Developing a Primary Science Curriculum: Recommendations based on the Primary Curriculum Advisory Group's Framework

Foreword

In 2018, the Primary Curriculum Advisory Group (PCAG) was established by the professional bodies: the Royal Society of Chemistry (RSC), the Royal Society of Biology (RSB), the Institute of Physics (IOP) and the Association for Science Education (ASE). We asked PCAG to produce advice on the future of the primary science curriculum, to support our own work on considering the science curriculum from ages 5 to 19.

As the professional bodies, we brought together highly regarded educators with experience and expertise in primary science to form PCAG and are enormously grateful to them for their commitment to this project and the imagination and intelligence that they have brought to it. They have drawn on evidence from a wide variety of sources and had meetings with many additional experts in the field – and continued at pace through the pandemic.

We consulted on the initial proposals for a framework for a Future Primary Science Curriculum with groups and committees belonging to each of the professional bodies, and a number of practising teachers. The final report describing the PCAG Primary Science Curriculum Framework[1] was published in October 2023 in English[2] and Welsh[3].

We welcome the advice received in the report and have used it to produce the recommendations that appear in the first section of this document. We will use both our recommendations and the PCAG report to inform policy positions and advice in the context of education and qualification reform across the UK and Republic of Ireland. The PCAG framework is both innovative and familiar and will make an extremely helpful and useable framework for developing new primary science curriculums that are fit for purpose.

[1] https://www.iop.org/about/news/report-on-future-of-primary-science-curriculum-published#gref
[2] https://www.rsb.org.uk/images/edpol/Primary_Curriculum_Advisory_Group_report.pdf
[3] https://www.rsb.org.uk/images/edpol/Primary_Curriculum_Advisory_Group_Report_Welsh.pdf

Introduction

Structure of this document

This document includes an extract from the PCAG report on pages 5–19. On the preceeding pages, as the professional bodies we have included an introduction with our recommendations (based on the report), highlighted some aspects that we would like to emphasise; and developed a guidance for primary teachers section. We have used this structure as an efficient way of sharing both the original report (with its framework) and our response to the report in a single document. Our recommendations align with those published by the Education Endowment Fund[4], through separate, independent, and simultaneous development, highlighting the need for the implementation of the recommendations when curriculum reform occurs.

Purpose of this document

The main purpose of this document is to present coherent guidance and a set of recommendations to policymakers and curriculum developers for designing a primary science curriculum. It has been created to ensure that we, as professional bodies and as a community of science educators, are ready for the next round of curriculum reviews.

The PCAG report may also be of interest to primary science subject leaders, senior leadership teams in primary schools, and those providing professional development in science for primary teachers. However, it is worth emphasising that this document is simply outlining a framework for future curriculum design. It is not a statutory document, or something that schools are required to work directly from; it was created so that the primary science sector is ready for the next curriculum review. The guidance we are publishing is therefore to show what is possible.

Recommendations

Our recommendations to policymakers and curriculum developers are as follows. The primary science curriculum should:

1. have a strong emphasis on purpose, considering not just what is taught and learned, but why and how, so that children develop a coherent and cognitively appropriate understanding of how the world works and their own agency within it;
2. help children identify with the sciences by providing opportunities for teachers to choose contexts that are relevant to their pupils;
3. help all children to feel included in the sciences through the experiences that they have, and the perspectives put on science narratives and by encouraging teachers to use contexts that are familiar to primary age children;
4. ensure the curriculum plans for progression to avoid content being taught before it is appropriate for the age/development stage of the child;
5. encourage children to think scientifically, to discuss and explain their thinking and, through practical experience, gain a sense of the nature and practices of the sciences.

[4] https://educationendowmentfoundation.org.uk/education-evidence/guidance-reports/primary-science-ks1-ks2

Main messages from the PCAG framework

Global citizenship

The PCAG curriculum framework sits within a wider vision for primary education: one where all children have the knowledge and agency to be responsible global citizens. Global citizenship describes individuals and communities who take responsibility for their actions and work towards making the world a more equitable and sustainable place. A new curriculum should enable children to develop the knowledge, skills and values they need to be global citizens through helping them to engage with societal, environmental and economic issues.

