Scheme of work

Combined Science: Synergy
Building blocks

This resource provides guidance for teaching the Building blocks topic from our new GCSE in Combined Science: Synergy (8465). It has been updated from the draft version to reflect the changes made in the accredited specification. Changes have been made to required practical activities in sections; 4.1.1.2 (Density), 4.1.1.4 (Heating and changes of state), 4.1.3.2 (Cell structures), 4.1.3.3 (Transport into and out of cells), 4.1.4.1 (Transverse and longitudinal waves) and 4.1.4.3 (Electromagnetic waves).

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

4.1 Building blocks

4.1.1 States of matter

Spec ref.	Summary of the specification content	Learning outcomes *What most candidates should be able to do*	Suggested timing (hours)	Opportunities to develop scientific communication and mathematical skills	Opportunities to apply practical and enquiry skills	Self/peer assessment Opportunities and resources *Reference to past questions that indicate success*
4.1.1.1	The three states of matter are solid, liquid and gas. Melting and freezing take place at the melting point, boiling and condensing take place at the boiling point. The three states of matter can be represented by a simple model. In this model, particles are represented by small solid spheres. Particle theory can help to explain melting, boiling, freezing and condensing. (HT only) Limitations of the simple model include that there are no forces between the spheres, and that	Recall and explain the main features of the particle model in terms of the states of matter and change of state, distinguishing between physical and chemical changes. (HT only) Explain the limitations of the particle model in relation to changes of state when particles are represented by inelastic spheres.	1	Building blocks circus – to help pupils deduce the over-arching theme for this unit. Pupils choreograph mimes showing particles in a substance such as water, as it changes state. What is the difference between melting and dissolving? WS 1.2 Recognise/draw simple diagrams to model the difference between substances in the solid, liquid and gas states. Describe and explain the different particle arrangements in solids, liquids and gases due to the bonds between the atoms.	If you have a kinetic model, you can use it to demonstrate the motion of particles in a liquid/gas. Or use a tray filled with ping-pong balls and shake it. You can vary the number of ping-pong balls to demonstrate the three states. New Horizons – Pluto. 'Exotic ices' have been discovered on Pluto – what might this mean? Discussion question: Is baking a cake chemistry?	Teachit Science resource (25267) 'Synergy: Unit 1 circus' BBC Bitesize – Kinetic theory Cyberphysics – The Particle Theory – states of matter Exampro user guide PowerPoint

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	atoms, molecules and ions are not solid spheres.			Describe the motion of particles in solids, liquids and gases. WS 3.5 Predict the states of substances at different temperatures given appropriate data. MS 1d Relate the size and scale of atoms to objects in the physical world. (HT only) Why are models used in physics? Critically evaluate the models used to describe and explain the behaviour of solids, liquids and gases.		
4.1.1.2	The density of a material is defined by the equation: $density = \frac{mass}{volume}$ $\rho = \frac{m}{V}$	Define density and explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules. Recall and apply the equation:	0.5	Discussion question: Why is frozen water unusual? Pupils suggest consequences if ice was more dense than liquid water. Explain why the different states of matter have different densities in terms of mass and volume of the material, eg why	Make models of solids, liquids and gases using plasticine. Does the model produced show the 3D structure of these states? Use the model of the tray filled with ping-pong balls if you haven't done it in The	Cyberphysics – The Particle Theory – states of matter Cyberphysics – Density

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	density, ρ, in kilograms per metre cubed, kg/m^3 mass, m, in kilograms, kg volume, V, in metres cubed, m^3	$density = \frac{mass}{volume}$ $\rho = \frac{m}{V}$ to changes where mass is conserved.		ice has a lower density than water. Draw diagrams to show the particle arrangement of solids, liquids and gases. Use the diagrams to explain the differences in densities between solids, liquids and gases MS 1a, 1b, 1c, 3c Recall and apply the equation: $density = \frac{mass}{volume}$ to changes where mass is conserved.	particle model of matter lesson. Evaluate the models used to explain the properties of solids, liquids and gases. **Required practical 1:** use appropriate apparatus to make and record the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of a regularly shaped object and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometer or Vernier callipers. Physics AT 1	

