Vertical Concepts - Progression in Scientific Concepts in the Mauldeth Road Curriculum

The following progressions are based on the ten big ideas of science based on the Association of Science Education's document Working with the Big Ideas in Science.

The ten big ideas of science

1. All matter in the Universe is made of very small particles.
2. Objects can affect other objects at a distance.
3. Changing the movement of an object requires a net force to be acting on it.
4. The total amount of energy in the universe is always the same but can be transferred from one energy store to another during an event.
5. The composition of the earth and its atmosphere, and the processes occurring within them, shape the earth's surface and its climate.
6. Our solar system is a very small part of one of billions of galaxies in the universe.
7. Organisms are organised on a cellular basis and have a finite life span.
8. Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.
9. Genetic information is passed down from one generation of organisms to another.
10. The diversity of organisms, living and extinct, is the result of evolution.

Vertical Concept	Definition	Units
1. All material in the Universe is made of very small particles.	Atoms are the building blocks of all materials, living and non-living. The behaviour of the atoms explains the properties of different materials. Chemical reactions involve rearrangement of atoms in substances to form new substances. KS3 Each atom has a nucleus containing neutrons and protons, surrounded by electrons. KS3 The opposite electric charges of protons and electrons attract each other, keeping atoms together and accounting for the formation of some compounds.	■ Y1, Everyday Materials - Objects can be distinguished by considering the material it's made from, and describing simple properties. ■ Y2, Uses of Materials - Different materials are recognisable by their properties. ■ Y3, States of Matter - Materials can be solids, liquids or gases. ■ Y4, States of Matter - If a material could be divided into smaller and smaller pieces it would be found to be made of pieces, particles, smaller than can be seen even with a microscope. These particles are not in a material; they are the material. ■ Y4, Electricity - Simple electrical circuits show the effects and properties of electricity caused by electrons moving within metal conductors. ■ Y5, Properties and Changes of Materials - When some materials combine, they do not change permanently and can be separated again. ■ Y5, Properties and Changes of Materials - Materials can be changed by heating and cooling. ■ Y5, Properties and Changes of Materials - When some materials are combined, they form a new material with different properties to the original materials. ■ Y6 Gases, Evaporation and Condensation - When materials change by heating and cooling it is because the behaviour of the particles changes. ■ (KS3 - The smallest piece of a material is called an atom. All materials, anywhere in the universe, living and non--living, are made of a very large numbers of these basic 'building blocks' of which there are about 100 different kinds.)

Vertical Concept	Definition	Units
2. Objects can affect other objects at a distance.	Some objects have an effect on other objects at a distance. In some cases, such as sound and light, the effect is through radiation which travels out from the source to the receiver. In other cases action at a distance is explained in terms of the existence of a field of force between objects, such as a magnetic field or the universal gravitational field.	■ Y1, Light - We need light to see the world around us. ■ Y2, Forces - Forces are pushes or pulls. Forces can make things speed up, slow down, change direction or change shape. ■ Y3, Light - Shadows are the absence of light. ■ Y3, Light - Light reaches our eyes, even though the light source may be far away. ■ Y3, Forces and Magnets - Magnets can attract and repel each other and attract other materials at a distance. ■ Y4, Sound - Sound comes from things that vibrate and can be detected at a distance from the source because the air or other material around the source is made to vibrate. Sounds are heard when the vibrations in the air reach our ears. ■ Y5 Forces - The non-contact force of gravity makes things fall to Earth. ■ Y5 Forces - There is gravitational force between all objects, but it is only felt when one or more of the objects has a very large mass. ■ Y3, Light - We see things because light travels from a light source, to objects and then to our eyes. ■ Y6, Light - Light travels in straight lines. ■ (KS3 - There is attraction and repulsion between objects that are electrically charged.) ■ (KS3 - Visible light and other forms of radiation can travel through any empty space.) ■ (KS3 - How quickly an object's motion is changed depends on the force acting and the object's mass. The greater the mass of the object, the longer it takes to speed it up or slow it down (inertia).) ■ (KS3 - Visible light and other forms of radiation can travel through empty space.)