Inclusion

It is essential that all children feel included in the sciences through valuing their experiences and through the thoughtful use of the contexts, imagery and narratives. This is partly through ensuring that they build a repertoire of shared experiences; partly through techniques within the classroom; and partly through the narratives attached to the sciences. Specifically, the curriculum should offer children a chance to learn about historic Western and non-Western contributions to the sciences, as well as cutting-edge contemporary research from diverse teams of scientists. Teachers should be encouraged to frame the successes of western science in the context of the times in which discoveries were made; at that time, some groups, cultures and nations were disadvantaged in their ability to participate in or to resource research and less able to claim credit and ownership for ideas that had been developed by them.

Contexts

Linking important scientific concepts with real-life contexts that are familiar and/or engaging to children, especially those that have a local flavour, can help them identify with the sciences, build their science capital, and improve their knowledge base, which can help them to make informed decisions, such as those regarding their health and wellbeing.

Essential experiences

The essential experiences listed in the curriculum framework are included to ensure that all children have opportunities to relate their new learning to personal experiences. We recognise that this is a fundamental equity issue, as concrete experiences form the basis from which children will draw evidence for their ideas and develop their knowledge and conceptual understanding. Not only can this ensure parity of esteem between children in different areas and provisions, but also prepares them for many more abstract concepts that will be presented to them in later stages of their science education.

Conceptual boundaries

The conceptual boundaries (in the knowledge maps) are aimed at tempering the temptation to include higher level content in statutory documents. They are not intended to restrict teaching; in some cases, with some children, a teacher may feel it appropriate to go beyond the boundaries described in a curriculum and we can trust their professional judgement to decide what material is appropriate. The boundaries are the limit of what is regarded as cognitively appropriate rather than what can be explored with some children.

Guidance from the professional bodies for primary teachers

1. *What will this mean for me as a teacher of primary science? Do I need to make a new science curriculum for my school now?*

This document is aimed at policymakers and curriculum developers to inform the next round of curriculum review. Whilst we hope that it is of interest to teachers and teacher educators, this document is not a new curriculum, even if in the future it does play a role in the formation of a new curriculum. There may be aspects that you feel you can include in your current practice; or there may be aspects that concern you – in which case, you can feed your concerns back to us using contact details at the end of the document.

If the recommendations and frameworks are adopted, we hope that through them, children will develop an identity with science and become familiar with using scientific evidence to inform their decisions when faced with global challenges. We also hope that they will give you more agency and flexibility about what you teach and how you teach science.

2. *Do the boundaries mean that we cannot talk about more advanced ideas? What if students want to take ideas further?*

If you feel comfortable, then discuss the ideas more deeply. You can also use formative assessment to decide if your students are ready to take the ideas further. If you do not know the answer, explain that to a child. And maybe follow up with a suggestion that you might try to find out together. The boundaries in the document are aimed at ensuring that children learn what is cognitively appropriate and it is not a *requirement* for every teacher and every child to study those ideas.

3. *Will I have to learn lots of new scientific ideas?*

We anticipate that you may develop or learn new approaches to teaching the sciences and how you represent and talk about the sciences to your students. This would ensure that children get wholly positive messages about the scientific ideas being taught. However, the primary curriculum should not require primary teachers to become expert scientists. Therefore, we expect that you will be able to step back from having to learn new scientific explanations.

The Primary Curriculum Advisory Group

Chair: Associate Professor Jane Turner, University of Hertfordshire
Professor Lynne Bianchi, University of Manchester
Ali Eley, Primary Science Teaching Trust
Liz Lawrence, independent consultant
Dr Alex Sinclair, St Mary's University, Twickenham

Read their original report to the professional bodies here.

Extract of the Primary Curriculum Advisory Group report

The next 15 pages carry an extract of the PCAG report.

