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TransformED

Northern Ireland Curriculum 2028

An entitlement to excellence and equity

Science

Draft curriculum framework for Public Consultation

This document forms part of a suite of curriculum materials published for consultation

Contents

Vision statement

Pupils' natural curiosity and sense of wonder about the world are cultivated through the learning of science as a disciplined and creative endeavour. Science seeks to explain and describe how our world and the broader universe works at a fundamental level.

By learning key explanatory ideas of science through a coherently structured progression, pupils develop the mental frameworks that allow them to explain familiar phenomena. They recognise patterns in the world around them, ask and answer scientific questions, see connections between different areas of knowledge and develop a command of precise scientific language. These scientific ideas encompass processes operating across different scales: from the atomic and cellular, to the human, terrestrial and cosmic. These support pupils' understanding of natural phenomena and, in turn, themselves, to develop.

Alongside this substantive knowledge, pupils develop the disciplinary knowledge needed to understand how science works and what scientists do. They learn that science is built on prior knowledge and is therefore cumulative and methodical; that many scientific ideas challenge intuition, revealing deeper structures beneath surface appearances; that scientific knowledge is always open to testing and refinement; that our established theories are our best current explanations that have so far stood up to testing; and that science is universal – it can be done by all and belongs to all.

Pupils learn the principles that underpin effective scientific enquiry, including observation and classification, the role of evidence, the development and use of models and the testing and evaluation of ideas. They learn how scientific enquiries generate evidence and how models, observations and reasoning are used to construct and refine scientific explanations. They develop disciplinary knowledge about how scientific claims are judged, how theories are strengthened and how scientific understanding advances over time.

Overall, pupils develop their abilities and strategies to think critically about scientific claims, compare and test ideas against evidence, seek understanding and consistency in explanations and ultimately draw conclusions from scientific evidence. In doing so, they learn that science provides powerful ways of reasoning about complex or unfamiliar situations and recognise the value of scientific thinking in wider contexts.

Science supports key interdependencies across subject areas. It provides contexts for applying mathematical ideas, strengthens understanding of natural processes studied in geography and underpins home economics. Knowledge gained in science also contributes to personal, social, civic and careers education, including understanding the human body, health and the environment.

Subject-specific categories

From Foundation Stage to Key Stage 2, science content is organised into three categories: life sciences, physical sciences and the nature, practices and norms of science. Life sciences is based on biology and physical sciences on physics and chemistry. It is therefore appropriate that these two areas are taught separately. A growing understanding of the nature, practices and norms of science is essential to both, however and can be integrated with content in the other two categories.

In **life sciences**, pupils develop understanding about what life is, focusing on life processes, the structure and function of living things and human health. They explore the diversity of life on Earth, how living things depend on one another and their environments, how organisms survive and reproduce through life cycles and are adapted to their habitats and why conservation is important to protect ecosystems and biodiversity for the future.

In **physical sciences**, pupils build an understanding of non-living systems, focusing on the fundamental principles that govern the physical world. This includes: the structure, properties and interactions of matter; forces, motion and energy; light and sound; the principles of electricity and magnetism; and Earth and space.

Through their study of the **nature, practices and norms of science**, pupils develop and apply their understanding of the many ways in which scientific knowledge can become established and they learn about the values of science and role of science in society.

At Key Stage 3, the curriculum is organised into three subject areas: **biology**, **chemistry** and **physics**. This is underpinned and enveloped by a fourth category, the study of the **nature, practices and norms of science**. These first three categories represent the core disciplines of the natural sciences. Each category considers the ways in which scientists observe the world around us and aim to explain it – in biology, considering living things and how they grow and interact; in chemistry, considering the fundamentals of matter and how our world and the materials within it are configured; in physics, seeking to describe and explain the way the world works and the laws that determine it. This shift from Key Stage 2 into science's distinct disciplines enables deeper, more specialised understanding of each discipline, aligned with how scientific knowledge is developed.

Cutting across these three categories is the fourth category of the nature, practices and norms of science, which represents the key disciplinary ideas and practices of how scientists explore and examine the world around us. This is not an isolated strand to be taught separately. Its knowledge should be applied through the lenses of the three subject-specific areas in order to build and deepen pupils' understanding of how science is conducted and to begin to use some of these approaches for themselves.

The progression is such that the Foundation Stage to Key Stage 2 category physical sciences naturally splits into the Key Stage 3 subjects physics and chemistry and the Foundation Stage to Key Stage 2 area of life sciences continues to Key Stage 3 as biology.

Foundation Stage

Foundation Stage science cultivates and builds on pupils' natural curiosity about the world around them by giving them a new vocabulary for making observations, noticing patterns and asking questions. Exploring real phenomena that they can see, touch and observe, pupils gain the building blocks which will furnish later conceptual understanding of key physical phenomena (e.g. motion, materials, forces, electricity, light and sound). Pupils learn basic facts about the growth, reproduction, variation and interdependence of living things. Through this knowledge, vocabulary and experience, including purposeful play, they begin to form foundational ideas about patterns, change and cause and effect in the physical and natural worlds.

