AQA
Realising potential

KEY STAGE 3 SCIENCE

Syllabus
An approach to teaching the programme of study

Version 2.2 June 2016

Contents

Are you using the latest version of this syllabus?

- You will always find the most up-to-date version of this syllabus on our website at aqa.org.uk/ks3sciencesyllabus
- We will write to you if there are significant changes to this syllabus.
- Individual Subject content pages can be downloaded from our website.

The KS3 Science Syllabus is supported and co-developed by the Sheffield Institute of Education at Sheffield Hallam University.

Overview of the KS3 Science Syllabus

	Part 1 Taught in year 7 or year 7/8*		Part 2 Taught in year 8 or year 8/9*	
Forces	Speed	Gravity	Contact forces	Pressure
Electromagnets	Voltage and resistance	Current	Electromagnets	Magnetism
Energy	Energy costs	Energy transfer	Work	Heating and cooling
Waves	Sound	Light	Wave effects	Wave properties
Matter	Particle model	Separating mixtures	Periodic table	Elements
Reactions	Metals and non-metals	Acids and alkalis	Chemical energy	Types of reaction
Earth	Earth structure	Universe	Climate	Earth resources
Organisms	Movement	Cells	Breathing	Digestion
Ecosystem	Interdependence	Plant reproduction	Respiration	Photosynthesis
Genes	Variation	Human reproduction	Evolution	Inheritance

* Suggested teaching: Each part should be taught over the period of minimum one year.

Enquiry processes: working scientifically

Analyse
- Analyse patterns
- Discuss limitations
- Draw conclusions
- Present data

Communicate
- Communicate ideas
- Construct explanations
- Critique claims
- Justify opinions

Enquire
- Collect data
- Devise questions
- Plan variables
- Test hypotheses

Solve
- Estimate risks
- Examine consequences
- Review theories
- Interrogate sources

1 Introduction

Aim of our syllabus

Our Key Stage 3 (KS3) Science Syllabus will help you create engaging lessons and promotes teaching for understanding rather than covering fragmented content. By following the framework within this syllabus, you will understand what your students need to know by the end of Key Stage 3 (KS3). Using a logical order of objectives, this syllabus uses big ideas and mastery goals to equip students for success at GCSE. It also provides a method to follow student progress as their understanding develops during KS3.

Relationship between the KS3 Science Syllabus and GCSE sciences

Our GCSE specifications describe content and processes that students need to demonstrate competence in. These areas are developed in KS3 so that students enter Key Stage 4 (KS4) with a level of proficiency.

In most cases, students have been studying science for eight or nine years by the time they start GCSE courses. To reach their potential, they need to study the examined content with a mastery of ideas and skills. This KS3 Science Syllabus will help you identify what mastery looks like. You can use it with the accompanying resources to help your students develop their knowledge, from understanding to application.

The big ideas principle

Students may complete KS3 with knowledge of individual concepts but lack the understanding to apply their knowledge to unfamiliar contexts. This syllabus provides students with this understanding. Using the big ideas principle, the generalisations, principles and models which connect concepts are at the heart of our syllabus. We believe this is how students learn to see the world analytically, to explain phenomena and make predictions – all skills they need for their next stage of scientific learning.

Our syllabus complements the programme of study by exploring links between the ideas at KS3. Teachers have told us the 140 ideas within the programme of study can lead to students moving to a new theme almost every lesson, this can prevent them from gaining a full understanding of key concepts.

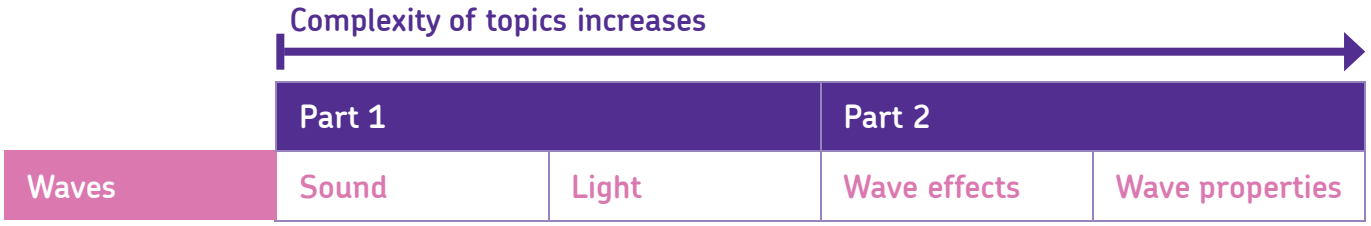
The programme of study lists 140 biology, chemistry and physics ideas and don't distinguish what's most/least important, nor the links between ideas.

This syllabus provides an alternative approach to KS3 content. Content is under 10 big idea headings: Forces, Electromagnetism, Energy, Waves, Matter, Reactions, Earth, Organisms, Ecosystems and Genes. Each idea contains four smaller topics: the building blocks for the big ideas.

A spiral design for understanding

It's easier for students to develop an understanding of a big idea by multiple interactions with the concepts within the idea. By connecting smaller ideas to more abstract ideas, students will be better prepared to apply these concepts when approaching an unfamiliar topic.

Each big idea topic contains four smaller topics that build in complexity. For example 'Waves', topics are ordered from simpler, more concrete topics 'Light' and 'Sound', to more abstract ones 'Wave properties' and 'Wave effects'. These have been created to avoid repetition, draw on various scientific skills and use different contexts.



Our suggested approach to the content is to tackle the first two topics within each idea during the first part of their studies (this should be a minimum of one year) and the third and fourth topics in the second part of their studies (this should also take the minimum of one year).

Mastery goals

Mastery means gaining a secure understanding of the big ideas. Understanding means both 'knowing' – having an accurate mental structure of the concepts and skills – and 'applying' – being able to use the knowledge flexibly across different situations.

So mastery goals are very clear statements of what it means for students to know and apply.

Know	Apply
Generalisations are patterns that link concepts together eg 'mixing an acid and alkali produces a chemical reaction, neutralisation, forming a chemical called a salt and water'. Principles are relationships between concepts, such as cause and effect eg in the topic Interdependence one principle is: 'population sizes are affected by competition with other species, predation, pollution and disease'. Models and systems are groups of concepts connected together in a way that simply describes phenomena eg in the topic Energy transfer; 'when energy is transferred, the total is conserved, but some energy is dissipated, reducing the useful energy'. **Skills** Important knowledge which needs to be practised repeatedly to become fluent. **Facts** Specific details such to be recalled such as the symbol for magnesium. **Keywords** The basic concepts or scientific terms that categorise scientific phenomena, objects and their properties.	The apply column demands that students move beyond recalling what they were taught (know) and using this to explain and describe something unfamiliar. Apply usually requires two thinking steps: firstly to identify critical and relevant elements of the idea, and secondly to put them together into a new form, eg in the topic of Current, an apply objective is 'use a sketch to describe how an object charged positively or negatively became charged up' and in the topic of Separate mixtures, the objective 'use the solubility curve of a solute to explain observations about solutions.'

Extend

Some students will exceed the mastery goals of know and apply. The third, 'extend' column in each topic grid, provides more challenging objectives, using the same knowledge, but requiring higher level thinking. There are three types of extend objectives:

1 Compare: analyse similarities and differences.

2 Evaluate: judge whether information is reasonable, or spot weaknesses.

3 Predict: suggest what will happen in a new situation.

While this syllabus provides several extend objectives, these should be considered as examples rather than targets. There are many more ways students can show they have exceeded the mastery goals.

Enquiry processes: working scientifically

Working scientifically gets students working in similar ways to scientists and our syllabus provides comprehensive coverage of working scientifically. We start with the main goal we want students to accomplish eg a process like analysing patterns. We break it down into two or three strategies, then the individual skill components for teaching and learning.

Similar to the subject content there are two dimensions for each working scientifically process: know and apply.

Know is know-how, or being able to carry out the skills accurately and fluently. Keywords are defined because processes require conceptual knowledge as well as skill. At KS3, know is sufficient for mastery.

Apply goes beyond what is generally expected and assessed at KS3. It is the thinking behind the doing, or describing and explains the principles to carry out skills and strategies.

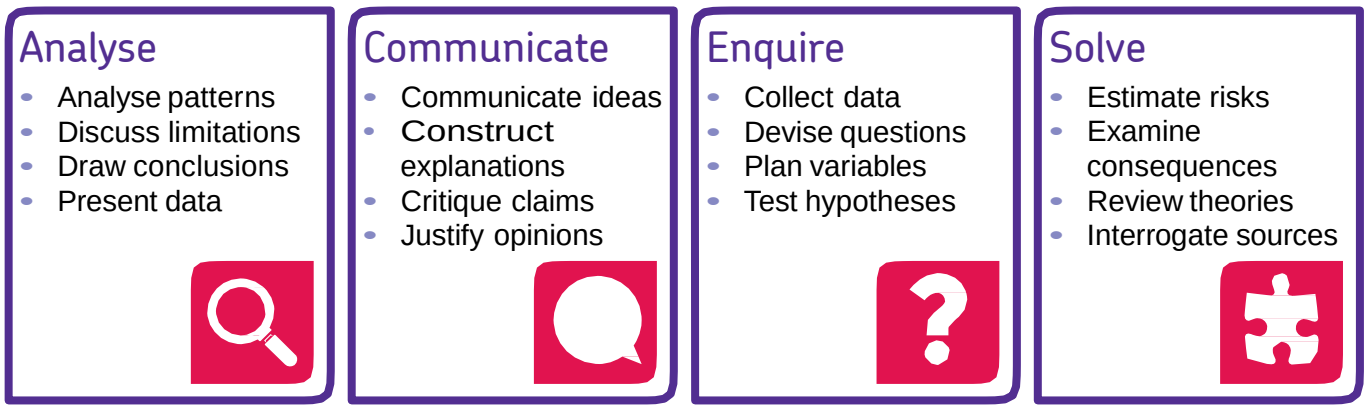
Effective lessons in science have two aspects to them: content and process. A lesson that is helping students to become more proficient is developing their command of key ideas and it is focusing upon enquiry skills. This syllabus, as with the programme of study it is based upon, clearly indicates the content and process separately. However this is to clarify their individual functions within lesson design, which will draw upon both. As the programme explicitly states, working scientifically "… must always be taught through and clearly related to substantive science content…"

In the same way that lessons will select and draw upon certain ideas to deliver, so they should also have a particular focus in terms of enquiry skills. A lesson that tries to address too wide a range of skills is likely to succeed in developing none. Therefore scientific enquiry in this syllabus has been structured in order to support effective navigation, planning and delivery of the requirements. Enquiry is divided into the areas of:

- **Analyse**, consisting of presenting data, analysing patterns, drawing conclusions and discussing limitations.
- **Communicate**, consisting of constructing explanations, communicating ideas, critiquing claims and justifying opinions.
- **Enquire**, consisting of devising questions, testing hypotheses, planning to control variables and collecting data.
- **Solve**, consisting of estimating risks, examining consequences, interrogating sources and understanding how scientific ideas change over time.