2. Rationale for the PCAG Primary Science Curriculum Framework

The PCAG Curriculum Framework is underpinned by the principle that a curriculum needs to make clear what it is for and should therefore begin with overarching aims which are then filled out in greater specificity (Reiss and White 2013). Thus, the PCAG Curriculum Framework for primary science starts with vision and aims, rather than content. The vision and aims inform not just what is taught and learned, but why and how. The science content specified is therefore justified as worthwhile knowledge (Stenhouse 1975): this includes the conceptual content (biology, chemistry and physics), the nature and processes of science (how science knowledge is and has been developed), and the application of science (how it can and should be used). The emphasis on purpose means that the different elements must work together so that children develop a coherent and cognitively appropriate understanding of how the world works and their agency within it. This is increasingly important if children are to manage the impact of their developing understanding and awareness of the biodiversity and climate crises on their own mental health (Hickman, 2020).

This primary science curriculum framework lays the foundations for future learning in science, and in its own right, and is therefore relevant and cognitively appropriate for children aged 3-11 years. The curriculum aims are integral to a broader primary curriculum and they strengthen the rationale for the place of science within this.

3. Vision and Aims for the PCAG Primary Science Curriculum Framework

Vision

To enable the design of a contemporary primary science curriculum, this curriculum framework is underpinned by a wider vision for primary education where all children flourish and can take their place in the world as informed and responsible citizens, ready and able to meet the global challenges of sustainable and equitable living.

Aims

The overarching aims of global citizenship are integral to the aims of the PCAG Curriculum Framework. A global citizen is defined as someone who:

- has an understanding of how the world works, and a sense of their own place in it;
- takes responsibility for their actions;
- participates in their wider community, from the local to the global;
- works with others to make the world a more equitable and sustainable place;
- respects and values diversity.

Informed by: Science and Global Citizenship (ASE and Oxfam)

The purpose of the PCAG Curriculum Framework is to enable designers to develop a primary science curriculum to give children the knowledge and agency to be responsible global citizens. Each of these curriculum aims is key to this.

Children will:

- have positive experiences of learning science and develop an identity with the sciences;
- learn about the nature and practices of science;
- gain scientific knowledge about some established ideas and explanations across the three key disciplines of biology, chemistry and physics;
- understand how science ideas and explanations have been used, and are used and applied in everyday life in and beyond their communities.

The vision and aims are informed by the following evidence.

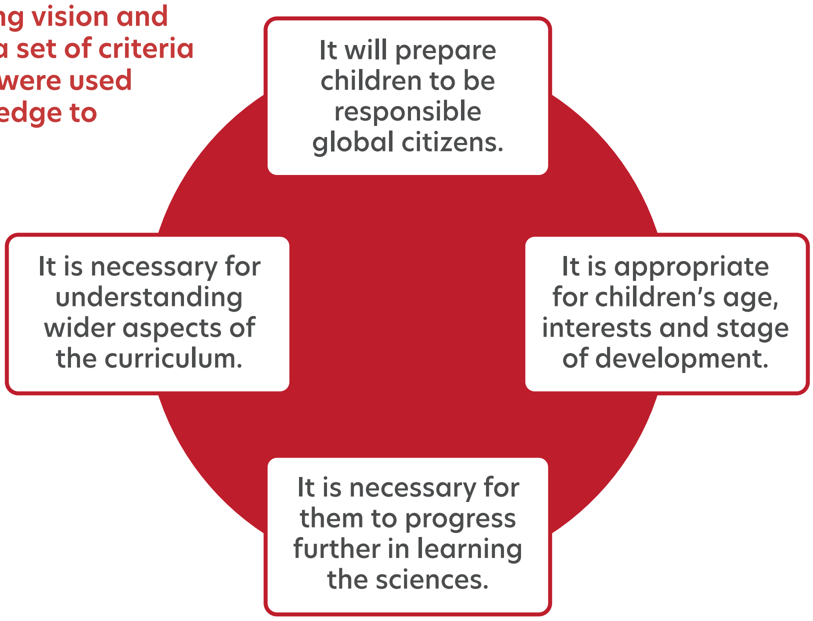
- Earth and humanity face global challenges which science can enable us to understand and meet (IPCC report 2022).
- Social justice issues within education. The need for equitable science education to enable all children to develop as scientifically literate and active citizens (Archer et al. 2015).
- "Education must develop every child's personality, talents and abilities to the full. It must encourage the child's respect for human rights, as well as respect for their parents, their own and other cultures, and the environment" (Article 29 - a summary of the UN Convention on the Rights of the Child; Unicef 1989).
- Educators should provide experiences that are meaningful, emotionally charged and imaginatively engaging, and have relevance now, not merely in the future (Dewey 1963, Egan 2008, Rinaldi 2006).
- There is a growing awareness of the impact on mental health, the distress, confusion and anxiety that follows increased awareness of the climate and biodiversity crisis generally, with concern often centred on how this is affecting children and young people (Hickman, 2020).

