Progression in the Science: Summary

Our curriculum has been designed to be the 'progression model' by setting out the specific knowledge we want children to learn, ordering it coherently and building in opportunities to check that children are remembering what they have been taught. This means that as children progress from unit to unit, year to year, they will be learning more and remembering more in science.

An effective science curriculum not only defines essential concepts and procedures for pupils to acquire, but also carefully outlines how pupils will progressively develop their understanding over time. The coherence between the two has been shown by research to be defining aspect of high-quality science curricula (Ofsted Science Research Review, 2021).

To achieve this coherence, the Curriculum pairs 'substantive with disciplinary knowledge, so that disciplinary knowledge is always learned within the most appropriate substantive contexts' (Ofsted Science Research Review, 2021):

- **Substantive knowledge** is 'knowledge of the products of science, such as models, laws and theories' and it is 'organised according to the 3 subject disciplines: biology, chemistry and physics' (Ofsted Science Research Review, 2021).
- **Disciplinary knowledge** is 'knowledge of the practices of science' (Ofsted Science Research Review, 2021).

In the Curriculum, substantive and disciplinary knowledge are intertwined. There is a focus on providing foundational knowledge and understanding (i.e. substantive) before shifting to the application of knowledge through scientific inquiry (i.e. disciplinary). This progression from substantive to disciplinary is intentional in our curriculum to ensure that students have a solid understanding of the concepts before they engage in experimentation.

Substantive knowledge

Substantive knowledge relates to the understanding of concepts, principles, theories, and ideas within science. It involves the understanding of the underlying principles and the "big ideas" of biology, physics and chemistry. The PKC Science curriculum has been organised into these disciplines, along with Earth Science as this is 'frequently considered to be a fourth but is typically taught through the other 3 disciplines in England's schools' (Ofsted Research review, 2021).

Examples of substantive knowledge studied across the curriculum which support pupil understanding of science:

Human Body	Space	Materials	Weather
Beginning in Reception, pupils gain an understanding of basic body parts and the essential roles of bones, muscles, and skin in facilitating bodily actions. They learn that physical or sensory impairments can lead to variations in how body parts function, and they begin to grasp the concept of human development from infancy to adulthood. In Reception, pupils deepen their understanding by learning that all living things, including humans, undergo growth and change throughout their lives. This foundational knowledge evolves in Year 1 as they delve into the five senses and their corresponding body parts, exploring how sensory information is processed by the brain. They become more aware of sensory challenges faced by some individuals,	As they step into Reception, pupils first grasp the notion of Earth as their home and are introduced to the idea of space exploration. They learn about astronauts, the individuals who venture beyond our planet, and understand the significance of the International Space Station. They become aware of the planets within our solar system, appreciating their unique characteristics, and become aware of distant stars. Additionally, they learn about iconic lunar landings and contemporary missions such as the Mars Rover. In Reception, learning circles back to Earth's seasons, reinforcing their connection to the natural world.	Beginning in Reception, pupils grasp the fundamental idea that the Earth and other celestial bodies, such as planets, are composed of various materials, including rock, ice, and gases. Moving into Year 1, pupils explore resources found on Earth. They distinguish between natural and manufactured resources, understanding that natural resources, like wood and metals, originate from the environment, while manufactured resources, such as plastics, are products of human creation. This insight into the origins of materials lays the groundwork for better comprehension of the world around them. In Year 2, pupils expand their knowledge by recognising common materials like wood, plastic, glass, and	During Reception, pupils grasp the basic concept of seasons and changing weather patterns (e.g. warmer springtime). As they move into Year 1, pupils delve deeper into understanding the seasons and weather, differentiating between the characteristics of autumn, winter, spring, and summer. They learn that we anticipate colder weather in autumn and winter, alongside the longer days of sunlight in the summer. Pupils explore the tools used to measure and predict weather, such as rain gauges, weather vanes, thermometers, as well as learning about the cloud types, which expands their understanding of meteorology. They come to appreciate that scientists (called meteorologists) study the weather, utilising computer technology to make weather forecasts, underscoring the