Enquiry activities

Our syllabus supports lesson design and delivery by suggesting enquiry activities. These are presented in the subject content sections above the know, apply, extend objectives and are intended to show ways of developing subject content knowledge and the enquiry skills to gain mastery of both.



Working scientifically activity grids

The working scientifically activity grids at the back of this syllabus show how the enquiry activities cover the working scientifically skills needed at KS3. These are just ideas and are not essential to the mastery of each topic. However we recommend students get the opportunity to develop each of the enquiry skills more than once during KS3.

Practical skills

Enquiry processes address the range stipulated by the programme of study and build effective foundations for GCSE. When students start their KS4 course they should be able to draw upon a solid foundation of competencies developed in KS3.

Dimensions of mastery compared to levels

The know, apply, extend framework in the syllabus provides a built in alternative with more detailed information about how much students understand than an overall National Curriculum level.

For each know within every topic, students can see where they are progressing from simpler knowledge (key words), to more complex knowledge and a deeper understanding (apply). This gives a detailed picture of student progress and helps you plan interventions to help them achieve their potential. This can be used for target setting and more precise teaching.

Programme of study coverage

The 140 statements in the KS3 programme of study are incorporated in the syllabus. Many are taught in more depth at KS4. A small number are taken further in the extend activities because treatment is less explicit in the know statements as these involve linking more than one big idea.

2 Enquiry processes

2.1 Analyse patterns

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Calculate a mean from a set of data. Read values from a line graph. Spot a data point that does not fit the pattern. Estimate values of data between known values. Identify the variables from information about an investigation. Identify a pattern in data from a results table or bar chart. Express a linear relationship between variables in the form 'When... doubles then... also doubles'	**Strategy** Select relevant data and do calculations. Identify patterns in data. Suggest relationships between variables.	Describe how anomalous data affects how easily you can identify a pattern. Interpret a sloping line on a graph to suggest the relationship between variables.

Keywords

Linear relationship: When two variables are graphed and show a straight line which goes through the origin, and they can be called directly proportional.

Outlier: A piece of data that does not fit the pattern.

Mean: An average of a set of data, calculated by adding all the values and dividing by the number of values.

2.2 Discuss limitations

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Identify variables that you could not control properly. Identify aspects of the method that did not go according to plan. Suggest reasons for differences in repeat readings. Compare your results to someone else's. Comment on whether your findings fit with known scientific explanations. Suggest better ways to control variables. Suggest ways to improve the method. Suggest ways to reduce measurement errors. Research other possible scientific explanations for your conclusion.	**Strategy** Analyse strengths and weaknesses in your inquiry. Suggest improvements and developments.	Describe how the size of the error in an investigation affects the strength of the evidence. Explain why having someone else repeat the experiment could increase confidence in the conclusion. Identify potential sources of random and systematic error.

Keywords

Experimental error: Variations in measurements, owing to the method, measurement techniques or the instrument.

Random and systematic error: Random errors are when the same quantity is measured and inconsistent values obtained. Systematic errors arise from an inaccuracy in the system and give rise to errors of the same value.

2.3  Draw conclusions

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Incorporate the pattern you found into an answer to the enquiry question. Suggest a scientific reason for your findings. Comment on whether there is a real difference between data. Justify whether anomalous results can be explained or ignored. Suggest other possible conclusions that could be drawn from your data. Quote any secondary data you have which led to the same conclusion.	**Strategy** Make conclusion and explain it. Judge whether the conclusion is supported by the data.	Make a conclusion and explain it. Judge whether the conclusion is supported by the data. Explain how in an investigation in which not all variables could be controlled that a conclusion could still be drawn. Identify further questions arising from the investigation.

Keywords

Secondary data: Results that have already been collected by another person.

Real difference: There is a real difference between two means if their ranges do not overlap much.

2.4 Present data

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Decide the type of chart or graph to draw based on its purpose or type of data. Design a table for the data being gathered. Label the *x* axis with the name of the independent variable and the *y* axis with the dependent variable. Write unit labels on the axes. Decide which numbers to start and finish with on each axis. Mark out an equal scale showing what each square of graph paper represents. Draw a straight line or a curve of best fit through the points.	**Strategy** Select a good way to display data. Draw line graphs to display relationships.	Explain why different kinds of data are better displayed on different kinds of graphs. Explain the choice of starting point for axes, zero or non-zero. Explain the choice of a straight line or curve of best fit. Explain the choice of type of graph.

Keywords

Continuous variable: Has values that can be any number.

Discontinuous variable: Has values that are words or discrete numbers.

Bar chart/column graph: Displays the values of categories.

Line graph: Shows the relationship between two continuous variables.

Pie chart: Shows the proportions or percentages that make up a whole.

Line of best fit: A straight or curved line drawn to show the pattern of data points.

Scatter graph: Shows the independent variable vs dependent variable.

2.5 Communicate ideas

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Write in a style to fit purpose and audience. Use clear language and well formed sentences. Read your text and rewrite anything that is not clear. Illustrate ideas with real-life examples. Use vivid words, describing real things. Add a diagram if it helps to make the meaning clearer. Use scientific vocabulary accurately, showing that you know its meaning and use appropriate units and correct chemical nomenclature. Check there are no mistakes in spelling, punctuation or grammar. Give evidence to back up everything you claim to be true. Make a list of all the points, and cover one point in each paragraph. Put the paragraphs in a sensible order. Use link words to help the reader connect sentences and paragraphs. Include everything necessary for the reader to understand, but leave out unimportant details.	**Strategy** Make it clear. Make it concrete. Make it correct. Make it coherent.	Describe how the strategies help communicate ideas better. Suggest how the ideas would be communicated for a different audience.

2.6 Construct explanations

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Record the observation you want to explain. Record observations using scientific words. Decide if a diagram might help the explanation. Suggest a scientific idea that might explain the observation. Describe the evidence for your idea. Explain why the evidence supports your idea.	**Strategy** Develop an explanation. Communicate your idea, evidence and reasoning.	Explain why an explanation is more believable when supported by data from an experiment.

Keywords

Observation: Information gathered by your senses.

Evidence: Information from an observation or experiment that supports an idea.

2.7 Critique claims

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Identify the claim. Comment on whether the claim is clearly stated. Identify all the evidence that is used. Comment on whether the evidence is scientifically accurate and relevant to the claim. Identify the reasoning that links the evidence to the claim. Comment on whether the reasoning follows logically from the evidence.	**Strategy** Check the claim. Check the evidence. Check the reasoning.	Explain how believable you think the claim is, by presenting all your evidence and reasoning.

Keywords

Claim: A statement that says something is true.

Evidence: The facts, scientific ideas, data or conclusions that support the claim.

Reasoning: Your ideas about what the evidence means, in the form of an argument for or against the claim.

2.8 Justify opinions

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills State the issue or decision to be made, along with the options. State your opinion with enough detail to be clear. List all the facts, scientific ideas, data, or conclusions that support your opinion. Identify the most important piece of evidence, as well as one or two supporting pieces of evidence. Acknowledge other options. Explain logically how each piece of evidence supports your opinion. Explain why each piece of evidence does not support other opinions.	**Strategy** State your opinion. Present your evidence. Explain your reasoning.	Explain how you could defend your opinion if someone criticises it. Identify ways in which a different opinion may be valid.

2.9 Collect data

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Choose a suitable range for the independent and dependent variable. Gather sufficient data for the investigation and repeat if appropriate. Prepare a table with space to record all measurements. Apply sampling techniques if appropriate. Check that the measuring instrument can measure the complete range of the independent variable. Check you can detect differences in the dependent variable. Use the measuring instrument correctly. Carry out the method carefully and consistently. See if repeated measurements are close. Remove outliers and calculate mean of repeats.	**Strategy** Choose range, interval, readings. Test suitability of measuring instrument. Gather data, minimising errors.	Explain why having a large range or many readings leads to accurate data. Describe the factors that influence the choice of range and interval for the variables.

Keywords

Range: The maximum and minimum values of a variable.

Interval: The gap between the values of the independent variable.

Control group: Those that are not exposed to the factor being tested.

Repeatable: When repeat readings are close together.

2.10 Devise questions

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Identify an observation that could be recorded or measured over time. Write a question in the format 'How does... change over time?' Identify a dependent variable. Identify an independent variable. Write a question linking variables in the form 'How does... affect...?' Identify two variables which may show a correlation. Write a question in the form 'Is there a correlation between… and…'	**Strategy** Write an observation enquiry question. Write a fair test enquiry question. Write a pattern seeking enquiry question.	Explain which type of enquiry is best for answering a given scientific question. Explain whether a given question can be investigated scientifically.

Keywords

Scientific enquiries: Different ways to investigate including observation over time, fair test and pattern seeking.

Variable: A factor that can be changed, measured and controlled.

Independent variable: What you change in an investigation to see how it affects the dependent variable.

Dependent variable: What you measure or observe in an investigation.

Correlation: A relationship between variables where one increases or decreases as the other increases.

2.11 Plan variables

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Decide how to vary the independent variable between planned values. Decide how to measure the dependent variable. List all the variables that could affect the dependent variable. Select important control variables. Identify how to control each control variable. List variables you cannot control.	**Strategy** Plan method. Identify control variables. Control the variables.	Explain why some variables are difficult to control. Describe how controlling variables is important in providing evidence for a conclusion.

Keywords
Control variable: One that remains unchanged or is held constant to stop it affecting the dependent variable.

2.12 Test hypotheses

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Identify and record key features of an observation. Write a scientific description of the observation, using key words. Suggest a hypothesis for the observation. Suggest an experiment to test the hypothesis. Predict what will happen if your hypothesis is correct. Decide whether the conclusion of the experiment agrees with your prediction. State whether or not the hypothesis is correct.	**Strategy** Think up a hypothesis. Make an experimental prediction. Conclude if hypothesis is correct.	Explain why a hypothesis may become stronger after it is tested. Describe what to do if the conclusion does not agree with your prediction.

Keywords

Hypothesis: An explanation you can test which includes a reason and a 'science idea'.

Observation: Information gathered by your senses.

Prediction: What you think will happen in an experiment.

2.13 Estimate risks

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Identify features of an investigation which are hazardous. Determine the nature of the hazard. Suggest the likelihood of that happening. Identify ways of reducing the hazard. Identify ways of reducing the risk. Weigh up the benefits and risks of an application of science to make a decision. Explain why you made this decision.	**Strategy** Identify risks and hazards. Identify control measures. Decide overall.	Suggest how the question being investigated can be safely explored in a school science laboratory.

Keywords

Risk: How likely something is to be harmful.

Hazard: A situation that presents a threat to people.

Benefit: Something good or helpful.

