Curriculum Principles: Science

INTENT: A powerful, knowledge-rich curriculum

By the end of their education, a student of Science at Dixons Fazakerley Academy:

- Know fundamental scientific principles from Biology, Chemistry and Physics that will provide a foundation for understanding and navigating the world. Student knowledge is structured around the big ideas in science which range from the particulate nature of matter to the cellular basis of living organisms, to space.
- understand the processes of scientific inquiry that leads to the creation and development of concepts and theories. Students will understand how science can be used to explain observations and make predictions about natural phenomena.

Our uniting 'sentence' is:

"The Science department empowered students to explore scientific concepts and to achieve academic excellence, whilst instilling a sense of excitement and curiosity about natural phenomena."

In order to deliver a powerful, knowledge-rich curriculum we have selected knowledge by:

- scientific knowledge is broadly hierarchical in nature – students must have a secure understanding of each key block of knowledge before progressing onto the next stage. Therefore, to support this, topics and their key concepts have been meticulously planned and ordered to ensure that students are always building on and deepening their previous learning.
- in Biology, at KS2, students develop their understanding of animals and plants and their life processes in KS2. At KS3 students learn about the structure, function and behaviour of living organisms in detail, building up from the microscopic cellular level to the macro-scale interactions in an ecosystem. These topics are extended at KS4, with the expectation that students learn to apply this knowledge and make links with other topics such as photosynthesis and homeostasis.
- in Chemistry, at KS2, students develop their understanding of abstract concepts such as solubility, conductivity and changes of state. At KS3, students start with a rigorous grounding in the fundamentals of secondary level chemistry: states of matter, the periodic table, chemical reactions and the behaviour of materials. Having mastered the foundation knowledge, students are fully equipped with the necessary knowledge and skills to tackle the more challenging KS4 content, such as chemical bonding and quantitative chemistry.
- in Physics, at KS2, students develop their understanding of forces, electricity, sound, light and space – focusing on concrete concepts and experiences, as well as introducing more challenging concepts such as energy, pressure and density. In KS4 the focus shifts to a more quantitative appreciation of the subject matter and develops mathematical skills.
- experimental work should be a key feature of all lessons at KS2 so that students can build confidence working practically and can start to appreciate the nature of scientific enquiry. To ensure all students have the same access to the Science curriculum at Dixons Fazakerley Academy, all students begin Year 7 with the topic 'working scientifically' where these skills are taught explicitly. These skills have been carefully mapped across all topics throughout KS3 and KS4 so that students are given many opportunities to apply and develop these concepts. For example, each topic deliberately includes several opportunities to revisit graph and table interpretation skills.

The threshold concepts in our subject are: …

- All matter in the universe is made of very small particles: students will understand that atoms are the building blocks of all matter, living and non-living. The behaviour and arrangement of atoms explains the properties of different materials. In chemical reactions atoms are rearranged to form new substances. Each atom has a nucleus containing neutrons and protons, surrounded by electrons. The opposite electric charges of protons and electrons attract each other, keeping atoms together and accounting for the formation of some compounds.

- Objects can affect other objects at a distance: students will understand that all objects have an effect on other objects without being in contact with them. In some cases the effect travels from the source to the receiver in the form of radiation (e.g. visible light). In other cases, action at a distance is explained in terms of the existence of a field of influence between objects, such as a magnetic, electric or gravitational field. Gravity is a universal force of attraction between all objects, however large or small. It keeps the planets in orbit around the sun and causes terrestrial objects to fall towards the centre of the earth. Changing the movement of an object requires a net force to be acting on it: Students will understand A force acting on an object is not seen directly but is detected by its effect on the object's motion or shape. If an object is not moving, the forces acting on it are equal in size and opposite in direction, balancing each other. Since gravity affects all objects on earth there is always another force opposing gravity when an object is at rest. Unbalanced forces cause a change in movement in the direction of the net force. When opposing forces acting on an object are not in the same line they cause the object to turn or twist. This effect is used in some simple machines.