like blindness or deafness. Pupils are introduced to mammals as warmblooded animals that give birth to live young. Year 2 extends their understanding to encompass the fundamental needs of animals, including humans, such as water, food, and air. They discover the significance of the skeletal and muscular systems in enabling movement and begin to understand how the body processes food. Understanding the role of the heart in pumping blood throughout the body and the importance of maintaining a healthy lifestyle adds depth to their knowledge. In Year 3, pupils learn to distinguish between voluntary and involuntary muscles, appreciating their role in mobility, while also understanding the protective function of bones and the brain as the centre of the nervous system. They further their grasp of nutrition's role in sustaining the body and the basic components and functions of the digestive system. Year 4 introduces the concept of cells as the building blocks of the human body and emphasises the importance of nutrition in maintaining overall	Year 1 builds upon this foundation by looking at the intricacies of seasons and weather, enabling pupils to name and describe the four seasons, thereby connecting classroom knowledge to real-life experiences. In Year 2, their knowledge of astronomy develops further as they learn more about the eight planets in our solar system, Earth's orbital journey around the Sun, and the mechanisms behind day and night. They also discover the Moon's orbit around Earth and its role in reflecting the Sun's light. The concept of constellations and the collaborative nature of scientific discovery in this unit further enrich their understanding of space. In Year 3, pupils explore the relationship between Earth's tilt and the changing seasons, deepening their understanding of the natural world's cyclical patterns. Additionally, Year 3 introduces them to the fundamental role of the Sun as Earth's primary source of light and the apparent movement of the Sun in the sky due to Earth's rotation. Year 4 presents the knowledge that space is a vacuum devoid of air	metal. They discern the unique properties of these materials, such as hardness, opacity, and flexibility, and appreciate how these properties influence the purpose for which these materials are employed. Pupils learn that inventors carefully select materials according to their specific properties when designing inventions. They begin to grasp the idea that particles make up materials and understand the differences between solids and liquids, paving the way for a more nuanced understanding of the underlying structure of matter. As they enter Year 3 and Year 4, pupils explore the properties of transparent and opaque materials and learn about rocks: their formation, classifications, and their ability to allow or block the passage of water. The introduction of permeability provides pupils with valuable insights into Earth's geological processes. Also contributing to this knowledge is their learning of how fossils are formed. Pupils extend their knowledge by understanding the concept of states of matter, recognising that water can exist as a solid, liquid, or gas, which is exemplified through the water cycle. They also learn about thermal conductivity and the selection of	significance of this learning for daily life. Building on this foundation, pupils proceed into Year 2, where they broaden their knowledge of environments by studying the weather conditions of diverse ecosystems like deserts and rainforests. In Year 3, pupils extend their knowledge on seasons, understanding Earth's axial tilt and its influence on weather changes throughout the year. They also explore animal migration, which enhances their knowledge of the interplay between weather conditions and where animals may choose to live. This progression in knowledge sets the stage for the exploration of ecology in Year 4, as pupils delve into the roles of producers, which make their own food from sunlight. The transition to Year 4 further deepens their understanding of weather through the water cycle, where they learn about the four stages, humidity and more on cloud formation.

health. Pupils explore different types of teeth and their functions, as well as the process of digestion and excretion, along with the essential vitamins and minerals necessary for the body. Pupils build upon their understanding of humans as mammals, learning that vertebrates have a backbone. In Year 5, students delve into the early stages of human growth: gestation, birth, and infancy. They also explore the physical and mental changes occurring during puberty, and they recognise that humans and animals experience growth stages of varying lengths. Finally, in Year 6, pupils gain an advanced understanding of the circulatory system, realising how the heart pumps blood, blood vessels transport it, and how heart rate can vary based on bodily needs. They also learn the composition of blood. Additionally, they explore reproduction, learning about the roles of male and female cells in fertilisation, the development of a zygote into an embryo and foetus, an exploring gestation in more depth.	particles, strengthening their knowledge of how sound travels. In Year 5, the concept of gravity, as a force that pulls objects toward the Earth's centre, is introduced. Their learning extends further as they learn about the Big Bang theory, the formation and characteristics of galaxies, and our position in the Milky Way. Understanding the complexity of the solar system, comprising eight planets and other celestial objects like asteroids and dwarf planets, contributes to a more comprehensive view of the cosmos. The phases of the Moon, human lunar exploration, and the universe's vastness become integral components of their space schema. Also, in Year 5, the Meteorology unit adds depth to their understanding, connecting the atmosphere's layers and their role in shielding Earth from the Sun's energy, along with the significance of ozone and its environmental implications. Finally, Year 6 delves into the concept of light, differentiating between natural and reflected light, and revealing the spectrum of sunlight.	materials based on their properties. This progression demonstrates the practical applications of materials and how their distinct properties influence their usage. In Year 5, pupils delve deeper into the specifics of properties and materials, including solubility and the processes of dissolution and separation of mixtures. They develop an understanding of reversible and irreversible changes, solidifying their grasp of how materials can transform and be utilised in various scientific contexts.	In Year 5, meteorology becomes the focal point, expanding their knowledge of weather systems and the factors influencing them, from atmospheric layers to air masses and fronts, as well as thunder and lightning.