Control measure: An action taken to remove the hazard or to reduce the exposure to it.

2.14 Examine consequences

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Identify groups who could benefit or be harmed positively or negatively by a new discovery or invention. Describe how each group could benefit or be harmed. Predict views that different groups will take on the new discovery or invention. Describe how the new discovery or invention could affect you. Identify possible consequences to particular habitats. Describe possible consequences to animals dependent on these habitats. Describe possible consequences to local air quality. Describe potential impacts further afield. Identify individuals or organisations who may gain or lose money from a new technology. Describe how it would affect each group financially.	**Strategy** Consider people. Consider the environment. Consider money.	Explain why different groups of people might reach different decisions. Explain whether you think personal or group consequences should take priority. Select the choice which maximises the benefits and minimises the harm. List relevant 'we should, or should not' rules that everyone should follow.

2.15 Review theories

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills Explain what is meant by a theory. State examples of theories in science. Describe the role of evidence in supporting theories. State examples of theories that have changed. Explain role of new evidence in changing theories. Explain role of argumentation in modifying theories.	**Strategy** Understand the role of a theory in science. Understand how scientific ideas have changed.	Explain why it sometimes takes a long time for a theory to be changed. Explain why argumentation is essential for the development of robust theories.

Keywords

Evidence: Measurements or observations offered to support or oppose a theory.

Argumentation: Using logical reasoning, debate and negotiation to reach conclusions.

2.16 Interrogate sources

Know		Apply
Individual skills	**Integration**	**Understand principles**
Skills **Comment on whether:** • the authors of the research are qualified scientists • the research was published in a peer reviewed journal • the research agrees with current scientific thinking • the researcher or funder might benefit from reporting the finding • the author might have a vested interest • the experimenter collected enough data • they gave a scientific explanation of the findings • the findings were backed up by other research.	**Strategy** Judge the reliability of the source. Check for bias. Evaluate the evidence for the claim.	Explain possible causes of bias from an experimenter or journalist. Explain how peer review makes a finding more believable.

Keywords

Peer reviewed: The checking of research by other scientists.

Bias: When an experimenter affects the outcome, or when a journalist favours a point of view.

Funder: Organisation or person that pays for scientific research.

Journal: Magazine which publishes science research for others to read.

3 Subject content

3.1 Forces

3.1.1 Speed

Investigate variables that affect the speed of a toy car rolling down a slope

Know	Apply
If the overall, resultant force on an object is non-zero, its motion changes and it slows down, speeds up or changes direction. **Skill** Use the formula: speed = distance (m)/time (s) or distance-time graphs, to calculate speed. **Facts** A straight line on a distance-time graph shows constant speed, a curving line shows acceleration. The higher the speed of an object, the shorter the time taken for a journey. **Keywords** **Speed**: How much distance is covered in how much time. **Average speed**: The overall distance travelled divided by overall time for a journey. **Relative motion**: Different observers judge speeds differently if they are in motion too, so an object's speed is relative to the observer's speed. **Acceleration**: How quickly speed increases or decreases.	Illustrate a journey with changing speed on a distance-time graph, and label changes in motion. Describe how the speed of an object varies when measured by observers who are not moving, or moving relative to the object.

Extend

Suggest how the motion of two objects moving at different speeds in the same direction would appear to the other.

Predict changes in an object's speed when the forces on it change.

3.1.2 Gravity

Explain the way in which an astronaut's weight varies on a journey to the moon

Know	Apply
Mass and weight are different but related. Mass is a property of the object; weight depends upon mass but also on gravitational field strength. Every object exerts a gravitational force on every other object. The force increases with mass and decreases with distance. Gravity holds planets and moons in orbit around larger bodies. **Skill** Use the formula: weight (N) = mass (kg) x gravitational field strength (N/kg). **Fact** g on Earth = 10 N/kg. On the moon it is 1.6 N/kg. **Keywords** **Weight**: The force of gravity on an object (N). **Non-contact force**: One that acts without direct contact. **Mass**: The amount of stuff in an object (kg). **Gravitational field strength, g**: The force from gravity on 1 kg (N/kg). **Field**: The area where other objects feel a gravitational force.	Explain unfamiliar observations where weight changes. Draw a force diagram for a problem involving gravity. Deduce how gravity varies for different masses and distances. Compare your weight on Earth with your weight on different planets using the formula.

Extend
Compare and contrast gravity with other forces. Draw conclusions from data about orbits, based on how gravity varies with mass and distance. Suggest implications of how gravity varies for a space mission.

3.1.3 Contact forces

Investigate factors that affect the size of frictional or drag forces

Know	Apply
When the resultant force on an object is zero, it is in equilibrium and does not move, or remains at constant speed in a straight line. One effect of a force is to change an object's form, causing it to be stretched or compressed. In some materials, the change is proportional to the force applied. **Skill** Sketch the forces acting on an object, and label their size and direction. **Keywords** **Equilibrium**: State of an object when opposing forces are balanced. **Deformation**: Changing shape due to a force. **Linear relationship**: When two variables are graphed and show a straight line which goes through the origin, and they can be called directly proportional. **Newton**: Unit for measuring forces (N). **Resultant force**: Single force which can replace all the forces acting on an object and have the same effect. **Friction**: Force opposing motion which is caused by the interaction of surfaces moving over one another. It is called 'drag' if one is a fluid. **Tension**: Force extending or pulling apart. **Compression**: Force squashing or pushing together. **Contact force**: One that acts by direct contact.	Explain whether an object in an unfamiliar situation is in equilibrium. Describe factors which affect the size of frictional and drag forces. Describe how materials behave as they are stretched or squashed. Describe what happens to the length of a spring when the force on it changes.

Extend
Evaluate how well sports or vehicle technology reduces frictional or drag forces. Describe the effects of drag and other forces on falling or accelerating objects as they move. Using force and extension data, compare the behaviour of different materials in deformation using the idea of proportionality. Explain how turning forces are used in levers.

3.1.4 Pressure

Investigate how pressure from your foot onto the ground varies with different footwear

Know	Apply
Pressure acts in a fluid in all directions. It increases with depth due to the increased weight of fluid, and results in an upthrust. Objects sink or float depending on whether the weight of the object is bigger or smaller than the upthrust. Different stresses on a solid object can be used to explain observations where objects scratch, sink into or break surfaces. **Skill** Use the formula: fluid pressure, or stress on a surface = force (N)/area (m^2). **Keywords** **Fluid**: A substance with no fixed shape, a gas or a liquid. **Pressure**: The ratio of force to surface area, in N/m^2, and how it causes stresses in solids. **Upthrust**: The upward force that a liquid or gas exerts on a body floating in it. **Atmospheric pressure**: The pressure caused by the weight of the air above a surface.	Use diagrams to explain observations of fluids in terms of unequal pressure. Explain why objects either sink or float depending upon their weight and the upthrust acting on them. Explain observations where the effects of forces are different because of differences in the area over which they apply. Given unfamiliar situations, use the formula to calculate fluid pressure or stress on a surface.

Extend
Use the idea of pressure changing with depth to explain underwater effects. Carry out calculations involving pressure, force and area in hydraulics, where the effects of applied forces are increased. Use the idea of stress to deduce potential damage to one solid object by another.

3.2 Electromagnets

3.2.1 Voltage and resistance

Compare the voltage drop across resistors connected in series in a circuit

Know	Apply
We can model voltage as an electrical push from the battery, or the amount of energy per unit of charge transferred through the electrical pathway. In a series circuit, voltage is shared between each component. In a parallel circuit, voltage is the same across each loop. Components with resistance reduce the current flowing and shift energy to the surroundings. **Skill** Calculate resistance using the formula: resistance (Ω) = potential difference (V) ÷ current (A). **Keywords** **Potential difference (voltage)**: The amount of energy shifted from the battery to the moving charge, or from the charge to circuit components, in volts (V). **Resistance**: A property of a component, making it difficult for charge to pass through, in ohms (Ω). **Electrical conductor**: A material that allows current to flow through it easily, and has a low resistance. **Electrical insulator**: A material that does not allow current to flow easily, and has a high resistance.	Draw a circuit diagram to show how voltage can be measured in a simple circuit. Use the idea of energy to explain how voltage and resistance affect the way components work. Given a table of voltage against current. Use the ratio of voltage to current to determine the resistance. Use an analogy like water in pipes to explain why part of a circuit has higher resistance.

Extend

Predict the effect of changing the rating of a battery or a bulb on other components in a series or parallel circuit.

Justify the sizes of voltages in a circuit, using arguments based on energy.

Draw conclusions about safety risks, from data on voltage, resistance and current.

3.2.2 Current

Compare and explain current flow in different parts of a parallel circuit

Know	Apply
Current is a movement of electrons and is the same everywhere in a series circuit. Current divides between loops in a parallel circuit, combines when loops meet, lights up bulbs and makes components work. Around a charged object, the electric field affects other charged objects, causing them to be attracted or repelled. The field strength decreases with distance. **Fact** Two similarly charged objects repel, two differently charged objects attract. **Keywords** **Negatively charged**: An object that has gained electrons as a result of the charging process. **Positively charged**: An object that has lost electrons as a result of the charging process. **Electrons**: Tiny particles which are part of atoms and carry a negative charge. **Charged up**: When materials are rubbed together, electrons move from one surface to the other. **Electrostatic force**: Non-contact force between two charged objects. **Current**: Flow of electric charge, in amperes (A). **In series**: If components in a circuit are on the same loop. **In parallel**: If some components are on separate loops. **Field**: The area where other objects feel an electrostatic force.	Describe how current changes in series and parallel circuits when components are changed. Turn circuit diagrams into real series and parallel circuits, and vice versa. Describe what happens when charged objects are placed near to each other or touching. Use a sketch to describe how an object charged positively or negatively became charged up.

Extend

Compare the advantages of series and parallel circuits for particular uses.

Evaluate a model of current as electrons moving from the negative to the positive terminal of a battery, through the circuit.

Suggest ways to reduce the risk of getting electrostatic shocks.

3.2.3 Electromagnets

Investigate ways of varying strength of an electromagnet

Know	Apply
An electromagnet uses the principle that a current through a wire causes a magnetic field. Its strength depends on the current, the core and the number of coils in the solenoid. **Fact** The magnetic field of an electromagnet decreases in strength with distance. **Keywords** **Electromagnet**: A non-permanent magnet turned on and off by controlling the current through it. **Solenoid**: Wire wound into a tight coil, part of an electromagnet. **Core**: Soft iron metal which the solenoid is wrapped around.	Use a diagram to explain how an electromagnet can be made and how to change its strength. Explain the choice of electromagnets or permanent magnets for a device in terms of their properties.
Extend	
Critique the design of a device using an electromagnet and suggest improvements. Suggest how bells, circuit breakers and loudspeakers work, from diagrams.	

