

Curriculum Vision - *Science*

What is the purpose of the curriculum?

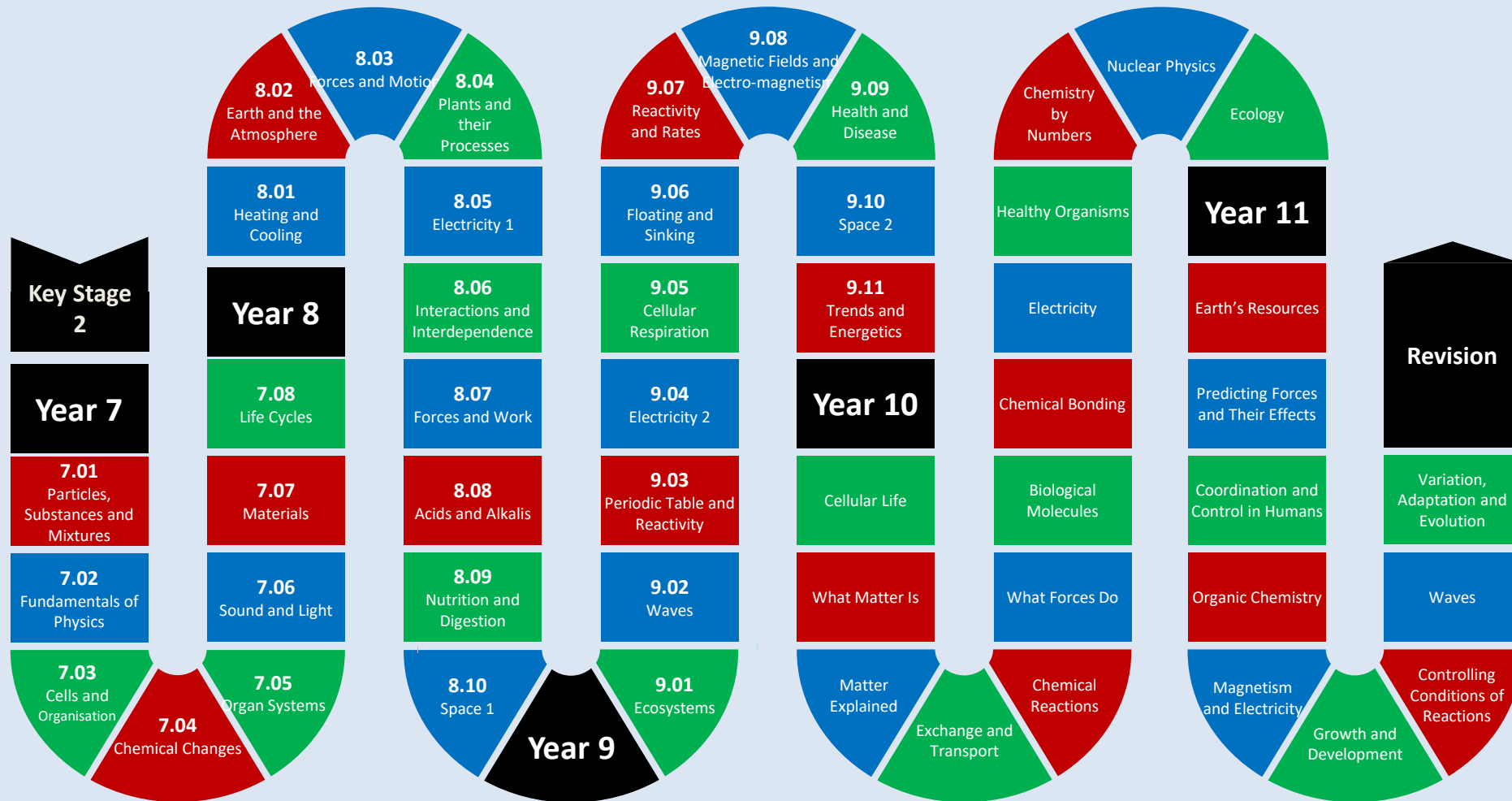
- Develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics.
- Ensure that students are equipped with the scientific knowledge required to understand the uses and implications of science, today and for the future.
- Mastering and embedding the foundational concepts that are required for GCSE.

Why is *science* an important subject?

A high-quality science education provides the foundations for understanding the world through the specific disciplines of biology, chemistry and physics. Science has changed our lives and is vital to the world's future prosperity, and all students should be taught essential aspects of the knowledge, methods, processes and uses of science. Through the learning of key foundational knowledge and concepts, students are supported in understanding how science can be used to explain what is occurring, predict how things will behave, and analyse causes.



Curriculum Five-Year Journey – Science



Curriculum Themes Overview - Science

In the United Curriculum, knowledge has been sequenced across units and across Years 7 to Year 11 to enable students to build a deeper understanding of scientific **themes**. These themes provide the basis for conceptual frameworks (or schemas) that students can develop over time. They can integrate new knowledge into the frameworks and make increasingly sophisticated connections between them.



In addition to substantive themes, there are disciplinary themes that students will return to regularly as part of Working Scientifically.



Biology Theme Ideas – Science

Theme	What's the big idea?
<i>Cells and Life</i>	<i>Organisms are made of one or more cells. Multicellular organisms have a hierarchical organisation of cells, tissues, organs and organ systems that work together to keep the cells alive. Cells need a supply of energy and molecules to carry out life processes.</i>
<i>Ecological Relationships</i>	<i>All organisms, including humans, depend on, interact with and affect the environments in which they live and other organisms that live there.</i>
<i>Inheritance and Reproduction</i>	<i>Each generation of organisms inherits characteristics from the one before, which arise from genetic information stored in the DNA of the genome and are affected by the environment. Organisms grow and develop as they get older; they pass genetic information to their offspring when they reproduce, and the life cycle begins again.</i>
<i>Health</i>	<i>Organisms must stay in good health to survive and thrive; the health of an individual organism results from interactions between the organism's body, behaviour, environment and other organisms.</i>
<i>Variation and evolution</i>	<i>There is a great diversity of organisms, living and extinct, with many similarities and differences between them. Differences between organisms cause species to evolve by natural selection of individuals better adapted to compete for limited resources when environmental conditions change, and the passing of advantageous heritable characteristics to subsequent generations. The diversity of organisms is the result of evolution by natural selection.</i>



Chemistry Theme Ideas – Science

Theme	What's the big idea?
Particles	All matter is made up of atoms. The behaviour and structural arrangement of atoms explains the properties of different materials.
Substances	Materials are either made of a single chemical substance or a mixture of substances which each have distinctive properties. The amount of a substance is measured in moles.
Chemical Reactions	During chemical reactions atomic nuclei and electrons are rearranged and new substances are formed.
Physical Earth	The rocks and landscape around us appear unchanging and permanent, but careful observation can detect the effects of weathering and erosion on exposed rocks, and the laying down of sediments that in the right conditions can be changed into new rock. Longer term processes transform rocks deep underground and bring fresh rock to the surface. Understanding the dynamic Earth helps us to identify and utilise resources it contains and to find ways to build a sustainable and environmentally stable future.
Earth Science	Substances can move between Earth's atmosphere, hydrosphere, geosphere and biosphere as part of large-scale systems.



Physics Theme Ideas – Science

Theme	What's the big idea?
<i>Motion and Forces</i>	<i>Force is a useful idea because it is the key to explaining changes in the motion of an object or in its shape. The motion of an object can be explained or predicted if you know the sizes and directions of all the forces that act on it. Understanding forces helps us to predict and control the physical world around us.</i>
<i>Matter</i>	<i>The world is made of matter. Matter is a more formal word for 'stuff'. Anything that can be stored in a container, or weighed, is matter. Scientific ideas can help to explain why a given material behaves as it does and may help scientists to develop new materials with specific properties.</i>
<i>Waves</i>	<i>The idea of waves is useful because it is the key to explaining how energy can be transferred from one object to another object by radiation, even when the objects are not touching. Waves carry information that can be detected by humans or manufactured detectors. Understanding waves helps us to communicate, explore the universe, and transfer energy to where we want it.</i>
<i>Electricity and Electromagnetism</i>	<i>The familiar everyday world we live in is largely a consequence of the properties and behaviour of electric charge. Matter is held together by electrostatic forces, and these influence chemical changes. Electricity and magnetism initially seem to be distinct phenomena but are later found to be closely interrelated. Understanding electricity and magnetism helps us to develop our technology and find applications that can transform our everyday lives.</i>
<i>Space Physics</i>	<i>The idea of Earth in space is important because we live on the Earth and it is the only planet that we know to have abundant and complex life. Understanding how the Earth and space systems interact, how they affect us, and how we affect them is vital for our survival. Exploring our origins and our place in the universe feeds the intrinsic curiosity of humans and develops a sense of wonder.</i>





Cells and Life

Note: Years 9-11 are indicative only.