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3. Changing the movement of an object requires a net force to be acting on it.	Objects change their velocity of motion only if there is a net force acting on them. Gravity is a universal force of attraction between all objects however large or small, keeping the planets in orbit around the Sun and causing terrestrial objects to fall towards the centre of the Earth.	■ Y2, Forces - Forces can push, pull objects, making them change shape or speed up, slow down or change direction. ■ Y3, Forces and Magnets - We can compare how different objects move on different surfaces. ■ Y5, Forces - When forces acting on an object are not equal and opposite in direction, they are unbalanced and will change an object's speed, direction or shape. ■ Y5, Forces - Unsupported objects fall towards Earth because of the force of gravity acting between the Earth and the falling object. ■ Y5, Forces - Air resistance, water resistance and friction act between moving surfaces. ■ Y5, Forces - Some mechanisms, including levers, pulleys and gears, allow a smaller force to have a greater effect. ■ Y5, Earth and Space - The downward force of gravity on an object on the Moon is less than that on Earth because the Moon has less mass on Earth. ■ (KS3 - How quickly an object's motion is changed depends on the force acting and the object's mass. The greater the mass of the object, the longer it takes to speed it up or slow it down (inertia).)

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4. The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Many processes or events involve changes and require energy to make them happen. Energy can be transferred from one body to another in various ways. In these processes some energy is changed to a form that is less easy to use. Energy cannot be created or destroyed. Once energy is released by burning fossil fuels, some of it is no longer available in a usable form.	■ Y2, Forces - Things around us can be made to change or happen. We can pull objects behind us or push them across the table. ■ Y2, Living things - All living things need food to give them energy. ■ Y2, Living things - The arrows in a food chain show where energy is being transferred from and to. ■ Y6, Electricity - Things around us can be made to change or happen. We can turn on a light bulb and make it brighter or dimmer. ■ Y6, Electricity - Voltage has an effect on how electrical components function. ■ (KS3 - Energy cannot be created or destroyed. When energy is transferred from one object to others, the total amount of energy in the universe remains the same; the amount that one object loses is the same as the other objects gain.) ■ (KS3 - Objects have energy because of their chemical composition, their movement, their temperature, their position in a gravitational or other field, or because of compression or distortion of an elastic material.)

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5. The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.	At the Earth's surface, radiation from the Sun heats the surface and causes convection currents in the air and oceans, creating climates. Below the surface heat from the Earth's interior causes movements in the molten rock. The solid surface is constantly changing through the formation and weathering of rock.	■ Y1, Plants - Plants grow in soil. ■ Y1, Seasonal Change - Seasons have different weather associated with them. ■ Y1, Seasonal Change - The length of day and night varies. ■ Y2, Animals - Air is all around us on Earth. ■ Y3, Rocks - There are different types of rock, they are formed in different ways and have their own, distinct, physical appearances. ■ Y3, Rocks - The action of water wears down rock gradually into smaller pieces. ■ Y3, Rocks - Much of the solid surface of the Earth is covered in soil, which is a mixture of pieces of rock of various sizes and the remains of organisms. Some soil also contains air, water and some nutrients. ■ Y5, Earth and Space - There is less and less air further away from the Earth's surface; space is a vacuum. ■ (KS3 - Weather is determined by conditions of the air. The temperature, pressure, direction and speed of the movement and the amount of water vapour in the air combine to create the weather.) ■ (KS3 - Radioactive decay of material inside the Earth since it was formed is its internal source of energy.)

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6. Our solar system is a very small part of one of millions of galaxies in the Universe.	Our Sun and eight planets and other smaller objects orbiting it comprise the solar system. Day and night and the seasons are explained by the orientation and rotation of the Earth as it moves round the Sun. The solar system is part of a galaxy of stars, one of many millions in the Universe, enormous distances apart, many of the stars having planets.	■ Y1, Seasonal Change and Y5, Space - Daytime is when the Earth is facing the Sun; night-time is when the Earth is facing away from the Sun. ■ Y3, Light - The Moon reflects light from the Sun. ■ Y5, Space - The Earth's rotation results in day and night. ■ Y5, Space - Planetary objects move in relation to the sun. ■ Y5, Space - Different planets in our solar system have different features. ■ (KS3 - The tilt of the Earth's axis gives rise to seasons.) ■ (KS3 - The movements of galaxies suggest that the Universe is expanding from a past state called the 'big bang', towards a future that is still unknown.)

Vertical Concept	Definition	Units
7. Organisms are organised on a cellular basis.	All organisms are constituted of one or more cells. Multi-cellular organisms have cells that are differentiated according to their function. All the basic functions of life are the result of what happens inside the cells which make up an organism. Growth is the result of multiple cell divisions.	■ Y1, Y2 Plants - Plants have different parts that do different jobs; root, stem, leaves and flowers. ■ Y3, Plants - Flowers have different parts that do different jobs so the flowering plant can reproduce. ■ Y3, Plants - The job of the flower is to create seeds contained in a fruit so the flowering plants can reproduce. ■ Y3, Animals, including humans - Humans and some other animals have a skeleton and muscles for support, protection and movement. ■ Y4, Animals including humans - Humans have a digestive system consisting of multiple organs carrying out different roles. ■ Y6, Animals including humans - The human circulatory system consists of multiple organs carrying out different roles. ■ Y6, Living Things - Micro-organisms are organisms that are so small that we cannot see them with our eyes alone. ■ (KS3 - All living organisms are made of one or more cells, which can only be seen through a microscope) ■ (KS3 - All the basic functions of life – growth, reproduction, extracting energy from food – are the results of what happens inside cells.) ■ (KS3 - Cells are often aggregated into tissues, tissues into organs, and organs into organ systems.)