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4.1.1.3	The molecules of a gas are in constant random motion. The temperature of the gas is related to the average kinetic energy of the molecules. The higher the temperature, the greater the average kinetic energy and so the faster the average speed of the molecules.	Describe the motion of molecules within a gas. Describe and explain how the motion of molecules in a gas changes as the gas is heated. Explain why molecules in a gas that are moving faster have a higher temperature.	1	How does the temperature of a gas affect the movement of the particles within it? Why are gas cylinders likely to explode in a fire?	To investigate the motion of gas molecules you can conduct a Brownian motion experiment using smoke cells viewed under a microscope. To carry out the experiment use Institute of Physics' Episode 601-1: Brownian motion in a smoke cell	Video clip YouTube: States of Matter Antonine Education – Thermal Physics Tutorial 3 – Molecular Kinetic Theory
4.1.1.3 cont.	When the molecules collide with the wall of their container they exert a force on the wall. The total force exerted by all of the molecules inside the container on a unit area of the walls is the gas pressure.	Describe why gases exert a force on a container. Explain what is meant by gas pressure in terms of the forces exerted by the gas molecules on a given area.	0.5	Explain in terms of gas pressure how blowing up a balloon too much can cause it to pop.	Research how the gas pressure in a submarine stops it from crushing at depth. Use PhET interactive simulations to model gas pressure: Gas Properties – Gas, Pressure, Volume	BBC Bitesize – Temperature and gas calculations
4.1.1.3 cont.	Changing the temperature of a gas, held at constant volume, changes the pressure exerted by the gas	Describe and explain how changing the temperature of gas increases the gas pressure inside the container.	1	Pupils develop and evaluate analogies that use people to represent particles in a gas, eg 'Beatlemania'; home crowd at	What does a barometer measure and how does it work? Have two sealed syringes: one filled with	BBC Bitesize – Temperature and gas calculations Video clip:

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	(known as the Pressure law).			Wembley; the effects of methods of crowd control. Explain why gas cylinders should not be placed near heat sources. Evaluate newspaper articles of local fires that have involved gas canisters exploding and the reasons for the explosion in terms of gas pressure. Why do aerosol deodorants say: keep away from fire? Why do car tyre pressures have to be checked when cold, rather than after a long drive? Find out why gas cylinders explode in fires (if not, look at questions above). Write a newspaper article on an explosion caused by exploding gas canisters explaining the reasons for the explosion in terms of gas pressure.	water, the other with air. Show you can compress the air one, but not the one filled with water.	YouTube: BBC Short Circuit – Physics – 01 – Pressure (18'47") 1 of 2 (Physics of Diving)

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				Explain why a balloon dipped into liquid nitrogen becomes smaller.		
4.1.1.4	Energy is stored inside a system by the particles (atoms and molecules) that make up the system. This is called internal energy. The amount of energy needed to change state from solid to liquid and from liquid to gas depends on the strength of the forces between the particles of the substance. The nature of the particles involved depends on the type of bonding and the structure of the substance. The stronger the forces between the particles the higher the melting point and boiling point of the substance.	Describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state. Describe how, when substances melt, freeze, evaporate, condense or sublimate, mass is conserved but that these physical changes differ from chemical changes because the material recovers its original properties if the change is reversed.	1	What is the difference between heat and temperature? Use images of William Lord Kelvin, Daniel Fahrenheit, Anders Celsius and James Prescott Joule to generate discussion. Discussion question: Why can burns from steam be more serious than burns from boiling water? What effect does increasing the temperature of an object have on the atoms that make up the object? Describe temperature as a measure of the average kinetic energy of the particles in a substance. Describe and explain how increasing the temperature of a substance affects the internal energy of a substance.	Model the behaviour of atoms within a solid as it is heated past its melting point. You can use the tray of ping-pong balls or the kinetic theory apparatus if available. Critically analyse the model and suggest improvements to it. Pupils predict how water changes state over time with increasing temperature by sketching a line graph. Investigate the heating curve for water by heating some ice in a beaker until the water evaporates. Use temperature sensors/data loggers to record the temperature	The Physics Classroom – What is Heat? Antonine Education – Thermal Physics Tutorial 1 – Heat Flow Cyberphysics – Heating ice to observe changes in state

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				Explain how the strength of the bonds between the particles will affect how much energy is needed to change the state of the substance. Evaluate data on the melting points and boiling points of different substances linked to the strength of the forces between the particles. Explain what is happening at each stage of the heating curve produced.	at fixed intervals, eg 30 seconds. A graph can be plotted of temperature against time.	
4.1.1.4 cont.	The increase in temperature of a system depends on the mass of the substance heated, the type of material and the energy input. The following equation, given on the Physics equations sheet, applies:	Define the term specific heat capacity and distinguish between it and the term specific latent heat. MS1a, 3c, 3d Use this equation to calculate energy changes during changes of state.	1	Describe and explain how the amount of water in a kettle affects how quickly it boils. Explain why a pan of cooking oil heats up faster than a pan of water, with the same mass of each, in terms of specific heat capacity. Why does a half-full kettle boil faster than a full one?	Plan a practical to investigate the rate of heating of various metals using a joulemeter to determine the energy input. If no joulemeter is available, use an ammeter, *I*, a voltmeter, *V*, and heat the material for a fixed amount of time, *t*.	BBC Bitesize – Specific heat capacity Cyberphysics – Specific Heat Capacity Teachit Science resource (23856) 'Hot rocks – how