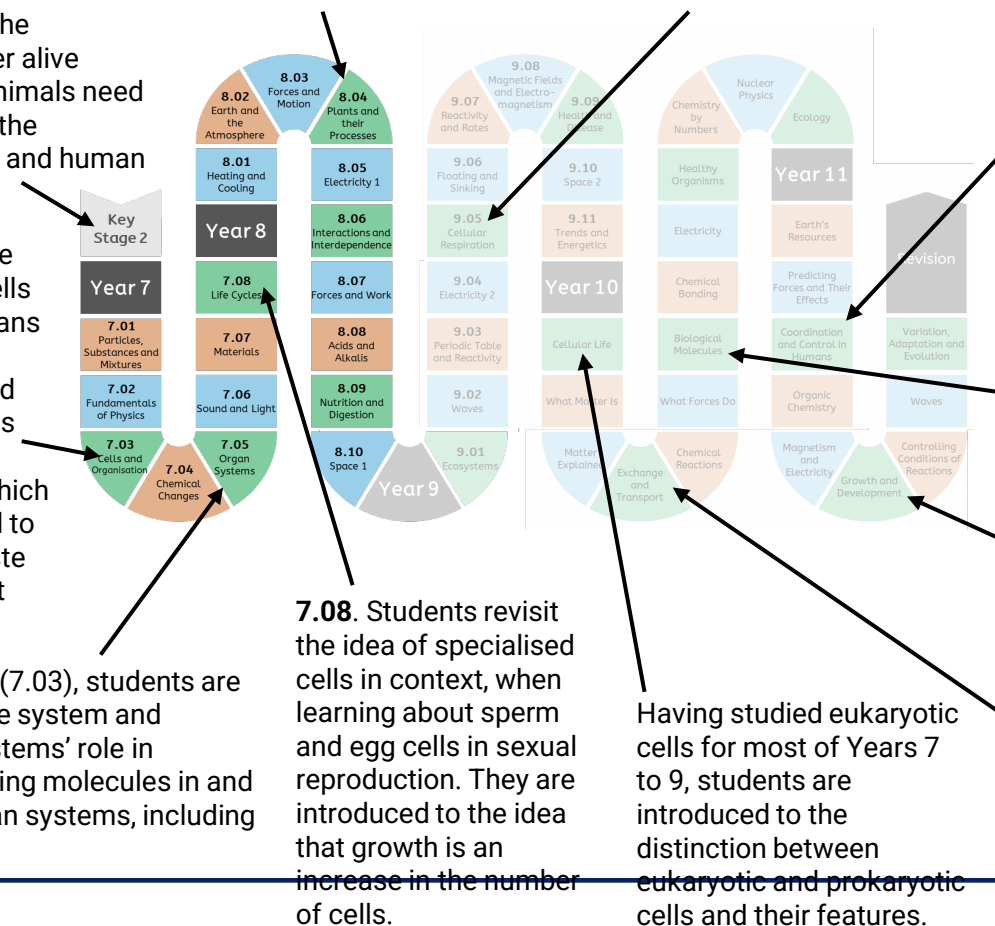
8.04. Students review the reactants and products in respiration (7.03, 7.05) and are taught about photosynthesis as the process by which plants produce glucose for respiration, and how the required oxygen is transported via diffusion through the stomata. As in 7.05, when the circulatory system in humans was introduced as a way of transporting products and reactants around the body, students are taught how these same substances are transported around plants.

KS2. Students should have been taught the difference between living, dead, and never alive things; basic needs of organisms; how animals need to eat (and plants make their own food); the digestive system and circulatory system; and human skeletons and muscles.

7.03. Students review relevant knowledge from KS2. They are then introduced to cells as the building blocks within tissues, organs and organ systems. They are taught the components of animal and plant cells and examine some specialised cells. Students are taught that all cells need oxygen and glucose for respiration, the process by which energy is released, and that all cells need to excrete carbon dioxide and water as waste products of this process. They are taught that this happens by diffusion (7.01).

7.05. Building on knowledge of what cells need for respiration (7.03), students are taught about the gas exchange system and revisit the digestive system and circulatory system in humans (KS2). They are taught these systems' role in breaking down larger molecules into smaller ones or transporting molecules in and out of cells via diffusion. Students are introduced to other organ systems, including the human skeleton and muscles in more depth than KS2.

9.04. Having seen aerobic respiration in the context of all cells (7.03) and specifically humans (7.05) and plants (8.04), students revisit aerobic respiration and investigate the relationship between respiration and exercise. They are then taught about anaerobic respiration in both plants, animals (humans) and microorganisms.



Students revisit what organisms (and cells) need to survive (7.01) and are taught how receptors and the nervous and hormonal systems maintain homeostasis.

Students revisit digestion and enzymes (7.05) and deepen this knowledge to include lock and key theory, named enzymes and word equations. This can be linked to the products for respiration.

Students revisit the idea that growth is an increase in the number of cells (7.08) and are taught about stem cells and differentiation.

Students revisit and deepen their understanding of how cells get what they need (7.05) with all types of transport: diffusion, osmosis and active transport.





Inheritance and Reproduction

Note: Years 9-11 are indicative only.



KS2. Students should have been taught about sexual reproduction in the life cycles of some animals, including humans, and plants, and how offspring are not normally identical to the parents. (They may also have been taught asexual reproduction in plants; this is non-statutory).

7.03. Students are introduced to the nucleus of a cell as the organelle that contains the genome. A placeholder definition is used for now: 'A cell's set of instructions for growth, development, and life processes.' More detailed and precise information about the genome will be provided in a later unit.

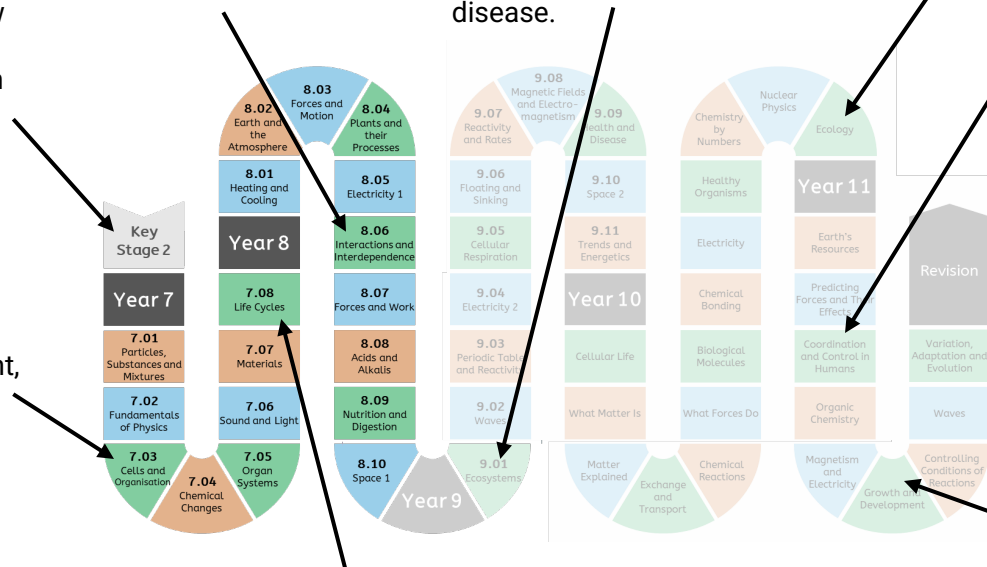
8.06. Students review the knowledge that offspring inherit half their genome from each parent, in the context of advantageous variation and evolution by natural selection.

9.01. Students are taught about biodiversity, one aspect of which is the importance of having a variety of genes in a given population, to help make the population more resilient to environmental changes and disease.

Students revisit biodiversity (9.01) and consider how biodiversity can be measured.

Students revisit the human reproductive systems, including the menstrual cycle (7.08), and are taught the role of named hormones in puberty and the menstrual cycle. They learn about contraception and are taught about hormonal and non-hormonal contraception. They are also taught about infertility in humans.

Students revisit the genome and inheritance (7.08) and are taught about inheritance, genotype and phenotype; predicting gene expression; and genetic disorders.



7.08. Students revisit the vocabulary of genome (7.03) and are taught that the genome is the complete set of generic information in any organism, organised into chromosomes. Chromosomes are structures made of DNA, which is a polymer (7.07). Genes are specific segments of DNA on chromosomes that provide instructions for cell processes and determine inherited traits. Offspring inherit half their genome from each parent.

Students are introduced to the idea that growth refers to an increase in the number of cells, and that this happens when cells enlarge and divide (without going into the detail of mitosis stages). Development involves changes in form and function as an organism matures, including developing specialised cells (7.03).

Students revisit the life cycle of humans (KS2) and are taught about the male and female reproductive systems, the processes of fertilisation, gestation, growth and development from embryo and birth, as well as growth and development from birth to adolescence and senior.

Students revisit the life cycle of plants (KS2) and are taught the sexual reproductive systems and asexual reproduction in some plants and bacteria.



Variation and Evolution

Note: Years 9-11 are indicative only.



7.08. Students are introduced to variation, including continuous and discontinuous variation and genetic and environmental variation. They consider the importance of variation within a species. At this stage, they do not explicitly link variation with adaptations. Separately, they revisit adaptations of specialised cells (7.03, 7.05) in male and female gametes.

8.04. Students revisit adaptation (7.03, 7.05, 7.08) in the context of adaptations of the cells, tissues, organs and organ systems involved in optimising photosynthesis, effectively transporting the reactants and products of photosynthesis, and reducing transpiration in plants.

KS2. Students should have been taught that living things produce offspring that normally vary and are not identical to their parents. They should have been introduced to the idea that organisms are adapted to suit their environment and that adaptation may lead to evolution of a species. They should have considered the fossil record as evidence for evolution. They will have classified plants as flowering or non-flowering and animals as vertebrates or non-vertebrates (and will have named some groups within these).

7.03. Students revisit the idea of adaptations (KS2) in the context of specialised cells.

7.05. Students revisit the idea of adaptation in the context of specialised cells (7.03), this time looking at the adaptations of cells, tissues and organs within the digestive system, circulatory system and gas exchange system.

8.06. Students explicitly connect the ideas of genetic variation within a species (7.08) and adaptations (7.03, 7.05) to explain how organisms come to be adapted to their environment. They are taught how some variation causes the organism to be better adapted and how, by natural selections, species evolve.

They also consider how organisms can be classified, building on simple classification from KS2.