- 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: students will understand that many processes or events involve changes and require an energy source to make them happen. Energy can be transferred from one body or group of bodies to another in various ways. In these processes some energy becomes less easy to use. Energy cannot be created or destroyed. Once energy has been released by burning a fossil fuel with oxygen, some of it is no longer availbale in a form that is as convenient to use.
- Organisms are organised on a cellular basis and have a finite life span: students will understand All organisms comprise 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 that make up an organism. Growth is the result of multiple cell divisions. Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. Students will understand that food provides materials and energy for organisms to carry out the basic functions of life and to grow. Green plants and some bacteria are able to use energy from the sun to generate complex food molecules. Animals obtain energy by breaking down complex food molecules and ultimately depend on green plants as their source of energy source. In any ecosystem there is competition among species for the energy resources and materials they need to live and reproduce.
- Genetic information is passed down from one generation of organisms to another: students will understand that genetic information in a cell is held in the chemical DNA. 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. The diversity of organisms, living and extinct, is the result of evolution. Students will understand all life is directly descended from a universal common ancestor that was a simple one-celled organism. Over countless generations changes resulting from natural diversity within a species led to the selection of individuals best suited to survive under certain conditions. Species not able to respond sufficiently to changes in their environment become extinct.

In order to achieve a true understanding of science, topics have been intelligently sequenced based on the following rationale:

- scientific knowledge is broadly hierarchical in nature – students must have a secure understanding of each threshold concept of knowledge before progressing onto the next stage. Therefore, to support this, topics and their key concepts have been meticulously planned and ordered to ensure that students are always building schema. Links have also been made with the maths curriculum to ensure that skills and concepts that are shared across the two subjects match up again to build schema.
- in Biology, in KS2, in biology the students broaden their knowledge of animals and plants, including their respective life processes. At the next progressive level, KS3, pupils delve deeper into the study of living organisms, examining their structural and functional characteristics, as well as their behaviour. This approach works its way up from the microscopic cell to the larger interrelated systems of an ecosystem. Building upon this foundation, the KS4 curriculum encourages students to expand upon their understanding by establishing connections with other topics, such as photosynthesis and homeostasis, while demonstrating the application of their knowledge.
- in Chemistry, at KS2, students at the KS2 level begin constructing their understanding of advanced principles like the ability of substances to dissolve, their conductive properties and changes they undergo in different states. At the next stage, KS3, the curriculum provides learners with a comprehensive basis in the fundamentals of secondary chemistry. They explore concepts such as the states in which matter exists, the elements of the periodic table, chemical transformations, and the traits of various materials. Once these core principles have been cemented, learners are prepared with the required skills and knowledge to take on more complex concepts at the KS4 level, such as quantitative chemistry and the nature of chemical bonding.
- In Physics, at KS2, learners gain knowledge about the essential principles of forces, sound, light, electricity and space. The curriculum emphasises elementary experiences and concrete concepts, in addition to introducing more complex topics such as energy, pressure, and density. Later, at the KS4 level of study, the focus moves towards an increased ability to appreciate the quantitative aspects of the subject matter, thereby developing meaningful mathematical skills.
- At Dixons Fazakerley, each student begins Year 7 with an in-depth introduction to the "working scientifically" topic to ensure that they all have the same foundation. These comprehensive skills have been intentionally integrated across every KS3 and KS4 topic, allowing learners various chances to put them into practice and build upon them. As an example, when interpreting graphs and tables, each subject covers many opportunities to revisit these critical skills.

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The Science curriculum will address social disadvantage and actively seeks to tell the stories of the marginalised by:

- We are careful not to assume any prior general knowledge or cultural capital and always teach new knowledge explicitly.
- the Education Endowment Foundation report (2017), examining the disadvantaged attainment gap in Science, states that the strongest factor affecting pupils' science scores is their literacy levels. In our department, we actively promote literacy in every lesson by explicitly teaching new vocabulary and reading and discussing challenging texts. Our academy-wide 'Rigorous Reading' approach also ensures all students are able to access the texts we read. We also support our students to answer questions in full sentences by verbally modelling sentence starters, giving adequate thinking time and allowing children to 'turn and talk' with a partner to improve oracy. We plan frequent extended writing tasks and support children with verbal rehearsal activities, sentence starters and keywords.
- in addition to frequent formative assessment within class, after each assessment cycle teachers analyse their class booklets along with question level analysis data to identify gaps in students' knowledge. During these data and planning days detailed intervention/prevention plans are produced which target and address these gaps in knowledge. This often takes the form of targeted cold calling during the Do Now, additional scaffolding within the lesson and small group intervention where appropriate.
- all students are taught the same rigorous curriculum. Although students at secondary level are taught in groups, we have the same high expectations of all students – we do not narrow or dilute the curriculum. All students are taught from the same work booklets so that everyone is given access to the same powerful and catalytic knowledge. That being said, teachers understand the need to supplement the work booklets with additional practice/scaffolds or extension material, as required for individual students
- when timetabling we believe that our science curriculum should be delivered to our most vulnerable learners by our most qualified, most accountable and most experienced teaching staff if it is to be equitable and maximise their opportunity to make progress.
- recognising diversity and inclusion is an active effort from all staff in the science department. We believe that our science curriculum should tell the stories of the marginalised for example celebrating the life and contribution of Henrietta Lack's HeLa Cells when teaching mitosis. Also teaching about HIV and drug development and links to the LGBTQIA+ community, and when studying materials at KS3 and KS4 referencing Stephanie Kwolek, the woman who invented Kevlar.

We fully believe Science can contribute to the personal development of students at Dixons Fazakerley Academy by:

- the social development of our students is nurtured through the explicit teaching and practice of effective teamwork and communication skills when working in groups for scientific investigations. Groups are selected by the teacher to ensure that students learn to effectively collaborate with others from different backgrounds or from outside of their friendship groups.
- Science naturally provides many opportunities for balanced discussions of moral and ethical issues. For example, we explore the moral complexities of organ transplant, the controversial use of genetic engineering and the disputed use of stem cells for disease treatment. Students are given time to discuss these issues both in pairs and as a class to allow students to develop spiritually.
- when teaching topics such as the theory of evolution and the 'Big Bang' theory, this provides a chance to develop students' cultural awareness as we can discuss viewpoints of these theories from different religions and cultures. We also discuss historical sexism in scientific developments – for example, the famous case of Rosalind Franklin's discovery of the structure of DNA.
- science lessons also provide a wealth of opportunities to explore personal development relating to physical and mental health. For example, students study the effects of smoking, drugs and alcohol from both a scientific and social perspective. When teaching about the digestive system, students are taught about the importance of a balanced diet and how to interpret nutritional information.
- we want students to become respectful and responsible citizens who contribute positively to society. For example, students are taught in detail about global warming, pollution and energy resources so that they understand the importance of recycling, reducing waste and cutting down their carbon footprint.

At KS3 and KS4, our belief is that homework should be interleaved revision of powerful knowledge that has been modelled and taught in lessons. This knowledge is recalled and applied through a range of low-stakes quizzing and practice.

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Opportunities are built in to make links to the world of work to enhance the careers, advice and guidance that students are exposed to:

- problem solving activities are built into the curriculum that allow students to apply scientific knowledge to certain career-based scenarios.
- each topic has a 'careers spotlight', where students will explore a profession linked to that particular unit of work. For example, when Year 8 students study chemical reactions, they learn about careers in chemical engineering.
- At KS3 an afterschool STEM club introduces students to project work empowering them to work like real scientists, technologists, engineers or mathematicians. Students choose their own topic and methodologies giving them complete freedom over their work and the opportunity to gain a CREST award.

We teach beyond the requirements of the National Curriculum by:

- opportunities to explore the history and philosophy of Science are embedded into the curriculum. For example, reading rich texts about an array of topics, such as: Semmelweis' work on germ theory and how new chemical elements get their names are included to build cultural capital.
- although students' practical skills are no longer assessed through coursework, we believe it is essential that all students can plan and carry out practicals using laboratory equipment safely and accurately so that they are fully prepared for future study and employment. At KS3, we want students to be exposed to a wide variety of practicals, such as investigations into the effectiveness of different brands of indigestion tablets. In KS4 there is a greater focus on the GCSE required practicals – but we are not restricted to this list of experiments.