3.2.4 Magnetism

Explore the magnetic field pattern around different types or combinations of magnets

Know	Apply
Magnetic materials, electromagnets and the Earth create magnetic fields which can be described by drawing field lines to show the strength and direction. The stronger the magnet, and the smaller the distance from it, the greater the force a magnetic object in the field experiences. **Facts** Two 'like' magnetic poles repel and two 'unlike' magnetic poles attract. Field lines flow from the north-seeking pole to the south-seeking pole. **Keywords** **Magnetic force**: Non-contact force from a magnet on a magnetic material. **Permanent magnet**: An object that is magnetic all of the time. **Magnetic poles**: The ends of a magnetic field, called north-seeking (N) and south-seeking poles (S).	Use the idea of field lines to show how the direction or strength of the field around a magnet varies. Explain observations about navigation using Earth's magnetic field.

Extend
Predict the pattern of field lines and the force around two magnets placed near each other. Predict how an object made of a magnetic material will behave if placed in or rolled through a magnetic field.

3.3 Energy

3.3.1 Energy costs

Compare the running costs of fluorescent and filament light bulbs

Know	Apply
We pay for our domestic electricity usage based on the amount of energy transferred. Electricity is generated by a combination of resources which each have advantages and disadvantages. Calculate the cost of home energy usage, using the formula: cost = power (kW) x time (hours) x price (per kWh). **Fact** Food labels list the energy content of food in kilojoules (kJ). **Keywords** **Power**: How quickly energy is transferred by a device (watts). **Energy resource**: Something with stored energy that can be released in a useful way. **Non-renewable**: An energy resource that cannot be replaced and will be used up. **Renewable**: An energy resource that can be replaced and will not run out. Examples are solar, wind, waves, geothermal and biomass. **Fossil fuels**: Non-renewable energy resources formed from the remains of ancient plants or animals. Examples are coal, crude oil and natural gas.	Compare the amounts of energy transferred by different foods and activities. Compare the energy usage and cost of running different home devices. Explain the advantages and disadvantages of different energy resources. Represent the energy transfers from a renewable or non-renewable resource to an electrical device in the home.

Extend
Evaluate the social, economic and environmental consequences of using a resource to generate electricity, from data. Suggest actions a government or communities could take in response to rising energy demand. Suggest ways to reduce costs, by examining data on a home energy bill.

3.3.2 Energy transfer

Explain the energy transfers in a hand-crank torch

Know	Apply
We can describe how jobs get done using an energy model where energy is transferred from one store at the start to another at the end. When energy is transferred, the total is conserved, but some energy is dissipated, reducing the useful energy. **Keywords** **Thermal energy store**: Filled when an object is warmed up. **Chemical energy store**: Emptied during chemical reactions when energy is transferred to the surroundings. **Kinetic energy store**: Filled when an object speeds up. **Gravitational potential energy store**: Filled when an object is raised. **Elastic energy store**: Filled when a material is stretched or compressed. **Dissipated**: Become spread out wastefully.	Describe how the energy of an object depends on its speed, temperature, height or whether it is stretched or compressed. Show how energy is transferred between energy stores in a range of real-life examples. Calculate the useful energy and the amount dissipated, given values of input and output energy. Explain how energy is dissipated in a range of situations.

Extend
Compare the percentages of energy wasted by renewable energy sources. Explain why processes such as swinging pendulums or bouncing balls cannot go on forever, in terms of energy. Evaluate analogies and explanations for the transfer of energy.

3.3.3 Work

Explain how an electric motor raising a weight is doing work

Know	Apply
Work is done and energy transferred when a force moves an object. The bigger the force or distance, the greater the work. Machines make work easier by reducing the force needed. Levers and pulleys do this by increasing the distance moved, and wheels reduce friction. **Keywords** **Work**: The transfer of energy when a force moves an object, in joules. **Lever**: A type of machine which is a rigid bar that pivots about a point. **Input force**: The force you apply to a machine. **Output force**: The force that is applied to the object moved by the machine. **Displacement**: The distance an object moves from its original position. **Deformation**: When an elastic object is stretched or squashed, which requires work.	Draw a diagram to explain how a lever makes a job easier. Compare the work needed to move objects different distances.

Extend

Use the formula: work done (J) = force (N) x distance moved (m) to compare energy transferred for objects moving horizontally.

Compare and contrast the advantages of different levers in terms of the forces need and distance moved.

3.3.4 Heating and cooling

Investigate how to prevent heat loss by conduction, convection and radiation

Know	Apply
The thermal energy of an object depends upon its mass, temperature and what it's made of. When there is a temperature difference, energy transfers from the hotter to the cooler object. Thermal energy is transferred through different pathways, by particles in conduction and convection, and by radiation. **Keywords** **Thermal conductor**: Material that allows heat to move quickly through it. **Thermal insulator**: Material that only allows heat to travel slowly through it. **Temperature**: A measure of the motion and energy of the particles. **Thermal energy**: The quantity of energy stored in a substance due to the vibration of its particles. **Conduction**: Transfer of thermal energy by the vibration of particles. **Convection**: Transfer of thermal energy when particles in a heated fluid rise. **Radiation**: Transfer of thermal energy as a wave.	Explain observations about changing temperature in terms of energy transfer. Describe how an object's temperature changes over time when heated or cooled. Explain how a method of thermal insulation works in terms of conduction, convection and radiation. Sketch diagrams to show convection currents in unfamiliar situations.

Extend
Sketch a graph to show the pattern of temperature change against time. Evaluate a claim about insulation in the home or for clothing technology. Compare and contrast the three ways that energy can be moved from one place to another by heating.

3.4 Waves

3.4.1 Sound

Relate changes in the shape of an oscilloscope trace to changes in pitch and volume

Know	Apply
Sound consists of vibrations which travel as a longitudinal wave through substances. The denser the medium, the faster sound travels. The greater the amplitude of the waveform, the louder the sound. The greater the frequency (and therefore the shorter the wavelength), the higher the pitch. **Facts** Sound does not travel through a vacuum. The speed of sound in air is 330 m/s, a million times slower than light. **Keywords** **Vibration**: A back and forth motion that repeats. **Longitudinal wave**: Where the direction of vibration is the same as that of the wave. **Volume**: How loud or quiet a sound is, in decibels (dB). **Pitch**: How low or high a sound is. A low (high) pitch sound has a low (high) frequency. **Amplitude**: The maximum amount of vibration, measured from the middle position of the wave, in metres. **Wavelength**: Distance between two corresponding points on a wave, in metres. **Frequency**: The number of waves produced in one second, in hertz. **Vacuum**: A space with no particles of matter in it. **Oscilloscope**: Device able to view patterns of sound waves that have been turned into electrical signals. **Absorption**: When energy is transferred from sound to a material. **Auditory range**: The lowest and highest frequencies that a type of animal can hear. **Echo**: Reflection of sound waves from a surface back to the listener.	Explain observations where sound is reflected, transmitted or absorbed by different media. Explain observations of how sound travels using the idea of a longitudinal wave. Describe the amplitude and frequency of a wave from a diagram or oscilloscope picture. Use drawings of waves to describe how sound waves change with volume or pitch.

Extend
Suggest the effects of particular ear problems on a person's hearing. Evaluate the data behind a claim for a sound creation or blocking device, using the properties of sound waves. Use diagrams to compare the waveforms a musical instrument makes when playing different pitches or volumes.

3.4.2 Light

Use ray diagrams to model how light passes through lenses and transparent materials

Know	Apply
When a light ray meets a different medium, some of it is absorbed and some reflected. For a mirror, the angle of incidence equals the angle of reflection. The ray model can describe the formation of an image in a mirror and how objects appear different colours. When light enters a denser medium it bends towards the normal; when it enters a less dense medium it bends away from the normal. Refraction through lenses and prisms can be described using a ray diagram as a model. **Skill** Construct ray diagrams to show how light reflects off mirrors, forms images and refracts. **Facts** Light travels at 300 million metres per second in a vacuum. Different colours of light have different frequencies. **Keywords** **Incident ray**: The incoming ray. **Reflected ray**: The outgoing ray. **Normal line**: From which angles are measured, at right angles to the surface. **Angle of reflection**: Between the normal and reflected ray. **Angle of incidence**: Between the normal and incident ray. **Refraction**: Change in the direction of light going from one material into another. **Absorption**: When energy is transferred from light to a material. **Scattering**: When light bounces off an object in all directions. **Transparent**: A material that allows all light to pass through it. **Translucent**: A material that allows some light to pass through it. **Opaque**: A material that allows no light to pass through it. **Convex lens**: A lens that is thicker in the middle which bends light rays towards each other. **Concave lens**: A lens that is thinner in the middle which spreads out light rays. **Retina**: Layer at the back of the eye with light detecting cells and where an image is formed.	Use ray diagrams of eclipses to describe what is seen by observers in different places. Explain observations where coloured lights are mixed or objects are viewed in different lights. Use ray diagrams to describe how light passes through lenses and transparent materials. Describe how lenses may be used to correct vision.

Extend

Use a ray diagram to predict how an image will change in different situations.

Predict whether light will reflect, refract or scatter when it hits the surface of a given material.

Use ray diagrams to explain how a device with multiple mirrors works.

3.4.3 Wave effects

Relate the impact of different types of waves on living cells to their frequency and the energy carried by the wave

Know	Apply
When a wave travels through a substance, particles move to and fro. Energy is transferred in the direction of movement of the wave. Waves of higher amplitude or higher frequency transfer more energy. **Keywords** **Ultrasound**: Sound waves with frequencies higher than the human auditory range. **Ultraviolet (UV)**: Waves with frequencies higher than light, which human eyes cannot detect. **Microphone**: Turns the pressure wave of sound hitting it into an electrical signal. **Loudspeaker**: Turns an electrical signal into a pressure wave of sound. **Pressure wave**: An example is sound, which has repeating patterns of high-pressure and low-pressure regions.	Explain differences in the damage done to living cells by light and other waves, in terms of their frequency. Explain how audio equipment converts sound into a changing pattern of electric current.

Extend
Suggest reasons why sound waves can agitate a liquid for cleaning objects, or massage muscles for physiotherapy. Evaluate electricity production by wave energy using data for different locations and weather conditions.

3.4.4 Wave properties

Use the wave model to explain observations of the reflection, absorption and transmission of waves

Know	Apply
A physical model of a transverse wave demonstrates it moves from place to place, while the material it travels through does not, and describes the properties of speed, wavelength and reflection. **Keywords** **Waves**: Vibrations that transport energy from place to place without transporting matter. **Transverse wave**: Where the direction of vibration is perpendicular to that of the wave. **Transmission**: Where waves travel through a medium rather than be absorbed or reflected.	Describe the properties of different longitudinal and transverse waves. Use the wave model to explain observations of the reflection, absorption and transmission of a wave.

Extend
Compare and contrast the properties of sound and light waves.
Suggest what happens when two waves combine.