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	$change\ in\ thermal\ energy = mass \times specific\ heat\ capacity \times temperature\ change$ $[\Delta E = m\, c\, \Delta\theta]$ change in thermal energy, ΔE, in joules, J mass, *m*, in kilograms, kg specific heat capacity, *c*, in joules per kilogram per degree Celsius, J/kg °C temperature change, $\Delta\theta$, in degrees Celsius, °C The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius. The energy needed for a substance to change			Why do sea breezes change direction day and night? Why is water used in hot water bottles? Define specific heat capacity. Describe the factors that affect how quickly a substance heats up, eg why does a half-full kettle heat up faster than a full kettle of water? Calculate the change in thermal energy, mass, specific heat capacity or the temperature change of a substance that is heated or cooled. The equation will be provided on the equations sheet. Pupils should be able to convert to SI units and use standard form in their answers. Explain why special concrete blocks are used in storage heaters. WS 3.5, MS 4a	Calculate the energy transferred, *E,* using: $E = I \times t \times V$ Determine the specific heat capacity of water by experiment. **Required practical 2:** an investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored. Physics AT 1 and 5	cavemen heated water’

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	state is called latent heat. When a change of state occurs, the energy supplied changes the energy stored (internal energy) but not the temperature. The energy needed for a substance to change state is called latent heat. When a change of state occurs, the energy supplied changes the energy stored (internal energy) but not the temperature.			Interpret heating and cooling graphs that include changes of state. MS 1a, 3c, 3d Use this equation to calculate energy changes when a material is heated.		
4.1.1.5	In chemistry, a pure substance is a single element or compound, not mixed with any other substance. Pure elements and compounds melt and boil at specific temperatures. Melting	Explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term 'pure'.	0.5	WS 3.5 Use melting point data to distinguish pure from impure substances.	Pupils investigate the effect of table salt on the melting point and boiling point of water.	

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	point and boiling point data can be used to distinguish pure substances from mixtures. In everyday language, a pure substance can mean a substance that has had nothing added to it, so it is unadulterated and in its natural state, eg pure milk.					

4.1.2 Atomic structure

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4.1.2.1	Stages in the development of atomic models: • Dalton atoms (1804) – spherical atoms that cannot be split up to explain the properties of gases and the formulae of compounds • Plum pudding model (1897) – it was found that the mass of electrons, which had recently been discovered, was very much less than the mass of atoms so they must be sub-atomic particles • the nuclear atom (1911) – an experiment which showed that most of the alpha particles	Describe how and why the atomic model has changed over time. Describe the difference between the plum-pudding model of the atom and the nuclear model of the atom. Describe why the new evidence from the scattering experiment led to a change in the atomic model.	1	Create a timeline for the history of the atomic model. Extended writing: Describe the differences between the plum-pudding model, nuclear model and atomic model. Describe why changes to the atomic model happened. High demand: Describe the experimental techniques involved in the history of the atomic model. Explain how the experimental techniques work.	WS 1.1 Explain, with examples, why new data from experiments or observations led to changes in atomic models. WS 1.1 Decide whether or not given data supports a particular theory.	Nobel Prizes and Laureates Atomic Structure Timeline Teachit Science resource 19980 'Plum pudding atoms'

	directed at thin gold foil passed through but a few bounced back, suggesting the positive charge was concentrated at the centre of each gold atom • discovery of neutrons in the nucleus (1932) – explained why the mass of atoms was greater than could be accounted for by the mass of the protons. Students are not required to recall dates or the names of scientists.					

<table>
<tr><td>4.1.2.2</td><td>Atoms are very small, having a radius of about 0.1 nm (1×10^{-10} m).

The radius of a small molecule such as methane, CH_4, is about 0.5 nm (5×10^{-10} m).</td><td>Recall the typical size (order of magnitude) of atoms and small molecules.</td><td>0.5</td><td>Show images of James Lovelock, an electron capture detector, a microwave oven and Gaea Greek goddess of Earth. What is the connection?

MS 1b

Recognise expressions in standard form.

WS 4.4

Use SI units and the prefix nano.

MS1 d

Estimate the size of atoms based on scale diagrams.</td><td>Model atoms (using physical models or computer simulations).</td><td>Video clip:

BBC Bitesize – Atomic structure

Video clip:

BBC Bitesize – How mass and atomic numbers explain atomic structure

YouTube:

Atomic Number and Mass Number</td></tr>
<tr><td>4.1.2.3</td><td>The radius of a nucleus is less than 1/10 000 of that of the atom (about 1×10^{-14} m).

The relative masses and charges of protons, neutrons and electrons:

<table><tr><th>Name of particle</th><th>Relative mass</th><th>Charge</th></tr><tr><td>Proton</td><td>1</td><td>+1</td></tr><tr><td>Neutron</td><td>1</td><td>0</td></tr><tr><td>Electron</td><td>Very small</td><td>–1</td></tr></table>
The number of protons in an atom of an element is its atomic number. All atoms of a</td><td>Recall the different charges of the particles that make up an atom.