4. Development of a set of criteria to justify knowledge in the PCAG Curriculum Framework

This PCAG Curriculum Framework for primary science was constructed through an iterative process, by a small group of primary practitioners and academics, in regular consultation with a range of sector experts from the following fields:

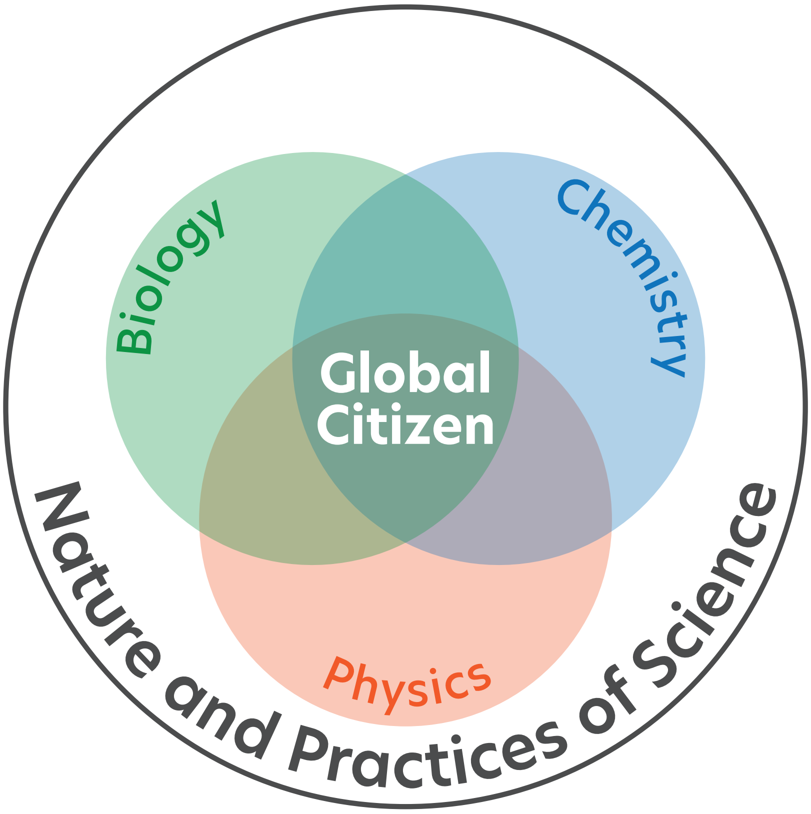
- primary and secondary science education
- the Learned Societies for science and history
- developmental psychology
- curriculum diversification
- curriculum design
- creativity in primary science
- early years

Once the overarching vision and aims were agreed, a set of criteria was created which were used to justify the knowledge to be included.



Importantly, science curriculum content from a wide range of jurisdictions was evaluated against these criteria. Notably, an open-minded approach to the activity was important to allow for the inclusion of content which does not fit into the historically agreed way of organising science curricula. Using the criteria as an organising principle resulted in some content that might be considered conventional not being included. Strenuous efforts were made to resist repeating 'historical' science curriculum content and organisation, although it is acknowledged that the work has been constrained by an epistemological rigidity inherited by the writers' own schooling and teaching experiences.