Life sciences

The structure and function of organisms

Pupils should learn:

- that some things are living and some are non-living (and have never been alive)
- to compare what animals (including humans) and plants need to stay alive (including water, food, air, light and a suitable temperature)
- to name and know the function of the main parts of the human body to include limbs, head, neck, hands, feet, eyes, ears, nose, tongue, skin and others, using anatomically correct names
- to observe and name a variety of plants in their natural habitat and name plant organs (including leaf, root, stem, flower)

Growth, reproduction and variation

Pupils should:

- learn that living things grow when they can obtain the materials they need to stay alive
- observe that living things have offspring of the same kind (e.g. sheep have lambs)
- experience natural environments (e.g. touching leaves, bark, listening to wildlife, and exploring natural materials)
- learn the names of a range of common animals

Interdependence of organisms

Pupils should learn:

- to compare different habitats (e.g. woodland, pond, polar habitats)
- that living things depend on a suitable environment and sometimes change their behaviours to adapt (e.g. hibernation, migration)
- that living things depend on each other (e.g. humans and animals depend on plants and/or other animals for food)

Physical sciences

Matter and materials

Pupils should learn:

- that objects are made from one or more materials
- the names, uses and discernible features (e.g. colour, texture, flexibility, transparency) of common materials

Forces and motion

Pupils should experience:

- the difference between objects at rest or in motion (e.g. rolling, sliding and spinning) and compare the effects of different surfaces on their motion (e.g. rough, smooth, wet, dry)
- the force of a push or a pull causing objects to begin to move, stop or change direction or shape

Electricity

Pupils should learn that:

- electricity (from batteries and mains outlets) gives energy to many things in our home to make them work (e.g. televisions), but can be dangerous

Light, sound and waves

Pupils should:

- learn that we see using our eyes
- learn that light is needed to see things, compare a range of common light sources (natural and artificial) and their uses and experience how shadows are formed

- learn that we hear using our ears
- know how to make sounds by striking, plucking or blowing objects (e.g. musical instruments)
- experience a range of common sounds and use the terms 'loud' or 'quiet' to describe them
- recognise the patterns of physical waves (e.g. water waves at a shore or from a pebble dropped in a pond; slinky, rippling fabric)

Earth and space

Pupils should learn that:

- our planet is called Earth
- the Earth goes around the Sun
- the Moon goes around the Earth

Nature, practices and norms of science

Pupils should learn that:

- observing the world around us helps us to learn about how things work
- science involves asking scientific questions, making predictions and noticing patterns to see whether our predictions were correct or not

Pupils should learn how to:

- ask simple questions about what they observe to find out more
- use some simple scientific equipment to observe, measure and record (e.g. magnifying glasses, measuring cylinders)
- interact with living things and the natural environment respectfully
- use simple books and resources to make sense of observations (e.g. to identify plants and animals)
- discuss and share their findings (e.g. from identifying and classifying materials) in different ways (e.g. verbal, pictorial)

Key Stage 1

Key Stage 1 science revisits and consolidates the key concepts and ideas from Foundation Stage, while introducing new knowledge and vocabulary which give pupils the ability to explain more scientific phenomena. Pupils learn how material properties change, how forces affect movement and how light and sound behave. They gain a richer vocabulary for describing, observing and asking scientific questions about the structure and functions of organisms and for classifying and comparing living things, their processes and diverse habitats. They learn to think more explicitly about the work of scientists, considering how scientists use specific methods to answer questions, with pupils gaining experience of scientific observation and experimentation.

Life sciences

The structure and function of organisms

Pupils should learn:

- that growth and nutrition are processes which occur in all living things
- that animals can change location to obtain food (and plants cannot)
- that the human body has bones, muscles and joints for movement, support and protection
- to name some major internal organs in humans (heart, lungs, brain, stomach) and identify their basic functions and approximate position (limited to the chest, abdomen and head)
- that some organs are linked and together carry out a life process (e.g. the mouth and some other organs, including the stomach, form the digestive system and support nutrition)
- the basic functions of plant organs (leaf, root, stem, flower, fruit)

Growth, reproduction and variation

Pupils should learn:

- that plants make their own food from air, water and sunlight (no other details of photosynthesis required)
- that growth can involve different life cycle stages (e.g. flowering plant/butterfly/mammal/amphibian/bird)

- that seeds are the way in which many plants produce offspring
- that in humans and some other animals, a female can become pregnant and a baby can be born
- that some diseases in plants and animals are caused by germs
- to compare the features (e.g. temperature, weather, landscape) of different habitats (e.g. tropical rainforest, desert, woodland, polar) and how animals have characteristics that allow them to live there
- to identify a variety of plants (common wild and garden plants including deciduous and evergreen trees) and animals in some local habitats and micro-habitats (e.g. in soil, tree, hedge, pond)
- that simple classification keys can help group and name/identify animals (e.g. vertebrates and invertebrates) and plants (e.g. flowering and non-flowering)

Interdependence of organisms

Pupils should learn:

- that organisms live in habitats where they are able to survive
- about simple food chains (including the terms carnivore, omnivore, herbivore, predator and prey)
- that some organisms rely on others for protection and living space (e.g. birds nesting in trees, fish in coral)
- about biological and behavioural changes of organisms across the four seasons (including deciduous trees, hibernation, migration)
- that some living things have become extinct and that this can occur when a habitat changes (e.g. dinosaurs)

Physical sciences

Matter and materials

Pupils should learn:

- that the properties of a material determine its specific uses (e.g. flexibility, buoyancy, absorbency, transparency)
- that materials can exist in different states i.e. as a solid, liquid or gas (e.g. the material water can exist as a solid (ice), liquid (water) or gas (steam)) and that heating or cooling can change a material's state
- that temperature is a measure of how hot or cold something is and that hot and very cold objects can be dangerous

Forces and motion

Pupils should:

- experience how an object's speed can be increased (e.g. by increasing the incline of a slope, or the force of a push) or decreased (e.g. by friction from a surface, or colliding with another object)
- experience and name a range of contact and non-contact forces, including friction, magnetism and gravity and know how they affect the movement of an object

Electricity and magnetism

Pupils should learn:

- that the force magnets exert is called magnetism
- that not all metals are magnetic
- that magnets have north and south poles and that like poles repel each other and opposite poles attract each other
- that the strength of a magnet and the distance between magnetic objects affects the size of the force

Light, sound and waves

Pupils should learn:

- that the eye senses light and to name the visible parts of the eye including the eyeball, eyelid, eyelashes, pupil and iris
- that we can only see an object if it reflects or emits light
- to explore how light passes through materials and classify them as transparent, translucent or opaque
- that light travels in straight lines from its source until it hits an object and that for opaque objects this explains how shadows form
- the basic parts of the ear including the outer ear, ear canal, ear drum
- that sounds are made by vibrations, which can travel through air or other materials as waves and be heard when vibrations reach our ears
- to explore how waves carry energy from one place to another; some we can see (e.g. water waves) and some we cannot see (e.g. sound)

Earth and space

Pupils should learn:

- that stars are spherical, giant balls of hot gases which emit heat and light
- that the Sun is a star that is much closer to us than all the others and that sunlight from the Sun brings energy to Earth providing light and warmth
- that Earth is a planet – a rocky mass which does not burn or emit light
- that our Solar System includes the Sun and planets that orbit it and that some planets can be seen with our eyes in the night sky
- to name the planets in order of increasing distance from the Sun

Nature, practices and norms of science

Nature of science and scientific knowledge

Pupils should learn that:

- in science we carry out scientific enquiries to explain how the world works
- different scientific questions are answered in different ways (e.g. classification can be used to sort materials into groups, whereas observing over time can be used to understand plant growth)

Investigating scientific questions

Pupils should learn how to:

- ask simple scientific questions and answer them using classification, identification and carrying out simple tests (appropriate to the content in this key stage)
- observe and talk about demonstrations that illustrate familiar and unfamiliar scientific phenomena and ideas
- use simple scientific apparatus to observe, measure and record (e.g. hand lens, ruler, stopwatch, egg timer), using units of measure where appropriate
- identify risks and suggest simple safety measures

Analysis, interpretation and communication

Pupils should learn how to:

- use different approaches to present scientific observations and data (e.g. tally charts, pictograms)
- use books and other secondary sources to help interpret data
- use the results of an investigation to reach and share simple conclusions about the questions we are trying to answer

Key Stage 2

At Key Stage 2 pupils build on their prior learning to gain a greater depth of understanding of concepts, structures and the nature of scientific enquiry. Key ideas from Key Stage 1, such as the nature of matter and living things, are built on with greater nuance and depth. The models used to explain scientific phenomena are more conceptual and abstract than those encountered in Key Stage 1, with this key stage equipping pupils with the knowledge, skills and conceptual understanding that will best support them to access future learning in Key Stage 3 (when they will engage in the three natural sciences as separate disciplines for the first time). Building on Key Stage 1, pupils continue to explore and grow their understanding of the way in which science is conducted and the role of science in society.

Life sciences

The structure and function of organisms

Pupils should learn:

- that the common processes in all living organisms are growth, nutrition, movement, obtaining energy from food, reproduction, excretion and sensitivity
- that many living organisms require oxygen and produce carbon dioxide in the process of getting energy from their food
- that plants by contrast are 'self-feeding' organisms which use resources from their environment (water, carbon dioxide, sunlight) to make food and oxygen via the process of photosynthesis
- how water is transported in plants, limited to the direction (soil > root > stem > leaf)
- about the basic structure and function of the human respiratory system (including and limited to lungs, trachea, bronchi, diaphragm, ribcage) and circulatory system (including and limited to heart, blood vessels, blood), linking these to life processes (e.g. obtaining and transporting oxygen and nutrients around the body)
- that microscopic examination of organisms shows that all living things are composed of units called cells

Growth, reproduction and variation

Pupils should learn:

- that reproduction is a characteristic process of living things, producing offspring of the same kind
- about the structure and function of parts of an insect-pollinated flower and the life cycle of flowering plants: flower production > pollination > fruit formation > seed dispersal > growth
- that reproduction in humans and other animals occurs between a male and a female and that fertilisation can be external (e.g. in amphibians) or internal (e.g. in mammals)
- the basic names of male and female reproductive organs needed to understand puberty (ovaries, testes, uterus)
- that organisms are adapted to their habitats and that fossils can provide information about organisms which lived on the Earth millions of years ago
- that organisms can be grouped based on their similarities and differences, including groups within a larger group, to include plants (flowering and non-flowering), animals (insects, fish, amphibians, reptiles, birds, mammals), fungi (moulds and mushrooms), and bacteria