3.5 Matter

3.5.1 Particle model

Relate the features of the particle model to the properties of materials in different states

Know	Apply
Properties of solids, liquids and gases can be described in terms of particles in motion but with differences in the arrangement and movement of these same particles: closely spaced and vibrating (solid), in random motion but in contact (liquid), or in random motion and widely spaced (gas). Observations where substances change temperature or state can be described in terms of particles gaining or losing energy. **Fact** A substance is a solid below its melting point, a liquid above it, and a gas above its boiling point. **Keywords** **Particle**: A very tiny object such as an atom or molecule, too small to be seen with a microscope. **Particle model**: A way to think about how substances behave in terms of small, moving particles. **Diffusion**: The process by which particles in liquids or gases spread out through random movement from a region where there are many particles to one where there are fewer. **Gas pressure**: Caused by collisions of particles with the walls of a container. **Density**: How much matter there is in a particular volume, or how close the particles are. **Evaporate**: Change from liquid to gas at the surface of a liquid, at any temperature. **Boil**: Change from liquid to a gas of all the liquid when the temperature reaches boiling point. **Condense**: Change of state from gas to liquid when the temperature drops to the boiling point. **Melt**: Change from solid to liquid when the temperature rises to the melting point. **Freeze**: Change from liquid to a solid when the temperature drops to the melting point. **Sublime**: Change from a solid directly into a gas.	Explain unfamiliar observations about gas pressure in terms of particles. Explain the properties of solids, liquids and gases based on the arrangement and movement of their particles. Explain changes in states in terms of changes to the energy of particles. Draw before and after diagrams of particles to explain observations about changes of state, gas pressure and diffusion.

Extend
Argue for how to classify substances which behave unusually as solids, liquids or gases. Evaluate observations that provide evidence for the existence of particles. Make predictions about what will happen during unfamiliar physical processes, in terms of particles and their energy.

3.5.2 Separating mixtures

Devise ways to separate mixtures, based on their properties

Know	Apply
A pure substance consists of only one type of element or compound and has a fixed melting and boiling point. Mixtures may be separated due to differences in their physical properties. The method chosen to separate a mixture depends on which physical properties of the individual substances are different. **Skill** Use techniques to separate mixtures. **Fact** Air, fruit juice, sea water and milk are mixtures. Liquids have different boiling points. **Keywords** **Solvent**: A substance, normally a liquid, that dissolves another substance. **Solute**: A substance that can dissolve in a liquid. **Dissolve**: When a solute mixes completely with a solvent. **Solution**: Mixture formed when a solvent dissolves a solute. **Soluble** **(insoluble)**: Property of a substance that will (will not) dissolve in a liquid. **Solubility**: Maximum mass of solute that dissolves in a certain volume of solvent. **Pure substance**: Single type of material with nothing mixed in. **Mixture**: Two or more pure substances mixed together, whose properties are different to the individual substances. **Filtration**: Separating substances using a filter to produce a filtrate (solution) and residue. **Distillation**: Separating substances by boiling and condensing liquids. **Evaporation**: A way to separate a solid dissolved in a liquid by the liquid turning into a gas. **Chromatography**: Used to separate different coloured substances.	Explain how substances dissolve using the particle model. Use the solubility curve of a solute to explain observations about solutions. Use evidence from chromatography to identify unknown substances in mixtures. Choose the most suitable technique to separate out a mixture of substances.

Extend
Analyse and interpret solubility curves. Suggest a combination of methods to separate a complex mixture and justify the choices. Evaluate the evidence for identifying a unknown substance using separating techniques.

3.5.3 Periodic table

Sort elements using chemical data and relate this to their position in the periodic table

Know	Apply
The elements in a group all react in a similar way and sometimes show a pattern in reactivity. As you go down a group and across a period the elements show patterns in physical properties. **Facts** Metals are generally found on the left side of the table, non-metals on the right. Group 1 contains reactive metals called alkali metals. Group 7 contains non-metals called halogens. Group 0 contains unreactive gases called noble gases. **Keywords** **Periodic table**: Shows all the elements arranged in rows and columns. **Physical properties**: Features of a substance that can be observed without changing the substance itself. **Chemical properties**: Features of the way a substance reacts with other substances. **Groups**: Columns of the periodic table. **Periods**: Rows of the periodic table.	Use data to describe a trend in physical properties. Describe the reaction of an unfamiliar Group 1 or 7 element. Use data showing a pattern in physical properties to estimate a missing value for an element. Use observations of a pattern in chemical reactions to predict the behaviour of an element in a group.

Extend
Predict the position of an element in the periodic table based on information about its physical and chemical properties. Choose elements for different uses from their position in the periodic table. Use data about the properties of elements to find similarities, patterns and anomalies.

3.5.4 Elements

Compare the properties of elements with the properties of a compound formed from them

Know	Apply
Most substances are not pure elements, but compounds or mixtures containing atoms of different elements. They have different properties to the elements they contain. **Skills** Use particle diagrams to classify a substance as an element, mixture or compound and as molecules or atoms. Name simple compounds using rules: change non-metal to –ide; mono, di, tri prefixes; and symbols of hydroxide, nitrate, sulfate and carbonate. **Fact** The symbols of hydrogen, oxygen, nitrogen, carbon, hydrogen, iron, zinc, copper, sulfur, aluminium, iodine, bromine, chlorine, sodium, potassium and magnesium. **Keywords** **Elements**: What all substances are made up of, and which contain only one type of atom. **Atom**: The smallest particle of an element that can exist. **Molecules**: Two to thousands of atoms joined together. Most non-metals exist either as small or giant molecules. **Compound**: Pure substances made up of two or more elements strongly joined together. **Chemical formula**: Shows the elements present in a compound and their relative proportions. **Polymer**: A molecule made of thousands of smaller molecules in a repeating pattern. Plastics are man-made polymers, starch is a natural polymer.	Name compounds using their chemical formulae. Given chemical formulae, name the elements present and their relative proportions. Represent atoms, molecules and elements, mixtures and compounds using particle diagrams. Use observations from chemical reactions to decide if an unknown substance is an element or a compound.

Extend

Use particle diagrams to predict physical properties of elements and compounds.

Deduce a pattern in the formula of similar compounds and use it to suggest formulae for unfamiliar ones.

Compare and contrast the properties of elements and compounds and give a reason for their differences.

Describe and explain the properties of ceramics and composites.

3.6 Reactions

3.6.1 Metals and non-metals

Use experimental results to suggest an order of reactivity of various metals

Know	Apply
Metals and non-metals react with oxygen to form oxides which are either bases or acids. Metals can be arranged as a reactivity series in order of how readily they react with other substances. Some metals react with acids to produce salts and hydrogen. **Facts** Iron, nickel and cobalt are magnetic elements. Mercury is a metal that is liquid at room temperature. Bromine is a non-metal that is liquid at room temperature. **Keywords** **Metals**: Shiny, good conductors of electricity and heat, malleable and ductile, and usually solid at room temperature. **Non-metals**: Dull, poor conductors of electricity and heat, brittle and usually solid or gaseous at room temperature. **Displacement**: Reaction where a more reactive metal takes the place of a less reactive metal in a compound. **Oxidation**: Reaction in which a substance combines with oxygen. **Reactivity**: The tendency of a substance to undergo a chemical reaction.	Describe an oxidation, displacement, or metal-acid reaction with a word equation. Use particle diagrams to represent oxidation, displacement and metal-acid reactions. Identify an unknown element from its physical and chemical properties. Place an unfamiliar metal into the reactivity series based on information about its reactions.

Extend
Deduce the physical or chemical changes a metal has undergone from its appearance. Justify the use of specific metals and non-metals for different applications, using data provided. Deduce a rule from data about which reactions will occur or not, based on the reactivity series.

3.6.2 Acids and alkalis

Devise an enquiry to compare how well indigestion remedies work

Know	Apply
The pH of a solution depends on the strength of the acid: strong acids have lower pH values than weak acids. Mixing an acid and alkali produces a chemical reaction, neutralisation, forming a chemical called a salt and water. **Facts** Acids have a pH below 7, neutral solutions have a pH of 7, alkalis have a pH above 7. Acids and alkalis can be corrosive or irritant and require safe handling. Hydrochloric, sulfuric and nitric acid are strong acids. Acetic and citric acid are weak acids. **Keywords** **pH**: Scale of acidity and alkalinity from 0 to 14. **Indicators**: Substances used to identify whether unknown solutions are acidic or alkaline. **Base**: A substance that neutralises an acid – those that dissolve in water are called alkalis. **Concentration**: A measure of the number of particles in a given volume.	Identify the best indicator to distinguish between solutions of different pH, using data provided. Use data and observations to determine the pH of a solution and explain what this shows. Explain how neutralisation reactions are used in a range of situations. Describe a method for how to make a neutral solution from an acid and alkali.

Extend

Given the names of an acid and an alkali, work out the name of the salt produced when they react.

Deduce the hazards of different alkalis and acids using data about their concentration and pH.

Estimate the pH of an acid based on information from reactions.

3.6.3 Chemical energy

Investigate a phenomenon that relies on an exothermic or endothermic reaction

Know	Apply
During a chemical reaction bonds are broken (requiring energy) and new bonds formed (releasing energy). If the energy released is greater than the energy required, the reaction is exothermic. If the reverse, it is endothermic. **Keywords** **Catalysts**: Substances that speed up chemical reactions but are unchanged at the end. **Exothermic reaction**: One in which energy is given out, usually as heat or light. **Endothermic reaction**: One in which energy is taken in, usually as heat. **Chemical bond**: Force that holds atoms together in molecules.	Use experimental observations to distinguish exothermic and endothermic reactions. Use a diagram of relative energy levels of particles to explain energy changes observed during a change of state.

Extend
Predict whether a chemical reaction will be exothermic or endothermic given data on bond strengths.
Use energy data to select a reaction for a chemical hand warmer or cool pack.

3.6.4 Types of reaction

Investigate changes in mass for chemical and physical processes

Know	Apply
Combustion is a reaction with oxygen in which energy is transferred to the surroundings as heat and light. Thermal decomposition is a reaction where a single reactant is broken down into simpler products by heating. Chemical changes can be described by a model where atoms and molecules in reactants rearrange to make the products and the total number of atoms is conserved. **Skill** Write word equations from information about chemical reactions. **Keywords** **Fuel**: Stores energy in a chemical store which it can release as heat. **Chemical reaction**: A change in which a new substance is formed. **Physical change**: One that changes the physical properties of a substance, but no new substance is formed. **Reactants**: Substances that react together, shown before the arrow in an equation. **Products**: Substances formed in a chemical reaction, shown after the reaction arrow in an equation. **Conserved**: When the quantity of something does not change after a process takes place.	Explain why a reaction is an example of combustion or thermal decomposition. Predict the products of the combustion or thermal decomposition of a given reactant and show the reaction as a word equation. Explain observations about mass in a chemical or physical change. Use particle diagrams to show what happens in a reaction.