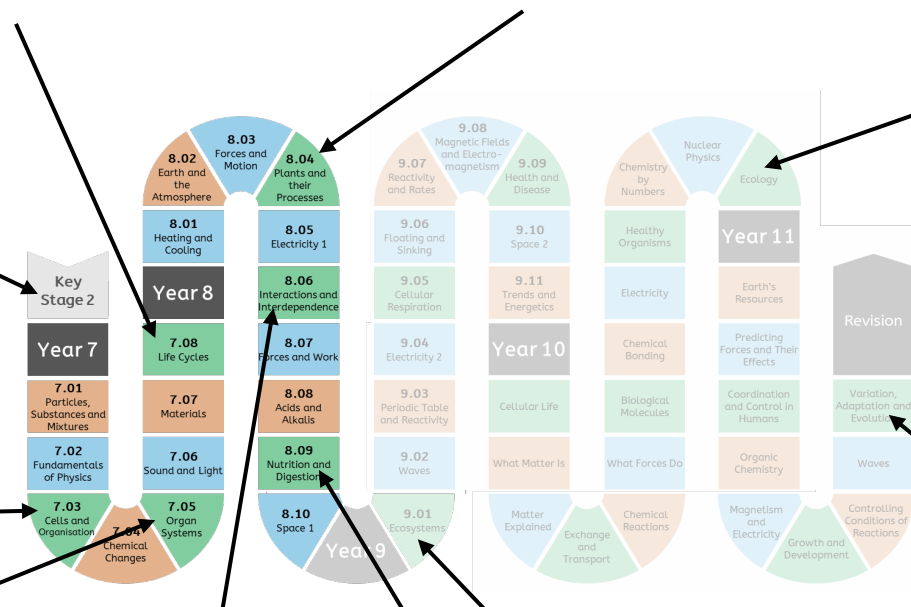
9.01. Students are taught about the importance of biodiversity, between species and within species.

8.09. Students revisit adaptations of digestive system (7.05) and add more detail, such as the role of enzymes, hydrochloric acid and bile.

Students revisit adaptations for given conditions (8.06) and consider the specific biotic and abiotic factors that make organisms' traits more or less advantageous and make them better or worse adapted. They revisit biodiversity (9.01) and are taught human impacts on biodiversity.

Students revisit the ideas of variation, advantageous adaptations and evolution by natural selection (8.06, Y10), and build on this with causes of genetic variation and mutations; evidence for evolution from the fossil record; and selective breeding. They also consider genetic, evolutionary relationships and how organisms may need to be reclassified.

(Note, students will revisit how cells, tissues, organs and organ systems are adapted throughout Year 10 and Year 11.)





Ecological Relationships

Note: Years 9-11 are indicative only.



8.04. Before revisiting food chains more explicitly, students are reminded of the importance of plants as producers (KS2), and are taught photosynthesis, the process by which plants produce food.

Students are also taught about the importance of plants in absorbing carbon dioxide from the atmosphere in the context of climate change (8.01 and **Geography** 7.01).

8.02. At the global scale, students are taught how humans have come to rely on fossil fuels.

KS2. Students should have been taught about some of the relationships between living things, including simple food chains and how animals rely on plants for food; and how organisms rely on their habitat for the things they need to survive.

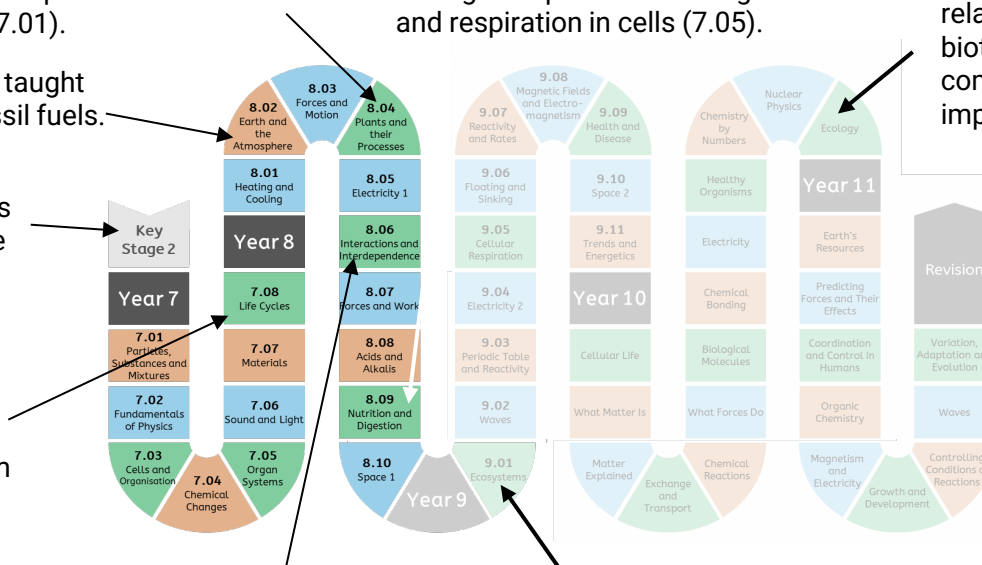
7.08. In the context of seed dispersal in plants, students revisit the idea from KS2 that organisms may heavily rely on each other for survival.

8.06. Formalising the ideas first introduced in KS2, students are taught vocabulary to describe ecosystem organisation (such as ecosystem, community, population, habitat, and environment). They revisit food chains (KS2) and are taught about biomass transfer, food webs and bioaccumulation. They are also taught about decay and the importance of microorganisms for the ecosystem.

Note: In **Geography**, students would have been introduced to a biome as a global ecosystem in Year 7. Alongside 8.06 in Science, students are taught 8.03: Ecosystems in Geography, in which students are taught how climate zones shape biomes, the features of two specific biomes, and the threats to these biomes in the context of climate change.

8.09. Students reinforce the idea that plants make their own food (8.04), and that animals (including humans) need to eat food (8.06). They are taught how the energy transferred to the human consumer in the food chain is released through the processes of digestion and respiration in cells (7.05).

Students revisit biomass transfer (8.06) and build on this with an understanding of trophic levels. They also revisit wider relationships (9.01) and consider how biotic and abiotic factors affect a community, including the biological impacts of climate change.



9.01. Having been taught the interdependence of organisms in terms of food and energy transfer (8.06) students consider wider relationships in an ecosystem, including how organisms can impact their environment, human issues and sustainability, the importance of biodiversity and conservation.





Health

Note: Years 9-11 are indicative only.



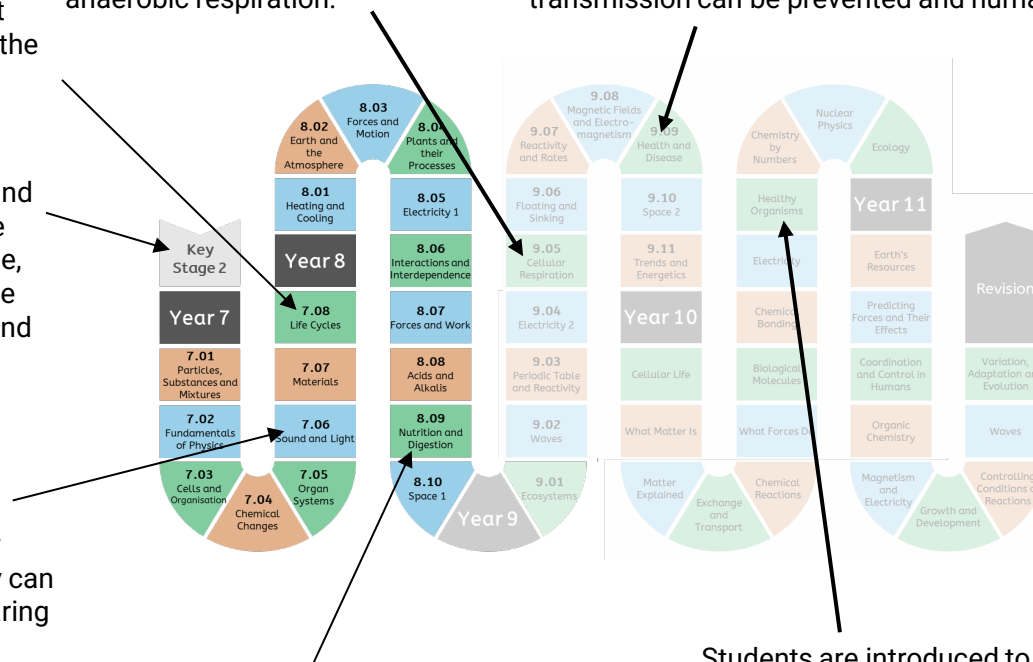
7.08. In the context of pregnancy, students revisit the impact of drugs and smoking (KS2) and are taught how these substances can affect the unborn baby.

KS2. Students should have been taught the basic needs of plants and animals for survival, as well as the importance for humans of exercise, diet and hygiene. They should have been taught the impact of drugs and lifestyle on the way their bodies function.

7.06. In the context of seeing and hearing, students are taught how lenses can correct vision and how hearing aids and other technology can be used to support those with hearing impairments.

9.05. Students revisit the importance of exercise (KS2) and are taught the short, medium and long-term effects of exercise in the context of aerobic and anaerobic respiration.

9.09. Students are introduced to causes of ill-health as imbalances (e.g. too little exercise), drugs and pathogens. Students are taught about the ways that drugs can affect the gaseous exchange system (7.05) and the circulatory system (7.05, 9.05). They are taught about pathogens (linking to understanding of unicellular organisms first introduced in 7.03), how transmission can be prevented and humans' first line of defence.



8.09. Students revisit the importance of diet (KS2) and are taught the components of food in a healthy human diet, and what each is needed for in the body. They are also taught the importance of bacteria in the human digestive system.

Students are introduced to the idea of non-communicable diseases and communicable diseases. They consider the risk factors for non-communicable diseases such as cardiovascular disease and cancer. They consider communicable diseases in plants and animals, and how organisms defend against them, including vaccinations in humans. They are taught how diseases are treated in humans with the use of drugs.





Particles

Note: Years 9-11 are indicative only.



7.06. Students apply their knowledge of particle arrangement (7.01) in each state to explain the how sound is transmitted through matter.