Describe why atoms have no overall charge.

Recall what atomic number represents.

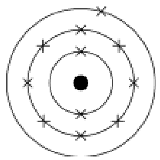
Use the periodic table to identify number of protons in different elements.</td><td>0.5</td><td>Recall structure of atom and the charges of each particle (KS3).

Using examples from the first 20 elements on the periodic table, students read off and work out the number of each charge different elements have.

Describe the relationship between number of positive and negative charges. Apply this relationship to explain why there is no overall charge.</td><td>Designing an appropriate table to display data on atomic numbers and number of atomic particles in different elements.</td><td>Explain to each other what atomic structure means, and why atoms have no overall charge.

Teachit Science resource (19388) 'Atomic structure – follow on cards'</td></tr>
</table>

	particular element have the same number of protons. Atoms of different elements have different numbers of protons. In an atom the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.			Referring to their table of data students write their rules to state what the atomic number is and why elements are different from each other. Extended writing: Describe the structure of atoms.		
4.1.2.4	The sum of the protons and neutrons in an atom is its mass number. Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element. Atoms can be represented as shown in this example: (Mass number) (Atomic number) $^{23}_{11}Na$	Relate differences between isotopes to differences in conventional representations of their identities, charges and masses.	0.5		WS 1.2 Calculate numbers of protons, neutrons and electrons in atoms and ions, given atomic number and mass number of isotopes.	
4.1.2.5	The electrons in an atom occupy the lowest available energy levels (innermost available shells closest to the nucleus). The electronic structure of an atom can	Recall that in each atom its electrons are arranged at different distances from the nucleus. Pupils should be able to represent the electronic	0.5	Describe how many electrons there can be in the first, second and third energy shells. Pupils design a game aimed at helping players learn the	Role play – using pupils to represent protons, neutrons and electrons, build up the idea of full and complete energy shells with 2 in the first,	YouTube: Energy Levels and Electron Configuration YouTube:

	be represented by numbers or by a diagram. For example, the electronic structure of sodium is 2,8,1 or  showing two electrons in the lowest energy level, eight in the second energy level and one in the third energy level.	structures of the first twenty elements of the periodic table in both forms. Pupils may answer questions in terms of either energy levels or shells.		electronic structures of the first 20 elements.	8 in the second and 8 in the third energy shell.	Drawing electron configuration diagrams Teachit Science resource (19411) 'Electron configuration'

4.1.3 Cells in animals and plants

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4.1.3.1	An electron microscope has a much higher resolving power than a light microscope. This means that it can be used to study cells in much finer detail. An electron microscope can magnify up to a million times (× 1000 000) or more, which is much more than a light microscope which has a useful magnification of only about a thousand times (× 1000). $magnification = \frac{image\ size}{real\ size}$	Describe the differences in magnification and resolution of light and electron microscopes. Explain how electron microscopy has increased understanding of organelles. Calculate the magnification of a light microscope. Carry out calculations using the formula: $magnification = \frac{image\ size}{real\ size}$ Rearrange the equation to calculate image size or magnification. Convert values for the units: cm, mm, μm and nm	1	Use a variety of resources to research the differences between a light microscope and an electron microscope. Use online materials to make a display of cell images from a light microscope and from an electron microscope. Write a newspaper article entitled: 'Microscope…..the best invention ever!' where pupils explain the significance of the microscope and discuss what the world would be like if microscopes were never invented. Calculate the real size of microscope images, and convert units as appropriate. Rearrange the equation to calculate a different unknown.	Use online and printed materials to calculate the real sizes of cells and structures. Limited to the differences in magnification and resolution. MS 1a,1b, 1c, 2h Carry out calculations involving magnification, real size and image size ((HT only) including numbers written in standard form). WS4.4 Use prefixes centi-, milli-, micro- and nano-. MS 1d, 2h Make order of magnitude calculations. Extension work: Use a microscope with graticule to measure	Observation activity materials: • microscope • graticule • prepared slides • calculator. Links to W1L3 'Developments in microscopy' lesson from AQA six week teaching pack: Biomimicry.