Extend

Compare the pros and cons of fuels in terms of their products of combustion.

Use known masses of reactants or products to calculate unknown masses of the remaining reactant or product.

Devise a general rule for how a set of compounds reacts with oxygen or thermally decomposes.

Balance a symbol equation.

Use mass of reactant in equation to determine mass of product eg magnesium and oxygen.

3.7 Earth

3.7.1 Earth structure

Model the processes that are responsible for rock formation and link these to the rock features

Know	Apply
Sedimentary, igneous and metamorphic rocks can be inter converted over millions of years through weathering and erosion, heat and pressure, and melting and cooling. **Fact** The three rock layers inside Earth are the crust, the mantle and the core. **Keywords** **Rock cycle**: Sequence of processes where rocks change from one type to another. **Weathering**: The wearing down of rock by physical, chemical or biological processes. **Erosion**: Movement of rock by water, ice or wind (transportation). **Minerals**: Chemicals that rocks are made from. **Sedimentary rocks**: Formed from layers of sediment, and which can contain fossils. Examples are limestone, chalk and sandstone. **Igneous rocks**: Formed from cooled magma, with minerals arranged in crystals. Examples are granite, basalt and obsidian. **Metamorphic rocks**: Formed from existing rocks exposed to heat and pressure over a long time. Examples are marble, slate and schist. **Strata**: Layers of sedimentary rock.	Explain why a rock has a particular property based on how it was formed. Identify the causes of weathering and erosion and describe how they occur. Construct a labelled diagram to identify the processes of the rock cycle.

Extend
Identify circumstances that indicate fast processes of change on Earth and those that indicate slower processes. Predict planetary conditions from descriptions of rocks on other planets. Describe similarities and differences between the rock cycle and everyday physical and chemical processes. Suggest how ceramics might be similar to some types of rock.

3.7.2 Universe

Relate observations of changing day length to an appropriate model of the solar system

Know	Apply
The solar system can be modelled as planets rotating on tilted axes while orbiting the Sun, moons orbiting planets and sunlight spreading out and being reflected. This explains day and year length, seasons and the visibility of objects from Earth. Our solar system is a tiny part of a galaxy, one of many billions in the Universe. Light takes minutes to reach Earth from the Sun, four years from our nearest star and billions of years from other galaxies. **Keywords** **Galaxy**: Collection of stars held together by gravity. Our galaxy is called the Milky Way. **Light year**: The distance light travels in a year (over 9 million, million kilometres). **Stars**: Bodies which give out light, and which may have a solar system of planets. **Orbit**: Path taken by a satellite, planet or star moving around a larger body. Earth completes one orbit of the Sun every year. **Exoplanet**: Planet that orbits a star outside our solar system.	Describe the appearance of planets or moons from diagrams showing their position in relation to the Earth and Sun. Explain why places on the Earth experience different daylight hours and amounts of sunlight during the year. Describe how space exploration and observations of stars are affected by the scale of the universe. Explain the choice of particular units for measuring distance.

Extend
Predict patterns in day length, the Sun's intensity or an object's shadow at different latitudes. Make deductions from observation data of planets, stars and galaxies. Compare explanations from different periods in history about the motion of objects and structure of the Universe.

3.7.3 Climate

Investigate the contribution that natural and human chemical processes make to our carbon dioxide emissions

Know	Apply
Carbon is recycled through natural processes in the atmosphere, ecosystems, oceans and the Earth's crust (such as photosynthesis and respiration) as well as human activities (burning fuels). Greenhouse gases reduce the amount of energy lost from the Earth through radiation and therefore the temperature has been rising as the concentration of those gases has risen. Scientists have evidence that global warming caused by human activity is causing changes in climate. **Facts** Methane and carbon dioxide are greenhouse gases. Earth's atmosphere contains around 78% nitrogen, 21% oxygen, <1% carbon dioxide, plus small amounts of other gases. **Keywords** **Global warming**: The gradual increase in surface temperature of the Earth. **Fossil fuels**: Remains of dead organisms that are burned as fuels, releasing carbon dioxide. **Carbon sink**: Areas of vegetation, the ocean or the soil, which absorb and store carbon. **Greenhouse effect**: When energy from the sun is transferred to the thermal energy store of gases in Earth's atmosphere.	Use a diagram to show how carbon is recycled in the environment and through living things. Describe how human activities affect the carbon cycle. Describe how global warming can impact on climate and local weather patterns.

Extend
Evaluate the implications of a proposal to reduce carbon emissions. Evaluate claims that human activity is causing global warming or climate change. Compare the relative effects of human-produced and natural global warming.

3.7.4 Earth resources

Predict the method used for extracting metal based on its position in the reactivity series

Know	Apply
There is only a certain quantity of any resource on Earth, so the faster it is extracted, the sooner it will run out. Recycling reduces the need to extract resources. Most metals are found combined with other elements, as a compound, in ores. The more reactive a metal, the more difficult it is to separate it from its compound. Carbon displaces less reactive metals, while electrolysis is needed for more reactive metals. **Keywords** **Natural resources**: Materials from the Earth which act as raw materials for making a variety of products. **Mineral**: Naturally occurring metal or metal compound. **Ore**: Naturally occurring rock containing sufficient minerals for extraction. **Extraction**: Separation of a metal from a metal compound. **Recycling**: Processing a material so that it can be used again. **Electrolysis**: Using electricity to split up a compound into its elements.	Explain why recycling of some materials is particularly important. Describe how Earth's resources are turned into useful materials or recycled. Justify the choice of extraction method for a metal, given data about reactivity. Suggest factors to take into account when deciding whether extraction of a metal is practical.

Extend
Suggest ways in which changes in behaviour and the use of alternative materials may limit the consumption of natural resources. Suggest ways in which waste products from industrial processes could be reduced. Use data to evaluate proposals for recycling materials.

3.8 Organisms

3.8.1 Movement

Explore how the skeletal system and muscular system in a chicken wing work together to cause movement

Know	Apply
The parts of the human skeleton work as a system for support, protection, movement and the production of new blood cells. Antagonistic pairs of muscles create movement when one contracts and the other relaxes. **Keywords** **Joints**: Places where bones meet. **Bone marrow**: Tissue found inside some bones where new blood cells are made. **Ligaments**: Connect bones in joints. **Tendons**: Connect muscles to bones. **Cartilage**: Smooth tissue found at the end of bones, which reduces friction between them. **Antagonistic muscle pair**: Muscles working in unison to create movement.	Explain how a physical property of part of the skeleton relates to its function. Explain why some organs contain muscle tissue. Explain how antagonistic muscles produce movement around a joint. Use a diagram to predict the result of a muscle contraction or relaxation.

Extend
Predict the consequences of damage to a joint, bone or muscle. Suggest factors that affect the force exerted by different muscles. Consider the benefits and risks of a technology for improving human movement.

3.8.2 Cells

Identify the principal features of a cheek cell and describe their functions

Know	Apply
Multicellular organisms are composed of cells which are organised into tissues, organs and systems to carry out life processes. There are many types of cell. Each has a different structure or feature so it can do a specific job. **Skill** Use a light microscope to observe and draw cells. **Facts** Both plant and animal cells have a cell membrane, nucleus, cytoplasm and mitochondria. Plant cells also have a cell wall, chloroplasts and usually a permanent vacuole. **Keywords** **Cell**: The unit of a living organism, contains parts to carry out life processes. **Uni-cellular**: Living things made up of one cell. **Multi-cellular**: Living things made up of many types of cell. **Tissue**: Group of cells of one type. **Organ**: Group of different tissues working together to carry out a job. **Diffusion**: One way for substances to move into and out of cells. **Structural adaptations**: Special features to help a cell carry out its functions. **Cell membrane**: Surrounds the cell and controls movement of substances in and out. **Nucleus**: Contains genetic material (DNA) which controls the cell's activities. **Vacuole**: Area in a cell that contains liquid, and can be used by plants to keep the cell rigid and store substances. **Mitochondria**: Part of the cell where energy is released from food molecules. **Cell wall**: Strengthens the cell. In plant cells it is made of cellulose.	Explain why multi-cellular organisms need organ systems to keep their cells alive. Suggest what kind of tissue or organism a cell is part of, based on its features. Explain how to use a microscope to identify and compare different types of cells. Explain how uni-cellular organisms are adapted to carry out functions that in multi-cellular organisms are done by different types of cell.

Know	Apply
Chloroplast: Absorbs light energy so the plant can make food. **Cytoplasm**: Jelly-like substance where most chemical processes happen. **Immune system**: Protects the body against infections. **Reproductive system**: Produces sperm and eggs, and is where the foetus develops. **Digestive system**: Breaks down and then absorbs food molecules. **Circulatory system**: Transports substances around the body. **Respiratory system**: Replaces oxygen and removes carbon dioxide from blood. **Muscular skeletal system**: Muscles and bones working together to cause movement and support the body.	

Extend
Make deductions about how medical treatments work based on cells, tissues, organs and systems. Suggest how damage to, or failure of, an organ would affect other body systems. Deduce general patterns about how the structure of different cells is related to their function. Find out how recreational drugs might affect different body systems.

3.8.3 Breathing

Investigate a claim linking height to lung volume

Know	Apply
In gas exchange, oxygen and carbon dioxide move between alveoli and the blood. Oxygen is transported to cells for aerobic respiration and carbon dioxide, a waste product of respiration, is removed from the body. Breathing occurs through the action of muscles in the ribcage and diaphragm. The amount of oxygen required by body cells determines the rate of breathing. **Keywords** **Breathing**: The movement of air in and out of the lungs. **Trachea (windpipe)**: Carries air from the mouth and nose to the lungs. **Bronchi**: Two tubes which carry air to the lungs. **Bronchioles**: Small tubes in the lung. **Alveoli**: Small air sacs found at the end of each bronchiole. **Ribs**: Bones which surround the lungs to form the ribcage. **Diaphragm**: A sheet of muscle found underneath the lungs. **Lung volume**: Measure of the amount of air breathed in or out.	Explain how exercise, smoking and asthma affect the gas exchange system. Explain how the parts of the gas exchange system are adapted to their function. Explain observations about changes to breathing rate and volume. Explain how changes in volume and pressure inside the chest move gases in and out of the lungs.

Extend

Evaluate a possible treatment for a lung disease.

Predict how a change in the gas exchange system could affect other processes in the body.

Evaluate a model for showing the mechanism of breathing.