KS2. Students should have been taught about states of matter and vocabulary of evaporation and condensation in the context of the water cycle. They may have encountered the particle model.

7.01. Students are introduced to the concept of matter and particles. They are not yet introduced to atoms/ molecules but use the simple particle model. Students learn how the particulate model of matter – and the arrangement, movement and forces of attraction between particles – can explain changes of state, melting and boiling points, evaporation below boiling points, diffusion, properties of matter in the solid, liquid and gas states (including gas pressure) and dissolving. The concept of the conservation of mass is introduced here in the context of physical changes (such as changing state and dissolving).

7.03. Students are reminded that cells – the building blocks of living things – are made of particles (7.01).

8.01. Students revisit the particle model (7.01) and use this to explain temperature of matter.

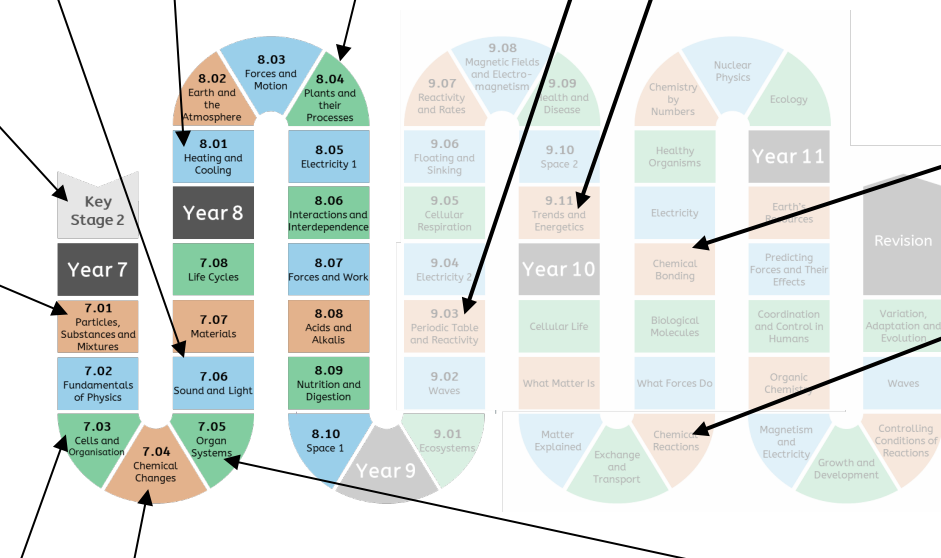
8.04. Students revisit their understanding of chemical changes and rearrangement of atoms in the context of photosynthesis and respiration.

9.03. Students build on their understanding of atoms (7.04) and are taught about the simple atomic model, including protons, neutrons and electrons. They also develop their knowledge of symbol equations (7.04) by learning to balance them.

9.11. Students develop their understanding of the atomic model (9.03) with the arrangement of electrons and how electron structure explains the trends in reactivity seen previously (9.07).

Students revisit the idea of intermolecular forces of attraction in the context of the particle model (7.01) and then develop their understanding of the atomic model (9.11) by learning about metallic bonding, giant ionic structures and covalent structures.

Students revisit the atomic model (9.03) and use this to understand the acid and base models. They'll apply this to understanding how concentration and strength determines the pH.



7.04. Having understood the fundamentals of particles (7.01), students are introduced to atoms, molecules and elements, and then compounds. They are taught how to represent these in diagrams and with symbols and chemical formulae.

They are then introduced to chemical changes as a rearrangement of these atoms. They represent these in diagrams, word equations and symbol equations (though they do not balance equations). They develop the idea of the conservation of mass (7.01) in this context.

7.05. Students revisit molecules (7.04) in the context of the gaseous exchange, digestive and circulatory systems in humans. They see how oxygen and carbon dioxide molecules are transported by diffusion, and how large molecules are broken down into smaller molecules in digestion.





Substances

Note: Years 9-11 are indicative only.



7.07. Students build on understanding of properties of materials and how these relate to their use (KS2) by considering the properties and use of ceramics, polymers and composite materials.

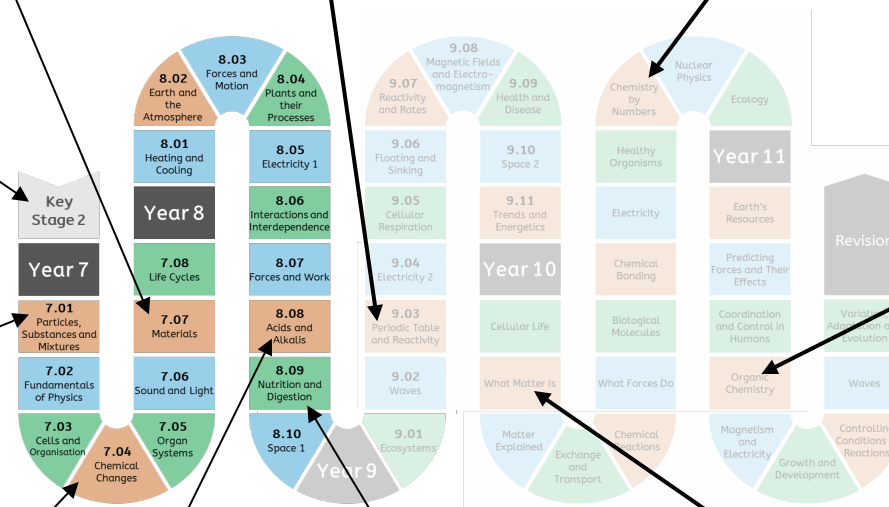
KS2. Students should have been taught about states of matter and vocabulary of evaporation and condensation in the context of the water cycle. They may have encountered the particle model. They will also have spent time describing the properties of different materials and grouping them according to these properties.

7.01. Building on changes of state (KS2), students are introduced to the concepts of matter and particles. Using the particle model, they are taught the difference between pure substances and mixtures. Within mixtures, there is a focus on solutions and the factors that affect solubility. Students are exposed to a wide range of techniques to separate mixtures.

7.04. Applying their understanding of elements and compounds, students are taught how the properties of compounds are different to those of the elements from which the compounds are made.

9.03. Having examined various properties of elements (7.01, 7.04), students consider the physical properties in the context of the periodic table.

Students are taught how an amount of a substance can be expressed in moles.



8.08. Students are introduced to acids and alkalis as substances that have similar properties. They are explained in terms of neutralisation reactions, and the pH scale for measuring acidity/alkalinity. They use simple indicators.

8.09. Students review polymers (7.07) in the context of digestion, and recognise that proteins and carbohydrates are polymers, (whereas fats are not). They also review pH (8.08) and its impacts on enzyme action.

Students revisit substances and their physical properties and how these can be trends can be described in the periodic table (9.03).

Students revisit polymers (7.07) and are introduced to hydrocarbon molecules and their properties. They are taught how crude oil is separated into hydrocarbons through fractional distillation, and how large hydrocarbons are broken down into smaller ones through cracking.





Chemical Reactions

Note: Years 9-11 are indicative only.



8.04. Students apply their knowledge of chemical changes in the context of respiration and photosynthesis.

KS2. Students should have focused mostly on physical, reversible changes (changes of state, separating mixtures). They should also have been taught that 'some changes result in the formation of new materials, and that this kind of change is not usually reversible, including changes associated with burning and the action of acid on bicarbonate of soda.'

7.04. Having understood the fundamentals of particles (7.01), students are introduced to atoms, molecules and elements, and then compounds. They are then introduced to chemical changes as a rearrangement of these atoms. They represent reactants and products in diagrams and word equations and write chemical formulae for compounds, as well as writing appropriate state symbols for chemical formulae. They develop the idea of the conservation of mass (first taught in the context of physical changes in 7.01) in this context.

Students observe the evidence for chemical changes, and focus on precipitation, oxidation, thermal decomposition, combustion and exothermic and endothermic reactions.

8.08. Students are introduced to another type of reaction: neutralisation. This adds to their knowledge of precipitation, oxidation, thermal decomposition and combustion reactions. They are also taught reactions of acids and metals.

9.07. Students consider new types of chemical reactions, including displacement reactions and how carbon can be used in these to extract metals.

Having encountered rates of reaction implicitly (for example, in the context of enzymes speeding up the rate of reaction in 8.09), they are focused on in this unit for the first time. Students measure how surface area, temperature and catalysts affect rates of reaction.

9.11. Students develop their understanding of the atomic model (9.03) with electrons arrangement and how electron structure explains the trends in reactivity seen in 9.07.

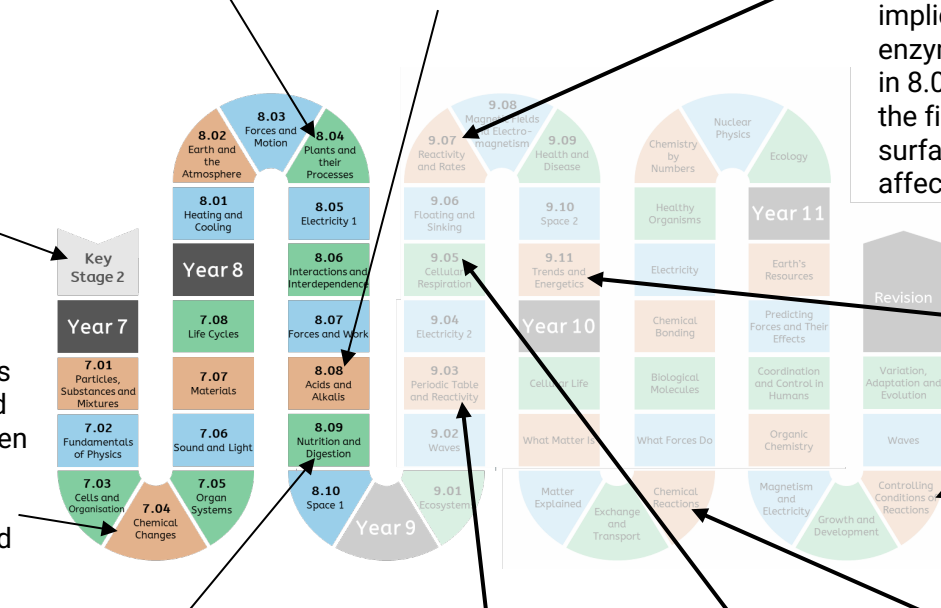
Students build their understanding of reaction rates (9.07) with collision theory. They also see reversible reactions and dynamic equilibrium.