Interdependence of organisms

Pupils should learn:

- about food chains of different lengths (including longer marine food chains) and that plants are producers and animals are consumers
- that in addition to feeding relationships, there are many examples of the interdependence of organisms (e.g. pollination by insects, seed dispersal by vertebrates, oxygen production by plants)
- different types of microbes (e.g. bacteria and viruses) exist and can impact human health and that vaccination helps the body recognise and remove them, and reduces transmission
- the term 'biodiversity', limited to species biodiversity and habitat biodiversity (the variety of species within a habitat and the variety of habitats in a particular area, e.g. a garden, a country)
- about ways in which human activities can change habitats and how these can positively (e.g. afforestation for carbon capture) or negatively (e.g. deforestation, air and water pollution) impact upon both species biodiversity and habitat biodiversity

Physical sciences

Matter and materials

Pupils should learn:

- that all materials are made of tiny units called particles (e.g. iron, carbon dioxide); in solids they are tightly packed in a fixed structure and can only vibrate in place, in liquids they can move around each other whilst still touching and in gases they are far apart and move freely
- that mass is the amount of matter in an object and is measured in grams (g) and kilograms (kg)
- that heating a material makes its particles move (or vibrate, if solid) faster and can cause a change from solid to liquid to gas
- the changes of physical state that occur due to heating and cooling (melting, boiling, evaporating, condensing, freezing) and how these apply to the water cycle and rock formation
- that heat is transferred through materials and to categorise materials as thermal conductors or insulators
- about types of changes that can be reversed (e.g. melting, freezing) and types of change that cannot be reversed (e.g. rotting, cooking)

Forces and motion

Pupils should learn that:

- energy is needed for things to happen. It can be stored in different ways, including in moving objects, in warm objects, in stretched or squashed objects, and in raised objects
- energy can be transferred between different stores, but it cannot be created or destroyed (it is always conserved)
- energy is measured in Joules (J)
- forces can exert pushes, pulls or twists and are measured in Newtons (N)
- forces can speed objects up, slow them down or change their direction (including resistive forces of friction)
- air resistance and water resistance are types of friction and are contact forces that oppose the movement of objects

Electricity and magnetism

Pupils should learn:

- that electricity flows through complete circuits and not through incomplete circuits
- to build simple circuits with common components (battery, switch, bulb, buzzer)
- that electricity provides the energy required for changes in components (e.g. bulb lighting, buzzer sounding, motor acting)
- that electric current is the flow (movement) of electricity and that series circuits have only one path for the current to flow around
- that electrical conductors allow electric current to pass through them and electrical insulators do not
- the difference between renewable and non-renewable sources of electricity and know some examples of each

Light, sound and waves

Pupils should learn:

- that light can transfer energy from one place to another and that when light is absorbed, the energy can be stored in different ways, for example by warming objects (thermal energy)
- to observe and compare how shadows change depending on the relative orientation and distance between an object and a light source
- that mirrors reflect light to show an image of an object and to experience reflection of a light ray using a plane mirror and multi-mirror arrangements (e.g. simple periscope)
- to observe that white light (including sunlight) is made up of a spectrum of colours that can be split when passing through transparent materials (e.g. prism, raindrops)
- that sound waves can travel through solid, liquids and gases

Earth and space

Pupils should learn that:

- the planets are arranged in order of increasing distance from the Sun and can be named in that sequence.
- the Earth spins on its axis once every day, causing night and day and making the Sun appear to rise in the east, move across the sky and set in the west

- a year is how long it takes the Earth to orbit the Sun and that the Moon orbits the Earth about once a month
- that the seasons are caused by the tilt of the Earth's axis towards or away from the Sun at different times of the year
- the Sun provides the majority of energy on Earth (directly and indirectly)
- our planet has an atmosphere, made up of gases, that is held by gravity. It contains the oxygen we breathe, traps heat and protects us from harmful sun rays and from meteors that burn up in it
- there are millions of solar systems in our galaxy (the Milky Way) and that the universe contains many galaxies
- humans can learn about Earth from space (e.g. about Earth's weather from cameras and measuring devices on satellites and the International Space Station)
- humans can learn about space by observing from Earth, or going into space itself (e.g. to enable close-up images of planets and clearer images of outer space unaffected by our atmosphere)

Nature, practices and norms of science

Nature of science and scientific knowledge

Pupils should learn:

- that a range of approaches are used in science to understand the world around us, to include:
    - fair and comparative tests
    - observation, identification and classification
    - looking for and recording patterns
    - making things
    - using secondary sources of data
- that measurements should be repeated to check if the results are the same, or similar (and know why differences might arise)
- that in science we make predictions and test them, using evidence from enquiries to support or disprove hypotheses
- that science is never complete and that theories are updated if new evidence emerges

- that science is a collaborative field and that the findings of science belong to everyone
- about local and international scientists and their contributions to the world

Investigating scientific questions

Pupils should learn how to:

- ask relevant scientific questions and identify different scientific approaches to investigate these
- plan and conduct observational enquires (on living and non-living objects of study from this key stage)
- plan and conduct comparative investigations and fair tests (in both the physical and life sciences), including:
    - how to identify variables
    - how to independently select and use appropriate scientific apparatus
    - how to identify risks and suggest safety measures when working scientifically
    - how to make observations and use a range of equipment to record a variety of simple measurements using standard units (including: length, area, capacity, mass, temperature)
    - how to use appropriate approaches to gather and record data in a variety of formats (e.g. numerical, tables, tally charts, sketches, maps)

Analysis, interpretation and communication

Pupils should learn how to:

- identify links, patterns and relationships from data and make predictions for further outcomes
- use appropriate approaches to present scientific data (e.g. diagrams, line graphs, bar charts)
- make appropriate conclusions on findings from investigations, reporting and presenting these in oral or written form and suggest improvements for further investigations
- use relevant scientific facts and evidence to support or challenge claims

Key Stage 3

At Key Stage 3, for the first time pupils build their knowledge of science through the lenses of the discrete but inextricably connected three natural sciences of biology, chemistry and physics, spending an equal proportion of curriculum time studying each discipline. Pupils learn facts, descriptions, explanations, relationships and processes in all three disciplines. This knowledge opens up understanding of the natural world and allows pupils to predict and explain how the world around them works by linking observations and evidence to underlying theoretical principles and laws. This empowers pupils to participate both as scientists and as citizens in a society with science at its core. At the same time, teachers explicitly draw pupils' attention to overarching ideas that pervade and connect all three disciplines. These include reducibility (explaining phenomena by identifying and considering the constituents of a system), equilibrium, change resulting from difference and conservation (e.g. of energy, matter, mass, momentum). Thus, pupils learn to recognise both the independence and the unity of the sciences. A deeper understanding and proficiency in scientific enquiry are developed, as is a greater appreciation of the universality of science (that science can be done by all and belongs to all) and of applications of science and its role in society. Teachers cultivate enduring positive impressions of science and ensure that pupils understand the potential and right of all citizens to engage with scientific questions which affect humankind.

Biology

The structure and function of organisms

Life processes

Pupils should learn:

- that respiration is the process by which energy is released from food in all living organisms
- that plants produce glucose from carbon dioxide and water using light energy absorbed by chlorophyll in the process of photosynthesis and they use glucose for energy, growth and storage
- the word equations for photosynthesis and respiration and know how these two biological processes are connected through their reactants and products
- that enzymes are biological catalysts
- about the process of digestion which involves enzymes, such as amylase and protease, which break down food into smaller, absorbable molecules

Levels of organisation

Pupils should learn:

- that cells are the basic unit of life and that plants and animals are multicellular organisms
- the structure of animal and plant cells (as seen under a light microscope) and the functions of key organelles
- that in most multicellular organisms, cells are organised into tissues and examples of specialised cells in plants and animals (e.g. root hair cells, muscle cells)
- the structural adaptations of some unicellular organisms (e.g. Paramecium, Chlamydomonas)
- how plant organs (leaf, root, stem, flower, fruit) support life processes, including how tissue layers present in typical leaves contribute to photosynthesis
- the structure and function of the main human body systems and how these systems work together and interact:
    - digestive system: mouth, oesophagus, stomach, small intestine (ileum only), large intestine, rectum, anus
    - circulatory system: heart (including four chambers), arteries, veins, capillaries, blood (including red blood cells, white blood cells, platelets, plasma)
    - respiratory system: nasal cavity, trachea, bronchi, bronchioles, lungs, diaphragm, ribcage, intercostal muscles

Growth, reproduction and variation

Growth and reproduction in plants and animals

Pupils should learn:

- that organisms grow by increasing the number and size of their cells
- about reproduction in flowering plants, including wind and insect-pollination, fertilisation, seed and fruit formation and dispersal methods
- that some organisms can reproduce asexually, including some plants and microbes
- the structure and function of the organs of the male and female reproductive systems in humans, including the stages of the menstrual cycle
- about fertilisation following sexual intercourse and about pregnancy and childbirth

Health and infectious diseases

Pupils should learn:

- that physical health is the condition of your body and that ill health can be caused by pathogenic microbes, lifestyle, your environment, or may be inherited
- about the impacts of exercise, asthma and smoking/vaping on the human respiratory and circulatory systems
- that some diseases in humans and other animals and plants are caused by pathogens (viruses, bacteria, protists and fungi)
- about the role of plant defences including the leaf cuticle and cell wall
- that symptoms of disease appear only when pathogens multiply to sufficient numbers
- how disease-causing pathogens are transmitted in animals and plants (including sexually transmitted infections in humans) e.g. through direct contact, sexual contact, airborne droplets, contaminated food or water and vectors such as insects
- that the human body can fight pathogenic infection through non-specific and specific defence mechanisms (no detailed immune response required)
- that medicines, including antibiotics, antifungals and analgesics, can be used to treat the causes/symptoms of some diseases
- how infection risk can be reduced through hygiene, sanitation, safe food handling, vaccination and contraception

Variation, adaptation, inheritance and evolution

Pupils should learn:

- that fertilisation is the fusion of nuclei containing deoxyribonucleic acid (DNA), passing coded genetic information from parents to offspring (inheritance) in the form of genes, carried on chromosomes
- that mutations are heritable changes in DNA and can have positive, negative, or neutral effects
- about the mechanism of evolution by natural selection and that fossil records provide some evidence for this process