5. Structure of the PCAG Curriculum Framework



This PCAG Curriculum Framework consists of four knowledge maps.

The **PCAG Knowledge Map for the Nature and Practices of Science** has been compiled so that children gain first-hand practical and enquiry experiences, and can relate these explicitly to why they are undertaking them. As a consequence, primary children are taught about the nature and practices of science at an appropriate level.

Three subject knowledge maps - **PCAG Knowledge Maps for Biology, Chemistry and Physics**, which include key features.

a) **Understanding for global citizenship:** the overarching understanding about planetary well-being, including its inhabitants, that children need to develop as global citizens.

b) **Subject knowledge children need by age 11:** identified from traditional and new national curricula subject knowledge for biology, chemistry and physics.

5. Structure of the PCAG Curriculum Framework

c) **Equity and inclusion; essential experiences that all children must have by age 11:** which ideally should be first-hand, although virtual experiences are also useful to:
   i) ensure that the abstract ideas of science children learn about in the future are grounded in a real-life context, and
   ii) provide an equitable basis for learning so that all children have the opportunity to relate new learning to personal experience and are more likely to develop an identity with science.

d) **Conceptual boundaries:**
   i) to ensure parity across all age phases, and
   ii) to enhance consistent progression between primary and secondary school
   iii) so that more complex areas of science are taught at a cognitively appropriate point.

This curriculum framework is structured to give educators a clear understanding of the purpose of everything that the children will be learning, and to enable them to make this explicit to the children themselves. This will support children to build a comprehensive and cohesive understanding of key scientific concepts in the context of sustainable living and planetary survival. It will also allow them to see their learning in science as relevant to their lives and to their future selves. Children's participation and engagement in science is central to the curriculum, and this framework offers opportunities for the development of a curriculum that will actively promote awe and wonder and nurture curiosity.

A key feature of the PCAG Curriculum Framework is the inclusion of essential experiences. In learning to make sense of the world around them, children draw on evidence they have encountered throughout their lives. While there is huge variation within this between one child and another, children with limited first-hand experiences are undeniably at a disadvantage. This is a fundamental equity issue, and the provision of rich essential experiences for children (particularly in the early and lower primary years) will go some way in addressing this. These concrete experiences form a basis from which children can draw evidence for their ideas, making children ready for the more abstract learning they will encounter at secondary school. Repeated and progressive experiences can provide new evidence and challenge children's current thinking, instilling good scientific habits of mind.

There is an increased focus on children learning that science began before the European Renaissance and enabling them to reflect on the scientific endeavours of a global scientific community. The PCAG Curriculum Framework seeks to make explicit the contribution to science of multiple cultures and ethnicities, as well as minority and suppressed groups in particular societies.

Appendices to the Curriculum Framework have been included to provide examples of how the scientific knowledge could be contextualised and enriched to develop understanding for global citizenship. The final column of these extended versions of the three Knowledge Maps makes links to the behaviours of humans as they apply and extend scientific knowledge and develop new technologies. Human actions and innovations are listed along with impacts, both positive and negative. The positive agency of humans to mitigate negative effects through scientific and technological solutions is also recognised, providing children with examples of how societies and individuals can take action in line with global citizenship.

6. The Nature and Practices of Science

It is vital that as children develop as global citizens they understand how scientific knowledge has been created and used in the past, how it is created and used now, and the types of questions that the discipline can and cannot answer. The emphasis in the PCAG Curriculum Framework is on science as a human endeavour which is influenced by our global, historical, and societal context. A primary science curriculum should build an understanding of how ideas change over time, how knowledge produced by science has strengths and limitations, and how it informs the decisions that society makes. Children should learn to evaluate these decisions and their positive and negative implications on the people and the world around them. Through this, they will learn how to use evidence from science to inform their own decision making towards positive action in their own lives.

Learning about the nature and practices of science therefore includes, but is not limited to, developing a range of prescribed scientific skills.

The PCAG Knowledge Map: Nature and Practices of Science offers descriptors for what the discipline of science is, what children should know about how scientists work and the experiences children should have to enable them to understand and apply the nature and practices of science.