Students broaden their understanding of displacement (9.07) reactions to consider redox reactions. They are also taught about electrolysis.

8.09. Students make connections between their knowledge of chemical reactions and the role of enzymes in breaking down larger molecules into smaller ones.

9.03. Students are taught about the chemical properties of group 1 elements, and the reactions between metals and oxygen; metals and water; and metals and acids. They are taught the reactivity series for metals without carbon and hydrogen.

9.05. Students apply their knowledge of chemical reactions and balancing equations in the context of aerobic respiration.





Physical Earth

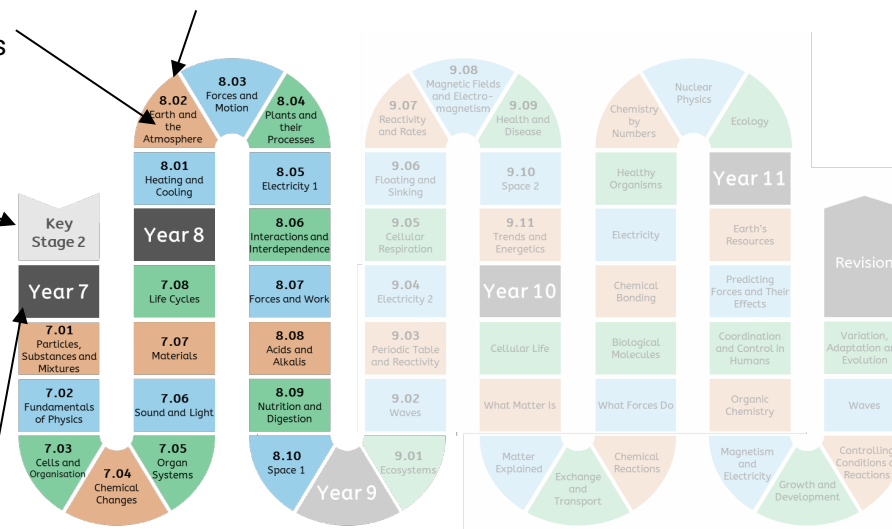
Note: Years 9-11 are indicative only.



8.02. Building knowledge of mountains, volcanoes and earthquakes (KS2 **Geography**), students are taught about the layers of the Earth, continental drift and tectonic plate movement, the formation and properties of igneous, sedimentary and metamorphic rocks. They are taught about how fossil fuels are formed. They are also introduced to different types of weathering.

KS2. Students should have been taught to group different types of rock based on simple physical properties (though they may not have explicitly been taught igneous, sedimentary and metamorphic). They will have been taught about fossils and how they are formed when once-living things are trapped in rock. In **Geography**, students should have been taught to 'describe and understand key aspects of mountains, volcanoes and earthquakes'.

In **Geography** 8.02: Coasts, students revisit knowledge of weathering and learn types of erosion including abrasion, attrition and hydraulic action. In **Geography** 8.04: Tectonics, students revisit the different rock types from 8.02 and apply this to the distribution of rock types in the British Isles. They also revisit the structure of the Earth from 8.02 and build on this with the movement of tectonic plates and how mountains and volcanoes are formed at plate boundaries. In this unit, they are also introduced to geological timescales, including glacial and interglacial periods.



In **Geography** 7.04: Rivers, students are introduced to erosion (vertical and lateral), transportation and deposition.





Earth Science

Note: Years 9-11 are indicative only.



8.02. Students build on their basic understanding of the atmosphere (**Geography** 7.02) and are taught the composition of the atmosphere, atmosphere changes and air quality changes. Students also revisit the greenhouse and enhanced greenhouse effect and apply their more scientific understanding of the transfer of energy by radiation and heating and cooling (8.01).

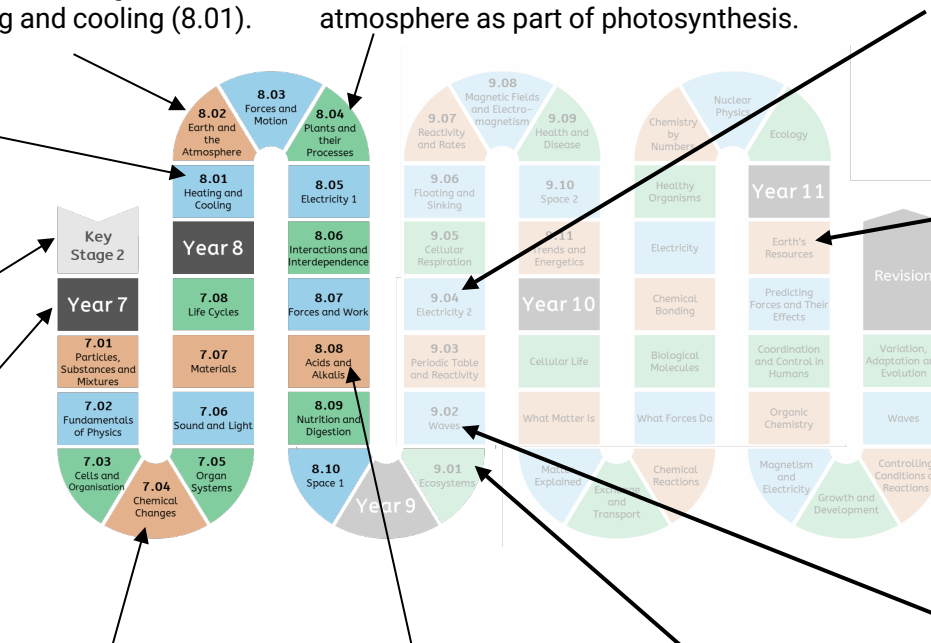
8.01. Students apply their knowledge of heating and cooling to their understanding of the greenhouse effect and enhanced greenhouse effect (**Geography** 7.02).

KS2. Students should have been taught the role of evaporation and condensation in the water process, in **Geography** as well as in Science.

In **Geography** 7.02: Introduction to Global Climate, students are introduced to the concept of the naturally-occurring greenhouse effect and the enhanced greenhouse effect caused by human activity, such as burning fossil fuels. They will use the vocabulary of global warming as a result of the enhanced greenhouse effect. Global warming (increase in temperature) is leading to wider climate change (change in wider long-term weather patterns).

8.04. Students apply their understanding of the enhanced greenhouse effect and consider the importance of plants in absorbing carbon dioxide – a greenhouse gas – from the atmosphere as part of photosynthesis.

9.04. Students review the renewable and non-renewable energy resources first taught in **Geography** 9.01 and focus on *how* these resources can be used to generate electricity.



7.04. Students can apply their knowledge of combustion reactions to the burning of fossil fuels that is contributing to the enhanced greenhouse effect (**Geography** 7.02).

8.08. Students revisit the composition of the atmosphere (8.02) and are taught about air quality in relation to acid rain with links back to chemical weathering (8.02).

9.01. Students revisit climate change from 8.02 and consider the impacts that it is, and will have, on ecosystems and biodiversity. Issues of food security and sustainability will be considered.

Students will be taught how the atmosphere evolved. They will review content from previous units and consolidate knowledge of climate change, its impacts and mitigations. They will be taught about potable water and managing waste.

9.02. Students build on knowledge of the greenhouse effect and the transfer of energy by radiation (8.02) and apply new knowledge of thermal radiation and infrared waves in the context of solar radiation and the greenhouse effect.





Matter

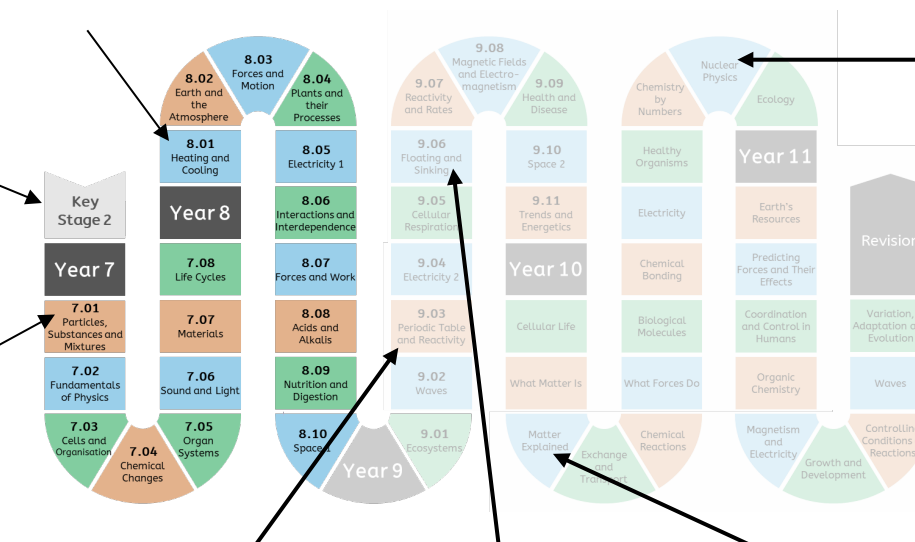
Note: Years 8-11 are indicative only.