Classification and identification

Pupils should learn:

- that organisms are classified into hierarchical groups according to common observable physical and behavioural characteristics which are based on similarities and differences (including at the macroscopic and cellular level)
- the main classification groups include kingdom, phylum, class, order, family, genus and species
- that scientists may use both common and scientific names for organisms
- that a species is a group of similar organisms which can successfully reproduce together and produce fertile offspring
- how to construct and interpret simple keys which can be used to identify living organisms both in the lab environment and in the field

Interdependence of organisms

Interdependence

Pupils should learn:

- that photosynthetic producers (plants, algae) are the main producers of food for consumers and that biomass production in a habitat depends upon plant growth
- about energy losses through food chains and food webs
- about the role of microbes (bacteria and fungi) in the recycling of matter via the decay food chain and about the conditions which promote decay

Environmental interactions and processes

Pupils should learn:

- that an ecosystem is made up of a biological community and the physical environment with which it interacts and about biotic and abiotic factors
- that materials needed for life are limited on Earth and are recycled through ecosystems (e.g. water, carbon [simple carbon cycle only])
- how to investigate the plants or animals living in a habitat, through sampling (e.g. grassland, woodland) and explore how observations are linked to environmental conditions and adaptations

Biodiversity and human impact

Pupils should learn:

- about the levels of biodiversity (including species, habitat, genetic and ecosystem biodiversity) and how humans can conserve biodiversity at each level
- that greater diversity and interactions with ecosystems increase their complexity and resilience to change
- about the benefits of biodiversity to humans including food security, clean water and medicines from plants and animals
- how climate change affects habitats, including rising temperatures, melting polar ice, coastal flooding, extreme weather
- about the impacts of habitat changes on biodiversity, including effects on adaptation and species interactions
- that biodiversity of organisms is dependent upon biodiversity of habitats and that changes in consumer (animal) biodiversity and producer (plant) biodiversity interdepend (e.g. the abundance of one species can impact upon others)

Chemistry

Matter

Atoms and elements

Pupils should learn:

- that atoms are tiny particles that are the building blocks of matter
- that elements are substances consisting of only one type of atom (e.g. gold)
- that the periodic table is a systematic arrangement of elements into groups and periods based on their properties
- how metals and non-metals are organised on the periodic table and the difference between their properties (e.g. state at room temperature, hardness, malleability, conductivity, appearance)
- the names of groups I, II, VII & 0 on the periodic table and about the characteristic properties of the elements in these groups
- that atoms consist of a nucleus containing protons and neutrons, with electrons orbiting in shells
- about the charges of protons, neutrons and electrons

- that atoms of an element always have the same number of protons which defines the element
- that electrons are arranged in shells around the nucleus and how to draw an electron configuration

Matter and materials

Pupils should learn:

- about the following terms to describe the properties of materials:
    - melting point
    - boiling point
    - malleable
    - ductile
    - brittle
    - crystalline
- that materials are made from substances that can either be elements or compounds
- that compounds are made from two or more different types of atom chemically joined together (e.g. carbon dioxide)
- that mixtures are made from more than one substance (e.g. salty water is made from salt and water)
- how to represent examples of elements, compounds and mixtures using particle diagrams
- the names and formulae for some common elements, compounds and mixtures
- about the difference between pure and impure substances and that pure substances have specific melting points
- that mixtures can be separated into components by physical methods and that common separation techniques include:
    - sieving
    - filtration
    - evaporation
    - simple distillation
    - fractional distillation
    - chromatography

- about examples of chemical tests that can be used to identify different substances, to include:
    - tests for hydrogen, carbon dioxide and oxygen gases
    - flame tests for sodium, potassium, calcium, lithium and copper(II) ions
- that molecules are the combination of two or more atoms bonded together and how to identify examples in both elements and compounds from particle diagrams
- about the proportions of different gaseous elements and compounds present in air
- that substances either have an atomic/molecular structure or a giant lattice structure and know everyday examples of each (e.g. salt, oxygen, neon and diamond)

Physical changes and chemical reactions

Physical changes

Pupils should learn:

- about the arrangements, movement and energy of atoms and molecules in solids, liquids and gases
- about the physical properties of solids, liquids and gases in terms of the movement and energy of particles
- that solids, liquids and gases can expand when heated
- that changes of state occur when matter transitions between solid, liquid and gas form without changing chemical composition and that mass is conserved during changes of state
- how changes of state occur in terms of the particle model and energy changes (to include sublimation and deposition)
- that gases have mass and that they exert pressure on the walls of their containers (and objects within containers) through collisions
- that diffusion is the net movement of particles from an area of higher concentration to an area of lower concentration
- that state changes and dissolving are examples of physical changes, which tend to be reversible
- the difference between the terms soluble, insoluble, solute and solvent and how to draw particle diagrams for soluble and insoluble substances
- how to investigate the varying solubility of different solids in water
- how to investigate the effect of temperature on solubility

Chemical reactions

Pupils should learn:

- that chemical reactions (changes) involve the rearrangement of atoms and molecules to form new substances
- that mass and energy are conserved in a chemical reaction
- the difference between exothermic and endothermic chemical reactions, in terms of the energy changes in the reactants, products and surroundings
- how to represent elements and compounds using chemical symbols and formulae
- how to represent chemical reactions using word equations
- how to represent simple chemical reactions using unbalanced symbol equations
- about the reactivity series (including the common metals and carbon) and how the relative reactivity of metals can be determined by comparing reactions with oxygen/acids/water/other metals
- some common indicators of chemical changes (e.g. colour change, gas production, temperature changes, production of a new substance)
- the characteristic features of a range of chemical reactions, including reactants, products and expected observations (e.g. oxidation, reduction, thermal decomposition, acid-base, acid-metal, acid-carbonate, metal-water, displacement)
- how common chemical reactions feature in industrial processes important for society (e.g. combustion in power plants)
- that a range of materials can be produced by industrial processes with unique properties that significantly differ from everyday elements and compounds, including alloys, polymers, ceramics
- that industrial processes are used to develop novel medicines and pharmaceutical products to support human health (e.g. production of the COVID vaccine)
- that aqueous substances have a pH value which describes whether they are acids, bases or neutral substances using the pH scale
- how to use indicators to identify substances as being acidic or basic (alkaline)
- that chemical changes are often irreversible and can be sped up or slowed down by changes in the temperature, concentration or surface area

- how to investigate the factors that affect the rate of a chemical reaction, to include:
    - effect of temperature
    - effect of concentration
    - effect of surface area
- that catalysts are substances that increase the rate of chemical reactions without being used up, allowing reactions that would otherwise not be possible to take place

Physics

Forces and energy

Forces

Pupils should learn:

- that forces have both magnitude and direction
- how to use a Newton meter (spring balance) to measure the magnitude of a force
- that multiple forces can combine to create a resultant (net) force acting on an object
- that a resultant force of zero indicates balanced forces (equilibrium) and a non-zero resultant force indicates unbalanced forces
- that all objects (e.g. the Earth, the Moon) attract other objects via the non-contact force of gravity, the strength of which increases with mass and decreases with distance
- that weight is the force on an object due to gravity acting on its mass
- that reaction force is an equal and opposite force occurring when objects are in contact with a surface (as per Newton's third law)
- that density quantifies the mass in a given volume
- that the relative density of an object compared to the fluid around it determines whether it will float or sink (its buoyancy)
- that the turning effect of a force is the moment (force applied x perpendicular distance from fulcrum) and that when clockwise and anticlockwise moments are equal the state is in equilibrium
- that levers, pulleys and gears can amplify the effect of a force by creating a greater moment about a fulcrum
- that pressure is a measure of the amount of force acting over an area, increasing with greater force and decreasing with greater surface area

- how to calculate pressure on surfaces using pressure = force ÷ area
- that solids can exert pressure through surfaces in contact, whilst liquids and gases, i.e. fluids, exert pressure on the walls or contents of their containers (e.g. on all objects on Earth by the atmosphere), increasing with depth and density

Energy

Pupils should learn:

- that energy is an idea that scientists use to explain why things are able to move or change
- about different stores of energy (e.g. kinetic, chemical, thermal, gravitational, elastic, electrostatic, magnetic, nuclear) and that energy can be transferred between stores
- that energy can be transferred via heating, electrical working, radiation, or mechanical working
- that in most energy transfers, some energy is dissipated (e.g. wasted as sound or heat to the surroundings)
- that power is the rate of energy transfer and is measured in Watts (W)
- that efficiency is the proportion of energy a device transfers to useful energy output
- that momentum tells us how hard it is to stop an object (e.g. comparing a bus and a bee moving at same speed) and is the product of mass and velocity

Motion

Pupils should learn:

- that speed is a measure of the distance an object travels in a given time (measured in metres per second) and that acceleration is the increase or decrease of speed
- to calculate variables in a journey using distance = speed × time
- to interpret distance-time and speed-time graphs qualitatively
- that an object continues in its state of rest or uniform motion unless acted upon by an unbalanced force (Newton's First Law)
- that an object will accelerate if acted upon by an unbalanced force (Newton's Second Law)
- that if two different objects exert forces on each other, these forces have equal magnitude but are in opposite directions (Newton's Third Law)

Electricity and magnetism

Energy and electricity

Pupils should learn:

- that insulators can be electrically charged by transferring electrons to or from them
- that like charges/charged objects repel each other and opposite charges/charged objects attract one another
- that if charges build up they can flow (discharge) between charged objects (e.g. lightning from storm clouds)
- that electric current is the flow of electrons in conductors, which requires a potential difference (voltage) between two points in a circuit
- that resistance is a property of all materials and components and that it moderates the flow of electric current
- that current is measured in amperes, or amps (A), potential difference is
- measured in volts (V) and resistance is measured in ohms (Ω)to compare the flow of current in series and parallel circuits and how to build these circuits
- how to use ammeters and voltmeters to measure the current and potential difference in series and parallel circuits
- how to use symbols for the following components to draw series and parallel circuit diagrams:
    - cell/battery
    - resistor
    - bulb
    - voltmeter
    - ammeter
- about the advantages and limitations of renewable and non-renewable sources of electricity and how different sources are used in the local electricity network to provide electricity to homes and industry
- that the majority of energy sources are directly or indirectly derived from solar energy and that the Sun's energy is a result of nuclear fusion (nuclei combining to release energy, no other details necessary) and that in contrast, nuclear fission power plants release the potential energy stored in atoms by breaking them apart