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					cells and calculate their real size.	
4.1.3.2	Plant and animal cells are eukaryotic cells which have a membrane, cytoplasm and a nucleus. Bacterial cells are prokaryotic cells. They are smaller than eukaryotic cells and have a cell wall, membrane and cytoplasm, but do not have a nucleus. Their genetic material is a single loop of DNA or several small rings of DNA called plasmids in the cytoplasm. Most animal cells have the following parts: • a nucleus, which controls the activities of the cell	Identify plant, animal and bacterial cells and classify them as eukaryotic or prokaryotic cells. Label diagrams of bacterial cells. Describe the differences between eukaryotic and prokaryotic cells in terms of structure and size.	1	Develop an argument for and against bacteria cells to be classified as plants or animals. Label a diagram of a bacterial cell. Construct a table to compare the structure of plant, animal and bacterial cells.	**Required practical 3:** use a light microscope to observe, draw and label a selection of plant and animal cells. A magnification scale must be included. Biology AT 1 and 7.	Assessment material: Cells and simple cell transport B2.1 PowerPoint

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	• cytoplasm, in which most of the chemical reactions take place • a cell membrane, which controls the passage of substances into and out of the cell • mitochondria, which is where aerobic respiration takes place • ribosomes, which is where protein synthesis occurs. Most human cells are like most other animal cells. In addition to the parts found in animal cells, plant cells often have: • chloroplasts, which absorb light to make food by photosynthesis					

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	• a permanent vacuole filled with cell sap. Plant and algal cells also have a cell wall made of cellulose, which strengthens the cell.					
4.1.3.3	Some substances move across cell membranes via diffusion. Diffusion is a spreading out and mixing process. Particles move from a region where they are in higher concentration to a region where their concentration is lower. Factors that affect the rate of diffusion across a membrane are: • the difference in concentration • the temperature • the surface area of the membrane.	Define the term 'diffusion'. Explain how temperature, concentration gradient and surface area affect the rate of diffusion.	1	Observe demos and suggest explanations: • Time how long it is before pupils can smell a perfume placed in a corner of the room. • Is the rate of diffusion different for different gases? Use concentrated ammonium hydroxide and hydrochloric acid in a large glass tube. • Does temperature affect the rate of diffusion? Fresh beetroot placed in iced water and warm water. Record observations and suggest explanations.	Choose investigations as appropriate: • potassium permanganate in beaker of water, potassium permanganate on agar • investigate diffusion of different acids and alkalis through agar • investigate rate of diffusion of glucose through cellulose tubing • use digital microscope to observe diffusion of particles in milk or yogurt solution.	Demo materials: • strong perfume • concentrated NH_4OH • concentrated HCl • gloves • mask • forceps • cotton wool • long glass tube with strips of damp litmus along length • beetroot • beakers • kettle • ice • two gas jars of NO_2

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				Watch a video or computer simulation of diffusion on BBC or McGraw-Hill website. Role play diffusion in gases and liquids at different temperatures and concentrations. Link to 4.1.1 Sates of matter Apply particle model to diffusion. MS 4a, 4b, 4c, 4d Plot, draw and interpret appropriate graphs.	Model diffusion. Observe slides or micrographs of villi, alveoli, root hair cells and leaves.	• two empty gas jars. Activity: BBC Bitesize - Movement across cell membranes McGraw-Hill Higher Education: Animation: How Diffusion Works TED Ed – Making waves: the power of concentration gradients
4.1.3.3 cont.	Water may move across cell membranes by osmosis. Cell membranes are partially permeable: they allow small molecules such as water through but not larger molecules. During osmosis water diffuses from where it is more concentrated (because the solute concentration is lower), through a	Define the term 'osmosis'. Explain how substances are transported into and out of cells through osmosis.	1	Set up a simple osmometer at the start of the lesson and measure how far the liquid in the capillary tube rises during the lesson. Explain the movement of water molecules as a special type of diffusion through a partially permeable membrane. Predict and explain what will happen to cellulose tubing bags filled with water or sugar	Make predictions with explanations. Investigate the effect of water and concentrated salt solution on onion/ beetroot/ rhubarb cells. Model osmosis. **Required practical 4:** investigate the effect of a range of concentrations of salt or	Demos: 1. Cellulose tubing filled with concentrated sugar solution attached to capillary tube held in clamp, beaker of water. 2. Four beakers (two of water and two of sugar solution); four

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	partially permeable membrane to where water is less concentrated (because the solute concentration is higher).			solution, placed in beakers of water or sugar solution. Observe and explain the effects of water and concentrated salt solution on cells of onion/beetroot/rhubarb. Use a model to show osmosis or get pupils to make a model. Watch a computer simulation of osmosis in plant and animal cells. Watch a video clip of osmosis in blood cells. Pupils research online 'osmotic power as a source of renewable energy'. Report to the class – define, describe, explain, evaluate. MS 4a, 4b, 4c, 4d Plot, draw and interpret appropriate graphs. MS 1c Calculate percentage gain and loss of mass.	sugar solutions on the mass of plant tissue. Biology AT 1, 3 and 5	cellulose sausages (two of water and two of sugar solution). Observation activity materials: • living plant cells: onion/beetroot/ rhubarb • microscopes • slides • coverslips • water • concentrated solution • pipettes • blotting paper. Model materials: • clear plastic box • plasticine for membrane • different sized balls for water and solute.