8.01. Students are taught to explain temperature of matter using the particle model of matter. They are taught to explain temperature change in different systems, and how energy tends to spread across a system. They review changes of state (7.01). Sublimation is introduced for the first time. New knowledge is applied to exothermic reactions (7.04). They are taught factors that affect the rate of change of temperature and apply this to their knowledge of the greenhouse effect (**Geography** 7.02). Thermal conduction is explained in the context of particles, and students are introduced to density and pressure (in simple terms) before learning about thermal convection. (Convection is revisited in 8.02 and in **Geography** 8.04.) Thermal radiation is described.

KS2. Students should have been taught to 'compare and group materials together, according to whether they are solids, liquids or gases' and taught that materials change state when heated or cooled. The vocabulary of 'matter' is not statutory.

7.01. Students are introduced to the concept of matter, made of particles. They are not yet introduced to atoms/molecules but use the simple particle model. Students learn how the particulate model of matter – and the arrangement, movement and forces of attraction between particles – can explain the changes of state (seen in KS2), melting and boiling points, evaporation below boiling points, diffusion, physical properties of matter in the solid, liquid and gas states (including gas pressure) and dissolving.



9.03. Students build on their understanding of atoms (7.04) and are taught about the simple atomic model, including protons, neutrons and electrons. This will develop in Year 10 in the context of nuclear physics.

9.06. Students build on their simple introduction to density (8.01) and are taught how density is measured and how it relates to upthrust, floating and sinking, as well as diffusion (7.01) and Brownian motion and pressure in fluids.

Students build on knowledge of temperature and matter (8.01) and are taught about specific latent heat and specific heat capacity. They also revisit and embed knowledge of density and pressure.

Students build on knowledge of the atomic model (9.03) and are taught about radioactivity (alpha, beta and gamma radiation); nuclear equations; fission and fusion; and applications in the context of electricity generation.





Motion and Forces

Note: Years 9-11 are indicative only.



8.03. Students build on their knowledge of forces (7.02) and focus specifically on motion and speed. They draw and interpret distance-time graphs. They also consider how speed can be increased by reducing the force of air resistance through streamlining.

KS2. Students should have been taught about magnets and magnetic forces that act at a distance. They should have been introduced to the non-contact force of gravity (in the context of objects falling towards the Earth) and the contact forces of air resistance, water resistance and friction. They will also have seen gears, levers and pulleys, but will not have understood the forces behind these.

7.01. In the context of particles, students apply their understanding of forces (KS2) to gas pressure and movement of particles.

7.02. This unit builds on the foundations of KS2 and ensures students have a solid understanding of the fundamentals of forces: that forces are pushes or pulls with a given direction and size that act on an object and can change the motion or shape of the object. They arise in pairs, and their direction and size can be modelled with arrows. Students are taught about resultant forces when forces are balanced (zero resultant force) and unbalanced (non-zero) forces. They revisit contact and non-contact forces (KS2) and name air resistance, friction, lift, normal contact force, thrust, upthrust, water resistance (contact) and gravity force and magnetic force (non-contact).

8.07. Students build on their practical experience of pulleys, levers and gears (KS2) and simple forces (7.01) and are taught about moments and balance; simple machines; work done and Hooke's law. Their knowledge of pressure in the context of gas pressure (7.01) is formalised here with the equation that connects pressure, force and surface area.

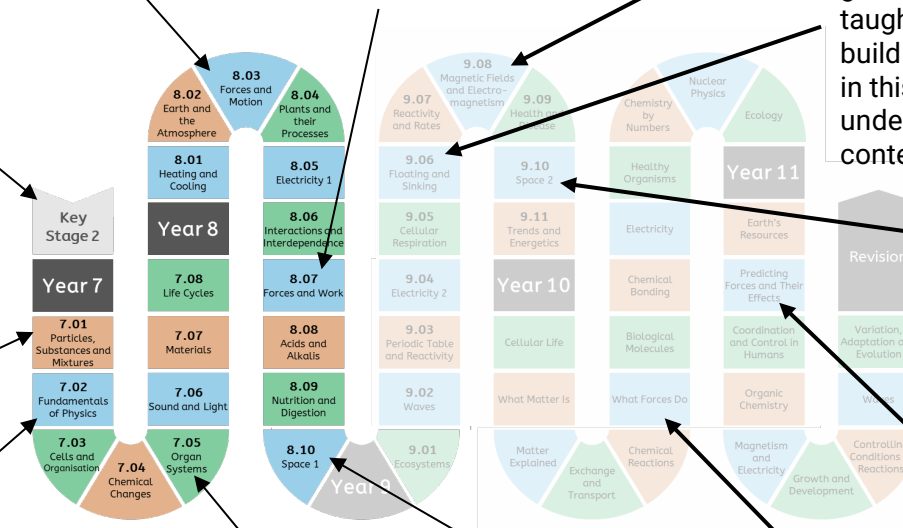
9.08. Students revisit magnetic forces (7.02) and are taught about magnetic poles and fields, including the Earth's magnetic field. They are also introduced to electromagnets.

9.06. Students build on understanding of gravity (7.02) and weight (8.10) and are taught about the force of upthrust. They build their understanding of density (8.01) in this context. They also build their understanding of pressure (8.07) in the context of atmospheric pressure.

9.10. Students revisit orbits (8.10) and are taught about the forces that cause bodies to stay in orbit, revisiting gravity force (7.02) and are taught about inertia.

To date, students have represented forces with arrows in single dimensions; they apply this to two dimensions. They are also introduced to momentum.

Students revisit forces and speed (8.03) and are taught about velocity, acceleration and velocity-time graphs. Students also build their understanding of work done, elasticity and Hooke's law (8.07).





Waves

Note: Years 9-11 are indicative only.



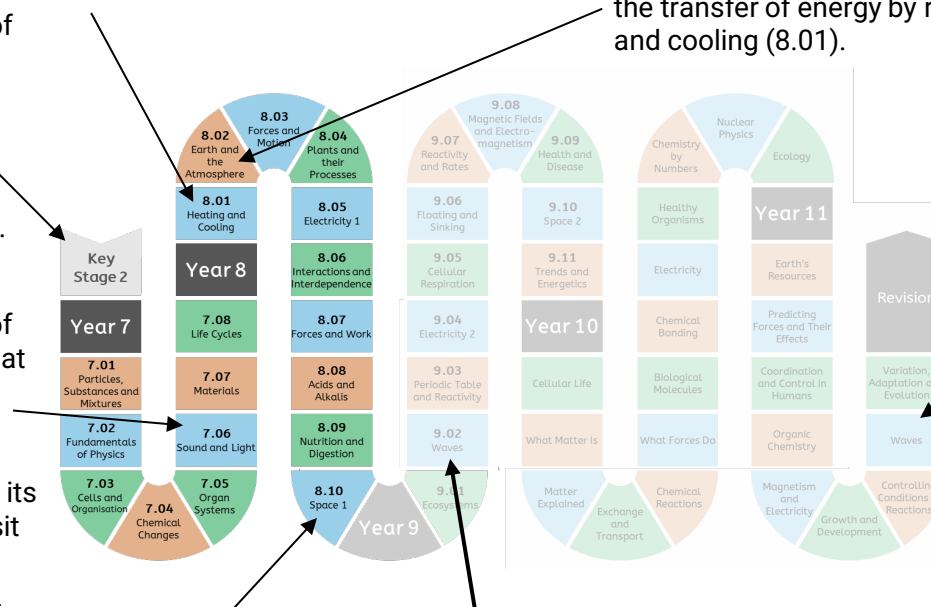
KS2. Students should have been taught to associate sound with something vibrating; how these vibrations travel through a medium to the ear; and how the volume of the sound relates to the strength of the vibrations. Students should have been taught that light appears to travel in straight lines and humans see because light travels from light sources and/or is reflected off objects and travel to the eye. There is no mention of waves.

7.06. Students build on their knowledge of sound being caused by vibrations and what changes its loudness and pitch (KS2), to understand how sound is transmitted via particles (7.01); how it can be absorbed, reflected and scattered; and what affects its speed as it is transmitted. They also revisit how humans hear.

Students develop their knowledge of light emanating from a source to illuminate objects, which is how we see them, and how shadows are evidence for light travelling in straight lines (KS2) to understand how whole areas can be lit up and how surfaces affect the reflection of light. They learn how humans see and what colour is; they explore what images are, including how refraction acts through lenses. The energy pathways related to light and sound are introduced.

8.01. Students build on knowledge of visible light (7.06), to apply it to a different type of light: infra-red radiation, in the context of heating and cooling processes.

8.02. Students revisit the greenhouse and enhanced greenhouse effect (**Geography** 7.02) and apply their more scientific understanding of the transfer of energy by radiation and heating and cooling (8.01).



Students build on their knowledge of light when they are introduced to electromagnetic waves and the electromagnetic spectrum, which includes visible light and infrared. They compare electromagnetic waves to sound waves.

8.10. Students revisit the transmission of sound and light, in the context of space as a vacuum.

9.02. Having seen the effects of waves and the pathway of radiation (7.06), students are formally introduced to waves as a vibration that transfers energy from place to place without transporting matter. They are taught about transverse and longitudinal waves, amplitude and frequency, superposition and speed. They compare light and sound waves. They are also introduced to infrared in the context of thermal radiation but are not yet introduced to the electromagnetic spectrum.





Electricity and Magnetism

Note: Years 9-11 are indicative only.



8.05. Students build on their concrete experience of electrical circuits (KS2) and are introduced to current and potential difference in the context of series circuits (parallel circuits follow in Year 9, to build understanding in small steps). Students are also introduced to the relationship between power, energy transferred and time, and how energy at home is typically measured in kWh. Students then consider the cost of electricity and efficiency of appliances.