3.8.4 Digestion

Evaluate how well a model represents key features of the digestive system

Know	Apply
The body needs a balanced diet with carbohydrates, lipids, proteins, vitamins, minerals, dietary fibre and water, for its cells' energy, growth and maintenance. Organs of the digestive system are adapted to break large food molecules into small ones which can travel in the blood to cells and are used for life processes. **Facts** Iron is a mineral important for red blood cells. Calcium is a mineral needed for strong teeth and bones. Vitamins and minerals are needed in small amounts to keep the body healthy. **Keywords** **Enzymes**: Substances that speed up the chemical reactions of digestion. **Dietary fibre**: Parts of plants that cannot be digested, which helps the body eliminate waste. **Carbohydrates**: The body's main source of energy. There are two types: simple (sugars) and complex (starch). **Lipids (fats and oils)**: A source of energy. Found in butter, milk, eggs, nuts. **Protein**: Nutrient your body uses to build new tissue for growth and repair. Sources are meat, fish, eggs, dairy products, beans, nuts and seeds. **Stomach**: A sac where food is mixed with acidic juices to start the digestion of protein and kill microorganisms. **Small intestine**: Upper part of the intestine where digestion is completed and nutrients are absorbed by the blood. **Large intestine**: Lower part of the intestine from which water is absorbed and where faeces are formed. **Gut bacteria**: Microorganisms that naturally live in the intestine and help food break down.	Describe possible health effects of unbalanced diets from data provided. Calculate food requirements for a healthy diet, using information provided. Describe how organs and tissues involved in digestion are adapted for their role. Describe the events that take place in order to turn a meal into simple food molecules inside a cell.

Extend
Design a diet for a person with specific dietary needs. Critique claims for a food product or diet by analysing nutritional information. Make deductions from medical symptoms showing problems with the digestive system.

3.9 Ecosystems

3.9.1 Interdependence

Use a model to investigate the impact of changes in a population of one organism on others in the ecosystem

Know	Apply
Organisms in a food web (decomposers, producers and consumers) depend on each other for nutrients. So, a change in one population leads to changes in others. The population of a species is affected by the number of its predators and prey, disease, pollution and competition between individuals for limited resources such as water and nutrients. **Fact** Insects are needed to pollinate food crops. **Keywords** **Food web**: Shows how food chains in an ecosystem are linked. **Food chain**: Part of a food web, starting with a producer, ending with a top predator. **Ecosystem**: The living things in a given area and their non-living environment. **Environment**: The surrounding air, water and soil where an organism lives. **Population**: Group of the same species living in an area. **Producer**: Green plant or algae that makes its own food using sunlight. **Consumer**: Animal that eats other animals or plants. **Decomposer**: Organism that breaks down dead plant and animal material so nutrients can be recycled back to the soil or water.	Describe how a species' population changes as its predator or prey population changes. Explain effects of environmental changes and toxic materials on a species' population. Combine food chains to form a food web. Explain issues with human food supplies in terms of insect pollinators.

Extend
Suggest what might happen when an unfamiliar species is introduced into a food web. Develop an argument about how toxic substances can accumulate in human food. Make a deduction based on data about what caused a change in the population of a species.

3.9.2 Plant reproduction

Use models to evaluate the features of various types of seed dispersal

Know	Apply
Plants have adaptations to disperse seeds using wind, water or animals. Plants reproduce sexually to produce seeds, which are formed following fertilisation in the ovary. **Facts** Flowers contain the plant's reproductive organs. Pollen can be carried by the wind, pollinating insects or other animals. **Keywords** **Pollen**: Contains the plant male sex cells found on the stamens. **Ovules**: Female sex cells in plants found in the ovary. **Pollination**: Transfer of pollen from the male part of the flower to the female part of the flower on the same or another plant. **Fertilisation**: Joining of a nucleus from a male and female sex cell. **Seed**: Structure that contains the embryo of a new plant. **Fruit**: Structure that the ovary becomes after fertilisation, which contains seeds. **Carpel**: The female part of the flower, made up of the stigma where the pollen lands, style and ovary.	Describe the main steps that take place when a plant reproduces successfully. Identify parts of the flower and link their structure to their function. Suggest how a plant carried out seed dispersal based on the features of its fruit or seed. Explain why seed dispersal is important to survival of the parent plant and its offspring.

Extend
Describe similarities and differences between the structures of wind pollinated and insect pollinated plants. Suggest how plant breeders use knowledge of pollination to carry out selective breeding. Develop an argument why a particular plant structure increases the likelihood of successful production of offspring.

3.9.3 Respiration

Use data from investigating fermentation with yeast to explore respiration

Know	Apply
Respiration is a series of chemical reactions, in cells, that breaks down glucose to provide energy and form new molecules. Most living things use aerobic respiration but switch to anaerobic respiration, which provides less energy, when oxygen is unavailable. **Fact** Yeast fermentation is used in brewing and bread-making. **Keywords** **Aerobic respiration**: Breaking down glucose with oxygen to release energy and producing carbon dioxide and water. **Anaerobic respiration (fermentation)**: Releasing energy from the breakdown of glucose without oxygen, producing lactic acid (in animals) and ethanol and carbon dioxide (in plants and microorganisms).	Use word equations to describe aerobic and anaerobic respiration. Explain how specific activities involve aerobic or anaerobic respiration.

Extend

Suggest how organisms living in different conditions use respiration to get their energy.

Describe similarities and differences between aerobic and anaerobic respiration.

3.9.4 Photosynthesis

Use lab tests on variegated leaves to show that chlorophyll is essential for photosynthesis

Know	Apply
Plants and algae do not eat, but use energy from light, together with carbon dioxide and water to make glucose (food) through photosynthesis. They either use the glucose as an energy source, to build new tissue, or store it for later use. Plants have specially-adapted organs that allow them to obtain resources needed for photosynthesis. **Fact** Iodine is used to test for the presence of starch. **Keywords** **Fertilisers**: Chemicals containing minerals that plants need to build new tissues. **Photosynthesis**: A process where plants and algae turn carbon dioxide and water into glucose and release oxygen. **Chlorophyll**: Green pigment in plants and algae which absorbs light energy. **Stomata**: Pores in the bottom of a leaf which open and close to let gases in and out.	Describe ways in which plants obtain resources for photosynthesis. Explain why other organisms are dependent on photosynthesis. Sketch a line graph to show how the rate of photosynthesis is affected by changing conditions. Use a word equation to describe photosynthesis in plants and algae.

Extend
Suggest how particular conditions could affect plant growth. Suggest reasons for particular adaptations of leaves, roots and stems. Compare the movement of carbon dioxide and oxygen through stomata at different times of day.

3.10 Genes

3.10.1 Variation

Graph data relating to variation and explain how it may lead to the survival of a species

Know	Apply
There is variation between individuals of the same species. Some variation is inherited, some is caused by the environment and some is a combination. Variation between individuals is important for the survival of a species, helping it to avoid extinction in an always changing environment. **Keywords** **Species**: A group of living things that have more in common with each other than with other groups. **Variation**: The differences within and between species. **Continuous variation**: Where differences between living things can have any numerical value. **Discontinuous variation**: Where differences between living things can only be grouped into categories.	Explain whether characteristics are inherited, environmental or both. Plot bar charts or line graphs to show discontinuous or continuous variation data. Explain how variation helps a particular species in a changing environment. Explain how characteristics of a species are adapted to particular environmental conditions.

Extend

Predict implications of a change in the environment on a population.

Use the ideas of variation to explain why one species may adapt better than another to environmental change.

Critique a claim that a particular characteristic is inherited or environmental.

3.10.2 Human reproduction

Relate advice to pregnant women to ideas about transfer of substances to the embryo

Know	Apply
The menstrual cycle prepares the female for pregnancy and stops if the egg is fertilised by a sperm. The developing foetus relies on the mother to provide it with oxygen and nutrients, to remove waste and protect it against harmful substances. **Facts** The menstrual cycle lasts approximately 28 days. If an egg is fertilised it settles into the uterus lining. **Keywords** **Gamete**: The male gamete (sex cell) in animals is a sperm, the female an egg. **Fertilisation**: Joining of a nucleus from a male and female sex cell. **Ovary**: Organ which contains eggs. **Testicle**: Organ where sperm are produced. **Oviduct**, or fallopian tube: Carries an egg from the ovary to the uterus and is where fertilisation occurs. **Uterus, or womb**: Where a baby develops in a pregnant woman. **Ovulation**: Release of an egg cell during the menstrual cycle, which may be met by a sperm. **Menstruation**: Loss of the lining of the uterus during the menstrual cycle. **Reproductive system**: All the male and female organs involved in reproduction. **Penis**: Organ which carries sperm out of the male's body. **Vagina**: Where the penis enters the female's body and sperm is received. **Foetus**: The developing baby during pregnancy. **Gestation**: Process where the baby develops during pregnancy. **Placenta**: Organ that provides the foetus with oxygen and nutrients and removes waste substances. **Amniotic fluid**: Liquid that surrounds and protects the foetus. **Umbilical cord**: Connects the foetus to the placenta.	Explain whether substances are passed from the mother to the foetus or not. Use a diagram to show stages in development of a foetus from the production of sex cells to birth. Describe causes of low fertility in male and female reproductive systems. Identify key events on a diagram of the menstrual cycle.

Extend
Explain why pregnancy is more or less likely at certain stages of the menstrual cycle. Make deductions about how contraception and fertility treatments work. Predict the effect of cigarettes, alcohol or drugs on the developing foetus.

3.10.3 Evolution

Review the evidence for theories about how a particular species went extinct

Know	Apply
Natural selection is a theory that explains how species evolve and why extinction occurs. Biodiversity is vital to maintaining populations. Within a species variation helps against environment changes, avoiding extinction. Within an ecosystem, having many different species ensures resources are available for other populations, like humans. **Keywords** **Population**: Group of organisms of the same kind living in the same place. **Natural selection**: Process by which species change over time in response to environmental changes and competition for resources. **Extinct**: When no more individuals of a species remain. **Biodiversity**: The variety of living things. It is measured as the differences between individuals of the same species, or the number of different species in an ecosystem. **Competition**: When two or more living things struggle against each other to get the same resource. **Evolution**: Theory that the animal and plant species living today descended from species that existed in the past.	Use evidence to explain why a species has become extinct or adapted to changing conditions. Evaluate whether evidence for a species changing over time supports natural selection. Explain how a lack of biodiversity can affect an ecosystem. Describe how preserving biodiversity can provide useful products and services for humans.

Extend
Predict and explain the changes in a population over time due to natural selection. Suggest an explanation, based on data, for how a particular evolutionary change occurred. Evaluate ways of preserving plant or animal material for future generations.

3.10.4 Inheritance

Model the inheritance of a specific trait and explore the variation in the offspring produced

Know	Apply
Inherited characteristics are the result of genetic information, in the form of sections of DNA called genes, being transferred from parents to offspring during reproduction. Chromosomes are long pieces of DNA which contain many genes. Gametes, carrying half the total number of chromosomes of each parent, combine during fertilisation. **Facts** The DNA of every individual is different, except for identical twins. There is more than one version of each gene eg different blood groups. **Keywords** **Inherited characteristics**: Features that are passed from parents to their offspring. **DNA**: A molecule found in the nucleus of cells that contains genetic information. **Chromosomes**: Thread-like structures containing tightly coiled DNA. **Gene**: A section of DNA that determines an inherited characteristic.	Use a diagram to show the relationship between DNA, chromosomes and genes. Use a diagram to show how genes are inherited. Explain how a change in the DNA (mutation) may affect an organism and its future offspring. Explain why offspring from the same parents look similar but are not usually identical.