7. The PCAG Knowledge Maps

PCAG Knowledge Map: Nature and Practices of Science

The learning descriptors within this Knowledge Map were compiled using ideas from the Understanding Science resources from the University of Berkeley, the Scientific Habits of Mind (Çalik and Coll, 2012), and the OECD (2017) definition of scientific literacy.

<table>
<tr><th>The nature and practices of science:</th><th>This knowledge underpins children's understanding of how:</th><th>Equity and inclusion: all children should be taught to:</th></tr>
<tr><td rowspan="3">• Science is universal, has been and is carried out in all cultures at all ages, creating a diverse scientific global community.</td><td>• scientists apply what they know to inform decisions and solve problems related to local and global challenges.</td><td>• apply their scientific knowledge and findings to different contexts and problems, including personal, local and global.</td></tr>
<tr><td rowspan="2">• science began before the European Renaissance, and has taken place across history and the globe.</td><td>• value and respond to the contributions of others within and beyond their own community.</td></tr>
<tr><td>• learn about scientific endeavours throughout history with examples from different cultures and historical periods.</td></tr>
<tr><td rowspan="3">• Science is a creative human endeavour which builds new knowledge to explain natural phenomena.</td><td>• scientists make inferences, are curious and imagine possibilities.</td><td>• be curious, demonstrating a passion for discovery,imagining possibilities.</td></tr>
<tr><td>• scientists observe to ask and answer scientific questions to build explanations about the natural world.</td><td>• ask, plan and answer their own scientific questions to explore possibilities and help explain the natural world.</td></tr>
<tr><td>• scientists work through an iterative enquiry process, in which answering one question often leads to other questions.</td><td>• identify new questions that have arisen from an enquiry.</td></tr>
<tr><td rowspan="3">• Science is an empirically based process (based on or derived from observation of the natural world).</td><td>• scientists make observations and collect, analyse and interpret data to test their ideas.</td><td>• gather data by making and recording observations and measurements.</td></tr>
<tr><td rowspan="2">• scientists identify links, patterns and relationships.</td><td>• analyse data to identify links, patterns and relationships.</td></tr>
<tr><td>• understand how to differentiate between questions that science can or cannot answer.</td></tr>
<tr><td rowspan="2">• Scientific knowledge is tentative and subject to change based on new evidence or new interpretations of existing evidence.</td><td>• scientists present and explain their ideas and evidence, are receptive to new ideas and may not always agree with each other.</td><td>• present and explain their findings to a range of audiences, inviting peer-review on their conclusions.</td></tr>
<tr><td>• scientists are sceptical, develop their ideas by using what they already know and new evidence.</td><td>• review and question their own ideas and understanding, as well as those of others, to appreciate that over time, areas of science can change and develop in response to new evidence.</td></tr>
<tr><td rowspan="2">• Science is a rigorous discipline where it is important to know how the evidence was collected and whether it can be trusted.</td><td rowspan="2">• scientists adhere to the accepted methodologies of enquiry and answer different types of scientific questions.</td><td>• use different enquiry methods to answer scientific questions.</td></tr>
<tr><td>• design and evaluate enquiries in order to maximise the trustworthiness of their data.</td></tr>
</table>

7. The PCAG Knowledge Maps

PCAG Knowledge Map: Biology

Understanding for global citizenship	The scientific knowledge children need by age 11...
• Biodiversity and its value. • The role of animals, plants, microorganisms and soils in healthy ecosystems. • The role of animals, plants, microorganisms and soils in human survival and health. • The interdependence of animals, plants, microbes and soil.	**Plants and Animals (including humans)** • Identification and classification. • Structure and function. • Life cycles and reproduction. • Conditions for survival and health. **Microbes** • Identification and classification of different types of microbes including fungi. • Conditions for survival, and growth. **Soil** • Composition and function. • Natural cycles of death and decay. **Interdependence** • Food chains and simple food webs. • Ecosystems and habitats. **Evolution** • Adaptations to environments. • Variation within species. • Inheritance through sexual and asexual reproduction. • Natural Selection. • Extinction. • Fossil formation and fossil records. **Interdependence** • Food chains and simple food webs. • Ecosystems and habitats. • Adaptations. • Cycling of nutrients.