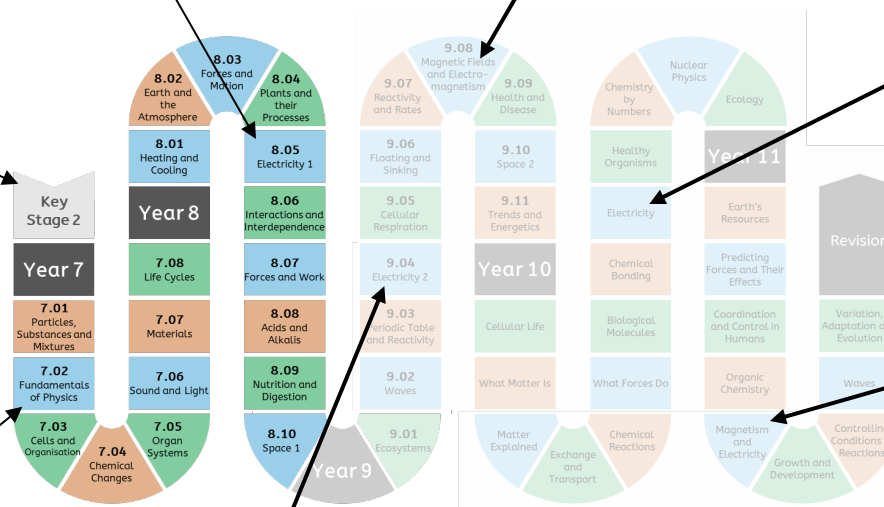
9.08. Students build on their concrete experience of magnets and magnetic poles (KS2) and magnetic forces (7.02) and are taught about magnetic fields, including the Earth's magnetic field. They are also introduced to electromagnets and the principles of DC motors.

KS2. The statutory content in the National Curriculum focuses on the concrete aspects of electricity: making a complete, series circuit; using switches and recognising common electrical conductors and insulators. Students should have been taught to associate the brightness of a bulb (or equivalent) with the number and voltage of cells in the circuit, and they should be able to recognise symbols when representing a simple circuit in a diagram. They should recognise repulsion and attraction between poles in magnets.

7.02. Students revisit simple electrical circuits (KS2) in the context of stores of energy and the electrical transfer pathway.

9.04. Students revisit current and potential difference (8.05) and apply this to parallel circuits. They are also taught resistance and Ohm's law, as well as insulators and static electricity (using knowledge of electrons, 9.03). Students review the renewable and non-renewable energy resources first taught in **Geography** 8.04 and focus on *how* these resources can be used to generate electricity.

Students also consider implications of generating and consuming electricity in **Geography** 9.03: Energy. Here, they consider renewable and non-renewable energy resources and review nuclear energy store when learning about the advantages and disadvantages of nuclear power. They are also taught about global electricity consumption and 'energy' security and poverty.



Students revisit charge, current, potential difference and resistance in series and parallel circuits and measure and calculate these within circuits. They also revisit the cost of electricity in the home.

Students revisit electromagnets and the principles of DC motors (9.08) and are formally introduced to the motor effect, electromagnetic induction and how DC motors work.





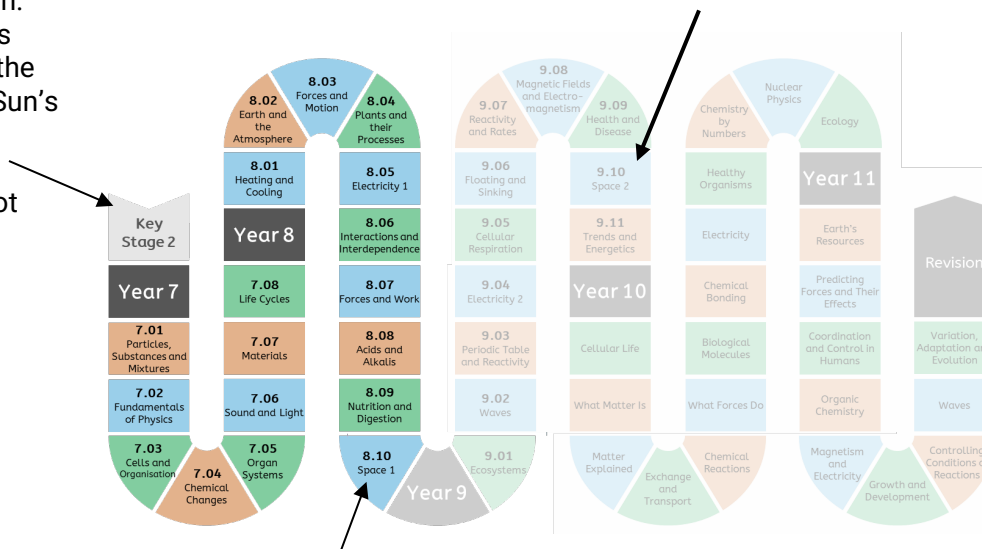
Space Physics

Note: Years 9-11 are indicative only.



KS2. Students should have been taught that the Earth and other planets orbit the Sun and that the Moon orbits the Earth. They should recognize that the Earth's rotation on its axis is responsible for the occurrence of day and night and the Sun's apparent movement across the sky. Students should have been taught to describe seasonal changes but are not expected to know how seasons are caused by the Earth's tilt.

9.10. Students apply knowledge of radiation (9.02) and forces and motion, particularly gravity force (7.02) in the context of space. Students revisit orbits (8.10) and are taught about the forces that cause bodies to stay in orbit, revisiting gravity force (7.02) and are taught about inertia. Students then apply knowledge of the atomic model and nucleus (9.03) to stellar evolution and the beginning of the universe.



In **Geography** 8.03 Ecosystems, students revisit climate zones, and are taught how temperatures are generally higher where thermal radiation from the Sun is transferred at the most direct (most perpendicular) angle, i.e. around the Equator.

8.10. Students revisit the basics of space physics (KS2) and are taught about a wider range of celestial bodies, their orbits and their groupings (including galaxies). They revisit day and night (KS2) and are taught why day length varies with seasons and why the Sun appears to move across the sky. They are also taught how the Earth's tilt causes seasons. Students also explore the nature of stars and galaxies and the scale of the universe.





Energy

Note: Years 9-11 are indicative only.



The concept of energy runs across all other themes, so is not a distinct theme in itself. This map exemplifies how energy is revisited in different contexts.

8.01. Students review energy stores and pathways (7.02) and are taught that temperature indicates the energy of particles in the material. Temperature changes when energy is transferred to or from the material's thermal energy store. There is also a transfer of energy objects during a change of state, due to the position of particles; the total energy is the internal energy of an object.

KS2. The statutory content of the National Curriculum does not include the term 'energy'. However, it is implicit in lots of statutory topics, such as food chains; changes in states of matter; and electricity. It is likely that students will have been exposed to the term – in everyday life as well as primary school lessons – and may arrive at secondary school with misconceptions.

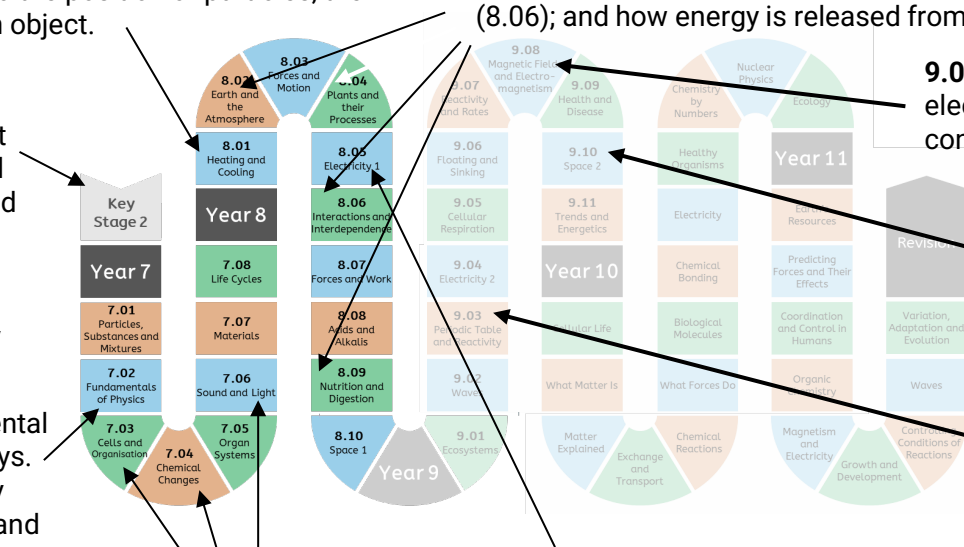
7.02. This unit introduces the fundamental concepts of energy stores and pathways. The focus is on the concepts of energy transfer between stores via pathways and the conservation of energy. In the examples, students will be introduced to the chemical store of energy, kinetic store of energy, elastic store of energy, gravitational store of energy, and thermal store of energy; students are not yet expected to learn about electromagnetic, vibration or nuclear stores of energy. They are introduced to transfer pathways: mechanically, electrically, heating, by radiation and by chemical reaction.

Students revisit energy stores and pathways in the contexts of fossil fuels as chemical energy store (8.02); to explain drag forces (8.03); glucose as a chemical energy store in photosynthesis and respiration (8.04); the electrical pathway in the context of electrical circuits and how energy used is calculated in kWh (8.05); chemical energy store of biomass and its transfer (8.06); and how energy is released from chemical energy store of food (8.09).

9.08. Students are introduced to the electromagnetic store of energy, in the context of electromagnetism.

9.10. Students revisit the nucleus of the atom and nuclear store of energy (9.03) in the context of stellar evolution.

9.03. Students are introduced to the atomic model and the nucleus. Here, they are introduced to the nuclear store of energy.



Students revisit the concept of energy stores and pathways in the contexts of respiration as the process that releases energy (7.03); exo- and endothermic reactions and the conservation of energy within these (7.04); sound and light and how energy is transferred by a mechanical pathway in sound and by radiation in light (7.06).