Disciplinary Knowledge

Disciplinary knowledge involves teaching students the foundational procedures and methods specific to the discipline of science itself. It focuses on how scientists conduct research, make observations, design experiments, and analyse data, following the principles and methods of the scientific community.

The Ofsted Science Research review (2021) identifies four content areas through which pupils make progress in relation to disciplinary knowledge:

Knowledge of methods that scientists use to answer questions

This statement is related to the various types of scientific inquiry, which encompass the ways scientists investigate and seek answers to scientific questions. At the primary level, we can explore the five types of scientific inquiry to teach pupils the methods that scientists use:

Observing Over Time	Pattern-Seeking	Grouping and Classifying	Comparative and Fair Testing	Researching using Secondary Sources
This refers to the observation of a change that occurs over a period of time. The period of time could be seconds, minutes, hours, days, weeks or months. This enables pupils to identify patterns, processes, variations and cycles. By observing over time, pupils can draw conclusions about how, when or why something occurs. Examples of observing over time that occur in the Curriculum:	Pattern seeking is an exploration of how two scientific phenomena link to one another (e.g. the relationship between two variables). This enables pupils to understand the connections between things and helps them to make conclusions about the factors that drive patterns. Examples of pattern seeking that occur in the Curriculum:	In the earlier years, grouping and classifying will start with simple tasks based on easily observable features (e.g. colour). As children progress through the curriculum, grouping and classification will become more complex (e.g. plant and animal cells). Throughout the curriculum, children will make use of tables and diagrams to help them group different things. Examples of grouping and classifying that occur in the	Comparative testing involves two or more groups or conditions to identify the effect of an independent variable (i.e. the thing you're changing) on a dependent variable (i.e. what you're measuring). Fair testing ensures all variables (except for the independent variable that you change) remain constant or controlled throughout. This ensures greater accuracy and reliability of results.	Researching using secondary sources helps pupils to understand how scientific knowledge has been formed and communicated over time. This helps them to build their science knowledge beyond their experiences in the classroom. This can take many forms: information texts, videos, pictures, diagrams, external visitors, museum visits etc. Examples of research using secondary sources that occur

• Y1 Human Body – observing how the size of the pupil changes in reaction to darkness and light • Y2 Materials – how water can change from solid to liquid • Y3 Light – observing how light reflects off different types of mirrors • Y4 States of Matter and the Water Cycle – observing how an ice cube changes state over time in different temperatures • Y5 Materials – observing dissolving and solutions Y6 Reproduction – observing how ginger, garlic and potatoes reproduce asexually •	• Y1 Seasons and Weather – linking weather, plant growth and animal behaviour to seasons Y2 Electricity – what is needed to construct a working electrical circuit Y3 Rocks – understanding ways rocks can be formed • Y4 Ecology – identifying the processes that living things have in common Y5 Living Things and Their Habitats – how newt and other amphibian life cycles are similar Y6 Human Body – how exercise affects heart rate •	Curriculum: • Y1 Materials and Magnets – materials by their properties • Y2 Living Things in Their Environments – things that are living, dead and never alive • Y3 Light - light sources as natural or artificial • Y4 Ecology - parts of a food chain and the organisms that can fulfil those roles • Y5 Materials - materials that dissolve or do not dissolve in water • Y6 Classification of Living Things – the five kingdoms of organisms	Examples of comparative and fair testing that occur in the Curriculum: • Y1 Plants – how cress seeds grow in different conditions • Y2 Materials and Matter – comparing the speed at which ice cubes melt in different conditions • Y3 Rocks – comparing the permeability of different rocks • Y4 Sound – comparing the volume of a drumbeat at different distances • Y5 Materials – which material is the best to keep liquids hot • Y6 Electricity – how the number of batteries affects the brightness of a bulb	in the Curriculum: • Y1 Seasons and Weather – weather data from Met Office • Y2 Human Body – pasteurisation and cowpox to fight off smallpox • Y3 Cycles in Nature – migration patterns • Y4 Electricity – how Thomas Edison and Lewis Latimer pioneered the lightbulb • Y5 Living Things and their Habitats – the work of David Attenborough and Jane Goodall • Y6 Classification of Living Things – using research to add unfamiliar examples to each kingdom

Knowledge of the apparatus and techniques, including measurement

This area of disciplinary knowledge is concerned with how to carry out specific procedures and protocols safely and with proficiency, including the accurate measurement and recording of data. This statement also refers to pupils understanding that all measurement involves some error and that scientists put steps in place to reduce this.