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						Animation: How Osmosis Works Video clip: BBC Bitesize – Movement across cell membranes
4.1.3.3 cont.	Some substances move across cell membranes via active transport. Active transport involves the movement of a dissolved substance from a region where it is less concentrated to a region where it is more concentrated. This requires energy from respiration. Active transport allows mineral ions to be absorbed into plant root hairs from very dilute solutions in the soil. It also allows sugar molecules to be absorbed from lower concentrations in the gut into the blood with a	Define the term 'active transport'. Describe where active transport occurs in humans and plants and what is transported. Explain why active transport requires energy. Explain how active transport enables cells to absorb ions from very dilute solutions. Explain the relationship between active transport and oxygen supply and numbers of mitochondria in cells.	1	Recap diffusion and osmosis. Compare them with active transport. Produce a comparison table. What does the name 'active transport' tell you about the process? Pupils think of alternative, descriptive names for diffusion and osmosis. Introduce active transport as absorption against the concentration gradient. Discuss when this might be useful. Pupils link the particle model and energy-transfer model to explain active transport.	Investigate the effect of oxygen availability on the growth of plants. Observe results in later lessons.	BBC Bitesize: Movement across cell membranes Teachit Science resource (19667) 'Movement of particles in and out of cells – follow on cards' Nuffield Foundation Tracking active uptake of minerals by plant roots Oxygen: gas jars with lids, glass tubes, fresh and boiled water to make mineral ion solution(s), black paper.

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	higher sugar concentration.			Pupils plan a 60 second presentation comparing and contrasting diffusion, osmosis and active transport. Research where active transport occurs in plants and humans and label these on diagrams with notes. Observe a video or pictures of plants growing in soil and in hydroponic solutions. Suggest why farmers and gardeners turn the soil and hydroponic solutions must be kept aerated. Use the Nuffield activity: Nuffield Foundation Tracking active uptake of minerals by plant roots Pupils can carry out a similar investigation to demonstrate the need for oxygen. Observe images of the mitochondria in root hair cells and cells lining the small		

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				intestine. Relate to active transport. Observe a computer simulation of active transport.		
4.1.3.4	The nucleus of body cells contains chromosomes. In body cells the chromosomes are normally found in pairs. There are 46 chromosomes in human body cells. DNA is in the chromosomes and each chromosome carries a large number of genes. Cells divide so that organisms can grow during the development of multicellular organisms, and repair damaged tissues. Dividing cells go through a series of stages called the cell cycle. During the cell cycle the genetic material doubles and	Describe simply how and why body cells divide by mitosis. Knowledge and understanding of the stages in mitosis are **not** required. Draw simple diagrams to describe mitosis. Draw a simple diagram to describe the cell cycle in terms of: • cell growth, when the number of organelles increases • replication of chromosomes, so the genetic material is doubled • separation of the chromosomes: division of the nucleus	1	Watch video clip showing mitosis. Discuss how organisms grow and relate this to cell division. Observe mitosis in cells. Role play the process of mitosis or use plasticine, pipe cleaners, beads etc to make a simple model. Draw simple diagrams to describe the cell cycle and mitosis. Activity: What would happen if…? Eg: a) … DNA did not replicate? b) …. chromosomes did not line up down the middle? c) … organelles did not replicate?	Use bioviewers or root tip squashes to show chromosomes and mitosis. Model mitosis.	BBC Bitesize – Stages of mitosis or cell division BBC Bitesize – The building blocks of cells (first part of Mitosis and meiosis) Observation activity materials: • bioviewers • microscopes • slides • coverslips • root tips. Nuffield Foundation Investigating mitosis in allium root tip squash Animation: Animal Cell Mitosis

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	then divides to give two new cells that are genetically identical to each other and to the original cell. Knowledge of the stages of the cell cycle and mitosis is not required. Before a cell can divide it must grow, and make copies of all the organelles such as mitochondria and ribosomes. It must also replicate the chromosomes in the nucleus. Then it can divide by mitosis. During mitosis the two complete sets of chromosomes are pulled to opposite sides of the cell. Two new nuclei form. Then the cell splits into two.	• division of the cell to form two identical cells.				