8.05. The tendency of energy to dissipate (8.01) is revisited in the context of useful and non-useful energy transfers. Students calculate efficiency of appliances.

Students continue to revisit energy stores and pathways throughout Years 9, 10 and 11.

They also consider implications of generating and consuming electricity in **Geography** 9.02: Energy. Here, they consider renewable and non-renewable energy resources and review nuclear energy store when learning about the advantages and disadvantages of nuclear power. They are also taught about global electricity consumption and 'energy' security and poverty.





Scientific Attitudes and Ways of Thinking



	7.01	7.02	7.03	7.04	7.05	7.06	7.07	7.08
Seeking objectivity	Develop questions about the 'natural world', importance of high-quality data: observation and measurement.	How and why scientific thinkers seek to collect high-quality data which is repeatable and reproducible.	The nature of quantitative and qualitative data and how both types of data can lead to trustworthy conclusions.	Measuring devices can have different resolutions; what systematic error is; how both affect the quality of data.		The importance of appropriate range and of how selecting systematic intervals can affect the quality of data.	How random error and its management can affect the quality of data.	
Development of methods and theories over time	They revisit 'scientific enquiry' and the part scientific method plays; which may include the use of variables.	They learn that, though there is no single scientific method, some include a hypothesis.	Enquiring without a hypothesis, without manipulating variables. How methods result from imagination and creativity.	How a prediction develops from a hypothesis and a chosen scientific method.	Students meet scientific methods where a hypothesis is tested, but where variables cannot be manipulated.	A category: no hypothesis, manipulation of variables possible; the main categories of scientific method.	Develop methods that have no hypothesis but with variable manipulation; they categorise methods.	How scientific knowledge builds and shifts over time due and new hypotheses can emerge.
Using a variety of models	How scientific models can be devised to explain observations, it is both descriptive and uses diagrams.	They meet examples of models which are mathematical and representational.	They begin to see the variety of models that can represent reality, but do not show everything at once.	Models are developed further with representational flow diagrams, of pictorial and before and after diagrams.	Models representing systems and flow of materials in and out of systems are explored.	Several models build students' range.		To consider how the same concept can be represented by different scientific models.
The importance of peer review		How high-quality data as applied by a scientific researcher's peers to establish trust for scientific claims.				To assess their own data for repeatability, and reproducibility, and if the method is well designed. To begin to review their own and others' data, and how well the conclusion (claim) fits the data.		





Enquiry and Fieldwork



	7.01	7.02	7.03	7.04	7.05	7.06	7.07	7.08
Planning for valid methods	The importance of planning a systematic enquiry using a scientific method, manipulating variables.	How to follow a hypothesis testing, variable manipulation method.	Plan with help a scientific method (no hypothesis, not manipulating variables); where measuring is not always possible.	Make a prediction and ensure the planned method will collect data that could confirm the hypothesis.	Develop an understanding of planning a hypothesis testing, non manipulative scientific method.	The process to decide how a scientific method is selected (apparatus and techniques). Plan a scientific method for: range, intervals, resolution, systematic error and random error.		
Common techniques and apparatus	Identify equipment and the techniques to use them; general ways of working in a school laboratory.	To use given diagrams to show set up, then draw them without guidance.	beakers, boiling tubes, Bunsen burner, clamp stand and clamp, condenser, conical flask, connecting wires, cover slip, crucible, evaporating basin, filter funnel, filter paper, force-meter, gauze, heat resistant mat, masses on hook, measuring cylinders, metre rule, microscope, microscope slide, mineral wool, pipe-clay triangle, pipette, power supply, raybox and comb, safety glasses, spatula, splint, stirring rod, stopclock, test tubes (Pyrex), test tube holder, thermometer, tongs, top-pan balance, tripod, watch glass chromatography, crystallisation, distillation using a condenser, filtering, heating liquids with a Bunsen burner, heating small amounts of substances with a Bunsen burner, microscopy.					
Planning valid methods which are safe	Follow the laboratory rules, knowing why it's important; the safety precautions to use a Bunsen burner.	What a hazard is and examples of from practical science, and their associated risks and control measures.		The hazards, risks and control measures for their enquiries.				
Making valid observations	What is meant by 'quantity' and how to measure certain quantities; plan the collection of data and carry it out.	Compare observations and measurements, and data; plan for repeatability and reproducibility.	Classify results as observations: qualitative or quantitative, as measurements; consider if the data is 'good enough'.	Collect data with regard to resolution and systematic error.	Observations can be primary or secondary data; how using both can improve the quality of data.	The importance of collecting over a range, with systematic and appropriate intervals between data points.	Collect data with regard to managing random error.	Review data throughout its collection: if values are within estimates; if the data is likely to be trustworthy.





Analytical and Evaluative Approaches



	7.01	7.02	7.03	7.04	7.05	7.06	7.07	7.08
Presenting data	Use given tables to record observations; the purpose of tables and what should be included: title, heading, units.	Some of the 'rules' of recording data systematically in a table.	Qualitative data cannot always be tabulated; e.g., recording biological specimen data.	How to decide which headings, numbers of rows and columns to prepare in data tables. Identify and exclude anomalies from data.		Further prepare tables and collect data systematically;		Construct bar charts from their data given guidance, using data that has been processed for random error.
Analysing data		How to qualitatively compare energy using end-point analysis.		How to calculate the mean from their repeated quantitative data.				
Interpreting data	Read off values from tables, with guidance.	Extract data from tables but with less guidance.	Use qualitative data to describe patterns in the data collected using the data that supports this analysis.		Read data from given line graphs and bar charts*, using it to identify and describe trends in collected data. *not scatter graphs or lines of best fit.			
Developing explanations	What is meant by a conclusion; to write appropriate conclusions from the collected data. How to use the presented data in a conclusion, to describe and explain trends or a relationship between the quantities investigated.		Write conclusions: describe and explain the reason for trends; how data shows this trend; relate the findings to a scientific model/explanation.			To write conclusions, including a statement as to the extent to which a prediction is correct (if there is one).	To check that their conclusion comments only on the data, without over-generalising.	





Applications of Science and its Implications



	7.01	7.02	7.03	7.04	7.05	7.06	7.07	7.08
Developing scientific knowledge through technology			How technology advances have enabled scientific researchers to use more uniform devices e.g. lenses, and to make measurements of quantities that were too small, too large, too distant, or too difficult to resolve before. How technology advances have enabled the use of measuring instruments rather than make subjective observations e.g. digital thermometer, and to automate calculations using computers, which are less prone to mistakes and quicker.				How technology advances have enabled scientific researchers to communicate, share and collaborate more effectively - sharing knowledge more widely and quickly.	
Developing technology through scientific knowledge		How scientific advances have enabled STEM workers to develop processes, instrumentation leading to scientific researchers being able to work differently.	For example, • new materials for use in research • new tools and machines, making mass production possible, thus more accessible, cheaper materials • new products, made more efficiently • new medicines or medical techniques e.g., using echoes to observe foetuses in the womb • clean water to more people					
Ethical, social, economic and political implications							The scientific and technological developments that have increased the human population and some possible implications of it. The implications of using raw materials in increasing amounts; using new raw materials from across the world; the impacts of polymers on society.	





Protocols for Measurement



7.01

7.02

7.03

7.04

7.05

7.06

7.07

7.08

Units

- What a 'unit' is and why they are important.
- Use words (and 'symbols') for units correctly.
- The units for length, time, mass, temperature, and force.
- The units for volume of a liquid.
- The units for loudness and frequency.

Notation and conversions

The use of scaling prefixes.

To use the 'milli', 'kilo' and 'centi' prefixes with confidence.

Symbols and formulae

Use mathematical formulae to complete calculations.

Formulae: total magnification = eyepiece x objective.



Careers opportunities - *Science*

Year	Specific opportunities for teaching about careers linked to Science
7	• Forensic Scientist (7.01 Particles examines separation techniques including chromatography, used in forensics). • Material Scientists (7.07 Materials examines opportunities for science to be applied to material design, with advanced materials being used in industries like aerospace, healthcare and renewable energy).
8	• Engineers (8.01 Heating and Cooling showcases how engineers use the knowledge taught in the unit regarding thermal energy transfer in the application of building design, solar cell design and heat exchangers). • Paleontologist, geologist and climate scientist (8.02 Earth and the Atmosphere highlights Earth processes, including fossil formation and culminates in examining changes to the Earth's atmosphere and the physical impacts on the planet).
9	• Radiographer (9.02 Magnetic Fields and electromagnets spends curriculum time analysing real world uses of electromagnets including in the fields of healthcare and MRI scanners). • Medical careers (9.05 Health and Disease showcases an application of the understanding of human health and disease in the context of medical settings).



Careers opportunities - *Science*

Year	Specific opportunities for teaching about careers linked to Science
10	- Analytical Chemist (C4 Chemical Change explores a range of chemical reactions and techniques used in analytical chemistry including the application of titrations). - Drug Discovery scientist (B3 Infection and Response highlights the drug discovery process and the variety of roles involved with creating a new drug and successfully bringing it to market. - Nuclear Physicist (P4 Atomic Structure showcases how an understanding of nuclear physics and decay can play a vital role in the nuclear power industry, both for power generation and safety).
11	- Optometrist (B5 Homeostasis and P6 Waves both teach pupils about lenses and their manipulation of light with is used in optometry when diagnosing and treating vision conditions). - Sonographer (P6 Waves highlights the uses of electromagnetic radiation in a variety of careers, with pupils examining sonography as a safe and least invasive procedure for medical imaging). - Forensic/Analytical Chemist (C8 Chemical Analysis and C9 Atmosphere explores a range of chemical techniques used in analytical chemistry to identify substances). - Genetic Engineer/Scientist (B6 Inheritance teaching pupils about the human genome and genetically inherited conditions, before exploring selective breeding and genetic engineering, both of which have pertinent current applications in the real world).