer solutions to problems arising from the applications and implications of forces

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5 The environment, Earth and the universe

5.1 Changing environment and sustainability

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe how natural and human processes have changed the atmosphere over time	• explain some of the changes that have led to the composition of the current atmosphere • recognise simple ideas of sustainable development	• use one or more models, such as the carbon cycle or food webs, to explain some of the consequences of changes in the environment	• use primary and secondary forms of evidence to describe and explain the impact of human actions at a local, regional and global level	• evaluate the accuracy and validity of primary and secondary evidence in relation to human impact on the biosphere • describe and analyse how complex data could be represented or misrepresented to justify decisions taken to manage sustainability	• link and synthesise data and evidence from a range of sources to explain human impact on the biosphere • describe how evidence and arguments from different political and economic perspectives have been used to justify decisions taken to manage sustainability

5.2 Changing Earth

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• recognise the processes involved in the formation of rocks	• describe the processes involved in the formation of sedimentary, metamorphic and igneous rocks and use the characteristics of the rocks to explain how they formed	• use the rock cycle as a model to explain the cyclical nature of rock-forming processes and the timescales over which they operate	• use the theory of plate tectonics to explain some of the major slow (long-term) changes and the distribution and nature of active zones on the surface of the Earth	• link plate tectonic theory to its supporting geological evidence	• apply and use the theory of plate tectonics to explain related geological phenomena

5.3 Earth, Space and beyond

Year 7	Year 8	Year 9	Year 10	Year 11	Extension
• describe the apparent movement of the Sun across the sky and the pattern in the changing appearance of the Moon	• describe the position of the Earth in relation to the position of other bodies in the Solar System and use this to explain some phenomena • recognise that astronomy and space science provide evidence about the Solar System	• apply models and use scientific data to explain the relative movement of the celestial bodies in the solar system • describe how astronomy and space science provide evidence of the solar system and galaxy	• explain some methods used to explore the solar system and galaxy (both from the Earth and from Space) • explain how the electromagnetic spectrum can inform the study the stars in our galaxy (and universe)	• evaluate the available evidence and explain why it favours an expanding universe as the current consensus model	• explain, using available evidence and models of the universe, why the ultimate fate of the universe is difficult to predict