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8. Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms.	Food provides materials and energy for organisms to carry out the basic functions of life and to grow. Some plants and bacteria are able to use energy from the Sun to generate complex food molecules - they are known as producers. Animals obtain energy by breaking down complex food molecules and are ultimately dependent on producers for energy. In any ecosystem there is competition among species for the energy and materials they need to live and reproduce.	■ Y2, Animals - Living things grow, need, water, air and food, react to their surroundings, move, get rid of waste and reproduce. ■ Y2, Animals - Animals need food, which comes by eating plants (herbivores) or by eating animals (carnivores), which have eaten plants or other animals. ■ Y3, Plants - Leaves make food for the plant. ■ Y2, Living Things & Their Habitats - Organisms are adapted to their environment which is called a habitat. ■ Y3, Plants - For life and growth, plants need air, light, water, nutrients from soil, and room to grow. ■ Y3, Plants - Plants make their own food using sunlight, carbon dioxide and water. ■ Y4, Animals including humans - Plants and animals are dependent on each other. The energy flow between them can be shown using food chains. ■ Y4, Animals including humans - Animals, including humans, need the right type of nutrition which they get from the food they eat. ■ Y4, Living things and their habitats - A living thing's environment can change and this can pose dangers. ■ Y6, Evolution - In any given habitat there is competition among species for the energy and materials they need to live. ■ (KS3 - Decomposers are essential (alongside producers and consumers) for a stable ecosystem.)

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9. Genetic information is passed down from one generation of organisms to another.	Genetic information in a cell is held in the chemical DNA in the form of a four-letter code. Genes determine the development and structure of organisms. In asexual reproduction all the genes in the offspring come from one parent. In sexual reproduction half of the genes come from each parent.	■ Y1, Plants, Animals and Y2 Plants, Living Things - Plants and animals reproduce (have offspring). ■ Y3, Plants - Reproduction in flowering plants is the job of the flower including pollination and seed formation. ■ Y5, Lifecycles - Organisms produce offspring of the same kind, but in many cases offspring are not identical with each other or with their parents. ■ Y5, Lifecycles - Plants and animals, including humans, resemble their parents in many features because information is passed from one generation to the next. ■ Y6 Evolution and Inheritance - Not all information is passed on from one generation to the other in the same way; some skills and behaviour have to be learned. ■ Y5, Lifecycles - Most animals reproduce sexually. Some plants reproduce sexually and others can reproduce asexually. ■ (KS3 - In a human body, most cells contain 23 pairs of chromosomes. These provide information that is needed to make more cells in growth and reproduction.)

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10. The diversity of organisms, living and extinct, is the result of evolution.	All life today is directly descended from a universal common ancestor that was a simple one-celled organism. Over countless generations changes resulted from natural diversity within a species which makes possible the selection of those individuals best suited to survive under certain conditions. Organisms not able to respond sufficiently to changes in their environment become extinct.	■ Y1, Plants, Animals - There is a wide variety of living things. ■ Y2, Living things and their habitats - Most living things live in habitats to which they are suited. Habitats provide for the basic needs of the plants and animals that live in them. ■ Y3, Rocks - Fossils are the preserved remains or traces of living things. ■ Y5, Living things and their habitats - Different animals (e.g. mammals, amphibians, insects, birds) have different life cycles. ■ Y6, Living things and life cycles - Plants and animals are classified based on specific characteristics. ■ Y6, Living things - Plants, animals and micro-organisms are classified based on specific characteristics. ■ Y6, Evolution and inheritance - There are many kinds of organisms that were once alive but are now extinct. We know about extinct animals from fossils. ■ Y6, Evolution and inheritance - Living things are found in certain environments because they have the features that enable them to survive there. This adaptation to their environment has come about because of the small differences that occur during reproduction, resulting in some individuals being better suited to the environment than others. In the competition for materials and energy, those that are better adapted will survive and are more likely to pass on their adapted feature to their offspring. ■ (KS3 - The natural selection of organisms has been going since the first form of life appeared on Earth 3.5 billion years ago.)