Magnetism

Pupils should learn:

- that all magnetic materials create an invisible magnetic field around them and how a compass can be used to measure the direction of magnetic field lines
- the shape of the magnetic field lines formed around a bar magnet and how to plot these field lines (e.g. using iron filings; plotting compasses)
- that the Earth creates its own magnetic field due to motion of its molten core creating electric currents, how to draw the Earth's magnetic field lines and that this field shields us from harmful particles

Waves

Waves and sound

Pupils should learn:

- about the differences between longitudinal and transverse waves and examples of each (including sound and light)
- about amplitude, frequency and wavelength
- that amplitude and frequency determine the loudness and pitch of sounds
- that the audible frequency range of human ears is approximately 20 Hz to 20,000 Hz and that this range declines with age
- that the speed of sound in air is approximately 330 m/s and that sound cannot travel in a vacuum

Light and colour

Pupils should learn:

- how to construct simple ray diagrams for point and extended sources of light
- that for a plane mirror the angle of incidence is equal to the angle of reflection (the law of reflection)
- how to construct simple ray diagrams involving plane mirrors, including the virtual image
- that refraction can occur when light changes speed and therefore direction when passing through transparent materials
- about some applications of reflection and refraction (e.g. telescopes, optical fibres, endoscopes)

- that dispersion is the splitting of white light to form a colour spectrum
- that an object's colour appears as it does (in white light) because the object's surface reflects that colour and absorbs the other colours
- that the speed of light in a vacuum is approximately 3×10^8 m/s and that nothing in the universe can accelerate past the speed of light

Space

Sun, Moon and stars

Pupils should learn:

- that the planets orbit the sun in elliptical orbits
- that a light year is the distance travelled by light in a vacuum in one year and to compare the proximity of the Sun (~8 light minutes away) and the nearest star beyond the Sun (Proxima Centauri, approximately 4.2 light years away)
- to compare the relative sizes of the planets and the Sun (e.g. that the volume of the Sun is about 1 million times that of Earth)
- that the illuminated portion of the Moon changes 'shape' over the course of its one-month orbit around Earth due to the relative positions of the Earth, Moon and Sun and these different 'shapes' of the Moon are called lunar phases
- that the Moon affects tides on Earth
- that solar and lunar eclipses occur due to the relative positions of the Earth, Moon and Sun
- that the Earth's atmosphere is a mixture of gases, primarily nitrogen and oxygen

Solar systems and the universe

Pupils should learn:

- about the history of heliocentric and geocentric Solar System theories (e.g. Ptolemy, Copernicus, Galileo, Kepler)
- about the use of artificial satellites in navigation, communication, weather forecasting and space research (e.g. the International Space Station, James Webb telescope)
- about exploration of space to understand where and how life might exist beyond Earth and how scientists detect possible signs of it

Nature, practices and norms of science

Nature of science and scientific knowledge

Pupils should learn:

- that a range of approaches are used in science to understand the world around us, to include:
    - experimental investigations, including fair tests
    - correlational and comparative studies
    - observation (including dissection), identification and classification
    - developing and using scientific models
    - making things including chemical synthesis
    - using secondary sources of data
- that scientific theories are used to predict and explain observable phenomena, and must be testable based on hypotheses based on evidence
- that science is universal: scientific claims are evaluated solely by the quality of evidence and reasoning, not by who made them
- that scientific theories are constantly tested and updated if new evidence emerges; our established theories have stood up to such testing
- that simplified models are used in science to approximate complex systems and phenomena; all models have limitations and depend on well-defined assumptions
- that scientific enquiry involves people seeking to solve problems and so is social in nature and must consider ethical implications
- that when evaluating information, scientists should:
    - be aware of potential impacts on the reliability of data (e.g. sample size)
    - consider whether relevant variables have been effectively controlled
    - consider the possible effects of measurement errors on calculations
    - consider the potential bias of those making claims about science and try to distinguish fact from opinion when evidencing claims
- about famous scientists and their work, including scientists from Northern Ireland

Investigating scientific questions

Pupils should be able to:

- identify scientific questions that can be answered through different scientific approaches
- plan and conduct a range of scientific enquiries (including experimental, observational and comparative)
- identify independent, dependent and controlled variables when conducting fair tests
- use laboratory apparatus safely, identify risks and suggest safety measures and know the meaning of common hazard symbols
- carry out measurements using SI units, being aware of the precision/error of the measurement devices used (including length, area, volume, mass, temperature, force, current, potential difference, speed)
- use different approaches to collect data (including tables, tally charts)

Analysis, interpretation and communication

Pupils should be able to:

- interpret and use simple formulae to represent relationships between variables and quantities
- calculate the mean value of a quantity based on a set of experimental data, identifying and excluding anomalous results when appropriate
- present data to a required number of decimal places
- convert units between orders of magnitude (e.g. metres to kilometres, grams to milligrams)
- use different approaches to present data (including line graphs, bar charts)
- identify patterns from data, interpolate and extrapolate trends and identify anomalous results
- develop scientific explanations linking experimental data and evidence to conclusions
- evaluate the strengths and weaknesses of different approaches to answer the same scientific question

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