Extend

Suggest arguments for and against genetic modification.

Suggest benefits from scientists knowing all the genes in the human genome.

Determine how the number of chromosomes changes during cell division, production of sex cells and fertilisation.

Find out why scientists Watson, Crick and Franklin were so important.

4 Working scientifically activity grid

Forces		Concept			
		Speed	Gravity	Contact forces	Pressure
Enquiry activity		Investigate variables on the speed of a toy car rolling down a slope	Explain the way in which an astronaut's weight varies on a journey to the moon	Investigate factors that affect the size of frictional or drag forces	Investigate how pressure from your foot onto the ground varies with different footwear
Analyse	Analyse patterns				
	Discuss limitations	●		●	
	Draw conclusions				
	Present data	●	●	●	
Communicate	Communicate ideas				
	Construct explanations	●	●	●	●
	Critique claims				
	Justify opinions				
Enquire	Collect data				
	Devise questions	●		●	●
	Plan variables				
	Test hypothesis	●		●	●
Solve	Estimate risks				
	Examine consequences				
	Review theories				
	Interrogate sources				

Electromagnets		Concept			
		Voltage and resistance	Current	Electromagnets	Magnetism
Enquiry activity		Compare the voltage drop across resistors connected in series in a circuit	Compare and explain current flow in different parts of a parallel circuit	Investigate ways of varying the strength of an electromagnet	Explore the magnetic field pattern around different types or combinations of magnets
Analyse	Analyse patterns			●	
	Discuss limitations				
	Draw conclusions	●	●	●	
	Present data	●	●	●	●
Communicate	Communicate ideas	●	●	●	●
	Construct explanations	●	●	●	●
	Critique claims				
	Justify opinions				
Enquire	Collect data			●	
	Devise questions	●	●	●	
	Plan variables	●	●	●	
	Test hypothesis	●	●	●	
Solve	Estimate risks			●	
	Examine consequences				
	Review theories				
	Interrogate sources				

Energy		Concept			
		Energy costs	Energy transfer	Work	Heating and cooling
Enquiry activity		Compare the running costs of fluorescent and filament light bulbs	Explain the energy transfers in a hand-crank torch	Explain how an electric motor raising a weight is doing work	Investigate how to prevent heat loss by conduction, convection and radiation
Analyse	Analyse patterns	●			●
	Discuss limitations	●			●
	Draw conclusions	●	●		●
	Present data				●
Communicate	Communicate ideas	●	●	●	●
	Construct explanations	●	●	●	●
	Critique claims	●			
	Justify opinions	●			
Enquire	Collect data				●
	Devise questions				●
	Plan variables				●
	Test hypothesis			●	
Solve	Estimate risks				
	Examine consequences	●			
	Review theories				
	Interrogate sources	●			

Waves		Concept			
		Sound	Light	Wave effects	Wave properties
Enquiry activity		Relate changes in the shape of an oscilloscope trace to changes in pitch and volume	Use ray diagrams to model how light passes through lenses and transparent materials	Relate the impact of different types of wave on living cells to their frequency and the energy carried by the wave and their uses	Use the wave model to explain observations of the reflection, absorption and transmission of waves
Analyse	Analyse patterns	●		●	
	Discuss limitations				
	Draw conclusions	●		●	●
	Present data				
Communicate	Communicate ideas	●	●	●	●
	Construct explanations	●	●	●	●
	Critique claims				
	Justify opinions				●
Enquire	Collect data				
	Devise questions		●		
	Plan variables				
	Test hypothesis	●	●		
Solve	Estimate risks				
	Examine consequences			●	
	Review theories				
	Interrogate sources				

Matter		Concept			
		Particle model	Separating mixtures	Periodic table	Elements
Enquiry activity		Use models to investigate the relationship between the properties of a material and the arrangement of its particles	Devise ways to separate mixtures, based on their properties	Sort elements using chemical data and relate this to their position in the periodic table	Compare the properties of elements with the properties of a compound formed from them
Analyse	Analyse patterns	●		●	●
	Discuss limitations	●		●	●
	Draw conclusions	●		●	●
	Present data	●		●	●
Communicate	Communicate ideas	●		●	
	Construct explanations	●		●	
	Critique claims				
	Justify opinions				
Enquire	Collect data		●		
	Devise questions		●		
	Plan variables				
	Test hypothesis		●		
Solve	Estimate risks	●	●		●
	Examine consequences				
	Review theories	●		●	●
	Interrogate sources				

Reactions		Concept			
		Metals and non-metals	Acids and alkalis	Chemical energy	Types of reaction
Enquiry activity		Use experimental results to suggest an order of reactivity of various metals	Devise an enquiry to compare how well indigestion remedies work	Investigate a phenomenon that relies on an exothermic or endothermic reaction	Investigate changes in mass for chemical and physical processes
Analyse	Analyse patterns	●	●	●	●
	Discuss limitations	●	●	●	●
	Draw conclusions	●	●	●	●
	Present data	●	●	●	
Communicate	Communicate ideas	●	●	●	●
	Construct explanations	●	●	●	●
	Critique claims		●	●	
	Justify opinions			●	●
Enquire	Collect data		●		●
	Devise questions		●	●	●
	Plan variables		●		
	Test hypothesis	●	●	●	●
Solve	Estimate risks	●	●	●	●
	Examine consequences	●			
	Review theories				
	Interrogate sources				

Earth		Concept			
		Earth structure	Universe	Climate	Earth resources
Enquiry activity		Model the processes that are responsible for rock formation and link these to the rock features	Relate observations of changing day length to an appropriate model of the solar system	Investigate the contribution that natural and human chemical processes make to our carbon dioxide emissions	Predict the method used for extracting a metal based on its position in the reactivity series
Analyse	Analyse patterns	●	●		●
	Discuss limitations	●			
	Draw conclusions	●	●		●
	Present data		●		●
Communicate	Communicate ideas	●	●	●	
	Construct explanations	●	●	●	●
	Critique claims				
	Justify opinions		●	●	
Enquire	Collect data				●
	Devise questions				
	Plan variables				
	Test hypothesis				
Solve	Estimate risks				●
	Examine consequences			●	●
	Review theories	●	●	●	
	Interrogate sources				

Organisms		Concept			
		Movement	Cells	Breathing	Digestion
Enquiry activity		Explore how the skeletal system and muscular system in a chicken wing work together to cause movement	Identify the principal features of a cheek cell and describe their functions	Investigate a claim linking height to lung volume	Evaluate how well a model represents key features of the digestive system
Analyse	Analyse patterns	●		●	
	Discuss limitations	●		●	
	Draw conclusions	●		●	
	Present data	●		●	
Communicate	Communicate ideas	●	●	●	●
	Construct explanations		●	●	●
	Critique claims	●		●	●
	Justify opinions	●		●	●
Enquire	Collect data				
	Devise questions	●			
	Plan variables	●		●	
	Test hypothesis	●		●	●
Solve	Estimate risks				
	Examine consequences				
	Review theories				
	Interrogate sources			●	

Ecosystems		Concept			
		Interdependence	Plant reproduction	Respiration	Photosynthesis
Enquiry activity		Use a model to investigate the impact of changes in a population of one organism on others in the ecosystem	Use models to evaluate the features of various types of seed dispersal	Use data from investigating fermentation with yeast to explore respiration	Use lab tests on variegated leaves to show that chlorophyll is essential for photosynthesis
Analyse	Analyse patterns			●	
	Discuss limitations		●		●
	Draw conclusions	●		●	●
	Present data		●	●	●
Communicate	Communicate ideas		●	●	●
	Construct explanations	●	●	●	●
	Critique claims		●		
	Justify opinions	●	●		
Enquire	Collect data		●	●	●
	Devise questions		●	●	●
	Plan variables		●	●	●
	Test hypothesis		●	●	●
Solve	Estimate risks				●
	Examine consequences			●	
	Review theories				
	Interrogate sources				

Genes		Concept			
		Variation	Human reproduction	Evolution	Inheritance
Enquiry activity		Graph data relating to variation and explain how it may lead to the survival of a species	Relate advice to pregnant women to ideas about transfer of substances to the embryo	Review the evidence for theories about how a particular species went extinct	Model the inheritance of a specific trait and explore the variation in the offspring produced
Analyse	Analyse patterns	●			
	Discuss limitations	●			
	Draw conclusions	●			●
	Present data	●			
Communicate	Communicate ideas		●		●
	Construct explanations		●	●	●
	Critique claims	●	●	●	●
	Justify opinions	●	●	●	●
Enquire	Collect data				
	Devise questions				
	Plan variables				
	Test hypothesis				
Solve	Estimate risks				
	Examine consequences	●	●		
	Review theories	●	●	●	●
	Interrogate sources	●	●	●	

5 Practical skills

Practical work is at the heart of science. It's also at the heart of all our qualifications.

There are three reasons for doing practical work in schools.

1 To support and consolidate scientific concepts (knowledge and understanding).
This is done by applying and developing what is known and understood of abstract ideas and models. Through practical work we make sense of new information and observations, and provide insights into the development of scientific thinking.

2 To develop investigative skills. These transferable skills include:
- devising and investigating testable questions
- identifying and controlling variables
- analysing, interpreting and evaluating data.

3 To build and master practical skills such as:
- using specialist equipment to take measurements
- handling and manipulating equipment with confidence and fluency
- recognising hazards and planning how to minimise risk.

Key competencies developed at KS3, provide a solid foundation of practical skills that students can draw on at KS4, these include:

- heat a measured volume of water until almost boiling, having selected and used appropriate equipment
- obtain and record a clearly focused image of a microscopic object
- find out at regular intervals the temperature of water being heated and tabulate observations to reveal the pattern
- separate ingredients from mixtures using appropriate techniques such as evaporation, filtration, chromatography and magnets
- measure the speed of a moving object using appropriate equipment
- measure changes in the pH of solutions using indicators
- carry out practical procedures using instructions without guidance and in a calm fashion with due regard to the safety of others
- observe and investigate a range of chemical reactions using equipment appropriately
- build electrical circuits using various components and measure current and voltage using an ammeter and voltmeter
- represent and interpret a range of simple circuit diagrams using appropriate symbols.

All these skills are developed in GCSE courses and built on in the development of skills and techniques. Students who have not had the opportunity to do this may find it harder to make good progress at KS4 and develop the skills they need.

Get help and support

Visit our website for information, guidance, support and resources at aqa.org.uk/subjects/science

You can talk directly to the science subject team

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