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4.1.3.5	Cells in reproductive organs divide by meiosis to form gametes (egg and sperm cells). Knowledge of the stages of meiosis is not required. When a cell divides to form gametes: • copies of the genetic information are made • the cell divides twice to form four gametes, each with a single set of chromosomes • all gametes are genetically different from each other. Gametes join at fertilisation to restore the normal number of chromosomes. The new cell divides by mitosis, and as the embryo	Explain the term gametes and describe their genetic material. Explain why sexual reproduction results in variety. Link to 4.4.4.1 Mutations. Draw diagrams to explain how gametes are formed in meiosis. Explain the number of chromosomes in the gametes during meiosis and fertilisation. Describe how an embryo is formed. Compare mitosis and meiosis.	1	To demonstrate cell division, pupils make static or animated models with commentary using lengths of string, pipe cleaners and modelling clay (to represent organelles). Consider fusion of sex cells at fertilisation and explain why gametes have only one set of chromosomes – use models or diagrams. Make models to show what happens during fertilisation (playdough is ideal) – this could be extended to a stop frame animation if ICT is available. Watch BBC video clip and access information on mitosis and meiosis (see resources). Produce a poster to compare mitosis and meiosis.	Use bio-viewers, video clips or images to show chromosomes and meiosis.	Using given or mutually agreed success criteria, use peers to assess models. Mitosis and meiosis: BBC Bitesize – The building blocks of cells Knowledge and understanding of the stages in meiosis are not required.

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	develops cells differentiate.					
4.1.3.6	At first the cells in an embryo can grow and divide to form any type of cell. They are stem cells. As an embryo develops, most of the cells differentiate and become specialised. Specialised cells carry out a particular function. Differentiation is essential to produce a variety of cells with different functions in multicellular organisms eg blood cells, nerve cells and muscle cells in animals, and root hair cells, xylem and phloem cells in plants. Cells that have become specialised cannot later change into different kinds of cells. However,	Define the term 'stem cell'. Describe the function of stem cells in embryonic and adult animals. Explain the importance of cell differentiation.	1	Write a job description for a newspaper for each type of specialised cell (xylem, sperm cell, red blood cell etc), eg: 'Sperm cell wanted – must be a strong swimmer…' This could be done using ICT. Watch video clips showing specialised plant and animal cells. What am I? Describe the key features of different specialised cells – pupils guess the cell type. Watch a video clip showing cell differentiation in plants and animals.	Observe prepared slides of specialised cells under the microscope, or use bioviewers. Observe root hair cells under a microscope in sprouting mung beans. Use of models.	Observation activity materials: • microscopes • slides • coverslips • sprouting mung beans • prepared slides • bioviewers • slide strips. Video clip: BBC Bitesize – Plant and animal cell structures Europe's stem cell hub – Stem cell videos and films Wellcome Trust – Medical uses of stem cells BBC Bitesize – Stem cells

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	there are some stem cells in most adult tissues that are ready to start dividing to replace old cells or to repair damage in the tissues where they are found.					Teachit Science resource (19669) 'Cells and their specialisms'

4.1.4 Waves

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4.1.4.1	In a transverse wave the oscillations are perpendicular to the direction of energy transfer. The ripples on a water surface are an example of a transverse wave. In a longitudinal wave the oscillations are	Describe the difference between transverse and longitudinal waves. Describe how ripples on water surfaces are examples of transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured.	1	Draw diagrams to show the features of transverse and longitudinal waves. Give examples of both transverse and longitudinal waves. Describe the propagation of both transverse and longitudinal waves.	What do waves look like? Do all waves have the same properties? Demonstrate how transverse and longitudinal waves travel using a slinky spring. Plan an experiment to measure the speed of	BBC Bitesize: General properties of waves Cyber Physics: Waves

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	parallel to the direction of energy transfer. Longitudinal waves show areas of compression and rarefaction. Sound waves travelling through air are longitudinal.	Describe evidence that in both cases it is the wave and not the water or air itself that travels. Describe how the speed of ripples on a water surface can be measured. Describe and explain how the speed of sound waves in air can be measured experimentally.		Explain the changes in air pressure caused by longitudinal waves in regions of compression and rarefaction. List the waves in the electromagnetic spectrum in order of shortest to longest wavelength.	sound in air. Eg bang two pieces of wood together facing a large wall and record the time taken to hear the echo. Measure the distance to the wall and double it. **Required practical 5:** make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements. Physics AT 4. If a ripple tank isn't available then the following two clips from Open University are available. Activities listed on Institute of Physics website Episode 309 Demonstrate a non-Newtonian fluid (corn	

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					starch) on a speaker cone or show clip	
4.1.4.2	Waves are described by their amplitude, wavelength, frequency and period. The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position. The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave. The frequency of a wave is the number of waves passing a point each second. $Period\ [T] = \frac{1}{f}$	Define: • wavelength • amplitude • frequency • peak • trough • period. Calculate the wavelength of a wave. Calculate the frequency of a wave given the number of waves and the time. Calculate the speed of a wave. Rearrange the equation to find any unknown given the other two values.	1	Calculate the wavelength of a wave from a labelled diagram of a wave. Calculate the frequency of a wave given the number of waves (possibly from interpreting a diagram) and the time. Calculate the speed of a wave. Rearrange the equation to find any unknown given the other two values.	What do waves do? What effect does increasing the amplitude/frequency of a sound wave have? Demonstrate the above using a loudspeaker and signal generator connected to an oscilloscope. Vary the frequency and then the amplitude on the signal generator – what is observed? Demonstrate that changing the frequency of a transverse wave on a length of rope changes the wavelength. Pupils could investigate how to accurately measure the period of a wave, ie time a fixed	Revision summary: waves Anatomy of a wave Cyber Physics: Waves The frequency and period of a wave