Pupils build their understanding of what constitutes accurate measurement through a collection of methods. For example, repeated measurements, keeping variables consistent and the use of measurement apparatus:

- Y1 Seasons and Weather – repeated measurements of rainfall
- Y2 Plants – comparing the measurement of cress growth in different conditions over time
- Y3 Plants – keeping the variables the same for both plants in a growth investigation
- Y4 Sound – using a decibel app/data logger to measure volume
- Y5 Forces – using a Newton meter to measure friction
- Y6 Human Body – using repeat measurements to measure pulse rate

Knowledge of data analysis

This statement refers to the pupil's ability to 'process and present scientific data in a variety of ways to explore relationships and communicate results to others'

The expectation with each repeated instance is that pupils develop their understanding of how that specific way of recording data is used to communicate the scientific knowledge relevant to that lesson. As such, pupils will use a way of recording data (e.g. tables) a multitude of times but in different contexts each time.

The Curriculum places great emphasis on pupils being able to communicate scientific understanding and that is why instances of data analysis appear in every unit. As a minimum expectation, every unit requires pupils to produce both written explanations and scientific diagrams
with labelling. In each unit, this is complemented by the relevant use of data recording: e.g. table, Venn diagram, bar chart, line graph.

	Autumn A	Autumn B	Spring A	Spring B	Summer A	Summer B
Year 1	**The Human Body** Diagram, labelling, written explanation	**Animals and their Needs** Written explanation, diagram, Venn diagram, labelling	**Seasons and Weather** Wall chart, table, diagram, written explanation, graph	**Taking Care of the Earth** Diagram, labelling, table, written explanation	**Plants** Written explanation, diagram, labelling, table	**Materials and Magnets** Labelling, table, written explanation
Year 2	**The Human Body** Written explanation, labelling, diagram, survey	**Living Things in their Environments** Chart, list, written explanation, diagram, labelling	**Electricity** Table, written explanation, diagram, labelling	**Plants** Diagram, labelling, written explanation	**Materials and Matter** Written explanation, diagram, labelling, table	**Astronomy** Diagram, labelling, written explanation
Year 3	**The Human Body** Table, written explanation, diagram, labelling	**Cycles in Nature** Diagram, labelling, table, written explanation	**Light** Written explanation, diagram, table, labelling	**Plants** Diagram, labelling, written explanation, table	**Rocks** Table, diagram, written explanation, labelling	**Forces and Magnets** Written explanation, diagram, table, labelling
Year 4	**The Human Body** Written explanation, diagram, labelling, table	**Classification of Plants and Animals** Table, diagram, labelling, written explanation, key	**Ecology** Written explanation, diagram, labelling	**Sound** Diagram, table, written explanation, labelling	**The Water Cycle** Diagram, written explanation, labelling	**Electricity** Written explanation, diagram, labelling
Year 5	**The Human Body** Diagram, labelling, table, graph, written explanation	**Materials** Diagram, labelling, table, graph, written explanation	**Living Things** Written explanation, diagram, labelling	**Forces** Diagram, labelling, table, written explanation, graph	**Astronomy** Diagram, labelling, written explanation	**Meteorology** Diagram, labelling, written explanation, table
Year 6	**The Human Body** Diagram, labelling, written explanation, graph, chart	**Classification of Living Things** Diagram, labelling, key, written explanation	**Electricity** Diagram, labelling, written explanation, table	**Light** Diagram, labelling, written explanation	**Reproduction** Diagram, labelling, written explanation	**Evolution** Written explanation, diagram, labelling,

Knowledge of how science uses evidence to develop explanations

This statement refers to how evidence is used to make valid conclusions. This includes pupils understanding that explanation is 'distinct from data and does not simply emerge from it'. Pupils need to understand how 'scientific models, laws and theories develop over time'. For pupils, this knowledge is taught using the table shown in the previous statement above, as well as learning how knowledge is shared within the scientific community:

- Y1 Seasons and Weather – meteorologists convey information about the weather
- Y2 Plants – botanists use botanical sketches
- Y3 Plants – agricultural scientist George Washington Carver encouraging farmers to rotate crops
- Y4 Electricity – inventor Lewis Latimer travelling to Canada, America and London to install electric streetlighting
- Y5 Astronomy – why it is important for scientists to know what other scientists have learned before them •
- Y6 Evolution – Darwin's drawings of the finches