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	period, *T*, in seconds, s frequency, *f*, in Hertz, Hz The period of a wave is how long it takes for one wave to pass a point. The wave speed is the speed at which the energy is transferred (or the wave moves) through the medium. All waves obey the wave equation: $wave\ speed\ =$ $frequency\ x\ wavelength$ $[v\ =\ f\lambda]$ wave speed, *v*, in metres per second, m/s frequency, *f*, in Hertz, Hz wavelength, *λ*, in metres, m				number, say 10 and then divide the time by this number. MS 1a, 1c, 3b, 3c Recall and apply the wave equation. MS 1b, 2a Complete calculations using standard form and give answers to an appropriate number of significant figures.	

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4.1.4.3	Electromagnetic waves form a continuous spectrum. Examples of uses of electromagnetic waves include: • radio waves – television and radio and radio telescopes • microwaves – satellite communications, cooking food • infrared – electrical heaters, cooking food, infra-red cameras • visible light – fibre optic communications • ultraviolet – fluorescent lamps, sun tanning • X-rays – medical imaging and treatments	Recall that electromagnetic waves are transverse, are transmitted through space where all have the same velocity, and explain, with examples, that they transfer energy from source to absorber. Recall that light is an electromagnetic wave. Describe the main groupings of the spectrum – radio, microwave, infrared, visible (red to violet), ultraviolet, X-rays and gamma rays, that these range from long to short wavelengths and from low to high frequencies, and that our eyes can only detect a limited range. Give examples of some practical uses of electromagnetic waves in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions.	1	Describe the properties of all electromagnetic waves. State that electromagnetic waves transfer energy from one place to an absorber of that energy. Give the order of the electromagnetic spectrum. Describe uses of each wave in the electromagnetic spectrum. Explain the suitability of each wave for its practical application. Suggest reasons why an electromagnetic wave may not be suitable for a given application. Produce a leaflet to show the uses and dangers of electromagnetic radiation. Explain the precautions taken in a hospital when carrying out an X-ray. Precautions should include steps taken to reduce	Where are electromagnetic waves used? Why are electromagnetic waves used when they are dangerous? Research the various uses of electromagnetic waves and how they are suitable for that application. **Required practical 6**: investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface. Physics AT 1 and 4. Investigate the range of Bluetooth communications between mobile phones.	BBC Bitesize: The electromagnetic spectrum Cyber Physics: The electromagnetic spectrum Teachit Science resource (19928) 'Electromagnetic radiation – what does what?'

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	• gamma rays – sterilising surgical instruments, treatment of cancer.			the risks for the patient and the radiographer.	Research the use of laser light in barcodes and in reading CDs. Demonstrate an optical fibre showing total internal reflection. Demonstrate a use of UV by shining a UV light onto a bank note, through tonic water or writing a message using a security marker and then holding a UV light over the message. WS 1.2 Show that the uses of electromagnetic waves illustrate the transfer of energy from source to absorber. MS 1a, 1c, 3c Recall and apply the relationship between frequency and wavelength across the	

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					electromagnetic spectrum.	
4.1.4.4	(HT only) Radio waves can be produced by oscillations in electrical circuits. When radio waves are absorbed they may create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit.	Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits.	0.5	Describe how radio waves can be produced in electrical circuits and also the effect that radio waves may have on electrical circuits.	How do radios work? Make a simple transistor radio. Research the first radio communication sent across the Atlantic. How do you make an electromagnetic wave?	Cyber Physics: Radio and TV waves
4.1.4.5	(HT only) Shiny surfaces act as mirrors when they reflect waves. Rough surfaces scatter waves in all directions. Electromagnetic waves change speed when they travel between different	Recall that different substances may refract, or reflect these waves; explain how some effects are related to differences in the velocity of the waves in different substances.	1	WS 1.2 Construct ray diagrams to illustrate the refraction of a wave at the boundary between two different media. WS 1.2 Use wavefront diagrams to explain refraction in terms of the change of wave speed.	Why can I get TV signal at home but not a mobile phone signal? Demonstration of the properties of microwaves using a microwave transmitter and a detector connected to a milli-ammeter.	BBC Bitesize: Refraction and diffraction Reflection, refraction and diffraction

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	substances such as from air to glass or water. As a result they change direction. This is refraction.				If you have a ripple tank you can demonstrate refraction as waves go into different depths of water, or use this video on Ripple tank reflection	