<table>
<tr><th>Equity and inclusion: essential experiences that all children must have by age 11</th><th>The conceptual boundaries</th></tr>
<tr><td>
• Grow different plants (including digging in soil) including flowers from bulbs and seeds.
• Visit a garden centre and talk to people who work there.
• Visit, observe and handle a wide range of living things in local habitats, using all their senses to explore them.
• Visit, observe and handle living things in contrasting habitats beyond their locality, using all their senses to explore them.
• Visit and compare different habitats across the seasons.
• Find out about habitats that are local, national and global.
• Encouraging wildlife into their own environment, e.g. placing or building bird boxes, bug hotels, bird tables, log piles, etc.
• Find out about life cycles of different living things, including first-hand experience e.g. strawberries, tomatoes, butterflies, human babies.
• Be involved in making healthy lifestyle choices.
• Grow plants, prepare and eat them.
• Visit a food grower and/or retailer and talk to the people who work there.
• Observe the weather and its effects at different times of the year.
• Visit a farm and talk to people who work there.
• Handle rocks, minerals and fossils.
• Take part in local and national campaigns promoting community engagement in growing things and celebrating green spaces.
</td><td>
What to include
• Classification at level of observable physical or behavioural features.
• Structure and function at the level of the organism and organ.
• Carbon dioxide in the air is used to build plant mass and that plants produce oxygen.
• Oxygen is required for all life processes and carbon dioxide is a waste product.
• Characteristics are inherited by individuals from their parent(s.)
• Food chains and food webs described as what is eaten by what.

What not to include
• Classification beyond observable physical or behavioural features.
• Structure and function at the level of cells and tissues.
• The term and process of photosynthesis.
• The term and process of respiration.
• Nutritional analysis beyond a balanced diet.
• The terms DNA and genes.
• The structure of microorganisms and the mechanism for how they cause disease.
• Food chains and food webs as energy transfer.
</td></tr>
</table>

7. The PCAG Knowledge Maps

PCAG Knowledge Map: Chemistry

Understanding for global citizenship	The scientific knowledge children need by age 11...

• How materials improve lives, including: food, warmth, shelter, aesthetics, tools, trading.
• Why materials are suitable for particular purposes.
• Materials as finite or renewable resources.
• Impact of the extraction, production, use and disposal of natural and human-made resources.
• Conservation of matter.
• Influence of changing temperatures on the causes of natural disasters, the water cycle, weather, and climate change.
	Materials
	• Types and names of everyday natural and manufactured materials.
	• Properties.
	• Sources.
	• Disposal.
	Temperature
	• Temperature as a measurement of how hot or cold something is.
	• Ways of raising the temperature.
	Changes to materials
	• Physical Changes.
	  • Changing state (reversible) caused by heating and cooling.
	  • Making and separating mixtures.
	• Chemical Changes - reactions (irreversible) caused by:
	  • Cooking and burning.
	  • Combining materials.
	  • Decay.

Equity and inclusion: essential experiences that all children must have by age 11	The conceptual boundaries
• Make things from different materials, including recycling. • Explore how materials float and sink. • Monitor and reduce waste within school. • Watch rubbish and recycling being collected. • Eat an ice lolly or ice cream, have an iced drink. • Play in puddles, handle ice and, if possible, snow. • Wash something (hair, clothes, other fabric, etc.) and dry it naturally and/or with a heat source. • Notice cooling water vapour in the air above hot water and draw pictures on a window/mirror with condensation. • Blow soap bubbles and bubbles through a straw and observe bubbles in fizzy drinks. • Explore materials that are a mixture of 2 states of matter e.g. shaving foam / squirty cream (liquid and gas) and sponges (solid and gas). • Handle different malleable solid materials e.g modelling clay, playdough, sticky tack, food doughs. • Handle powdery materials and other pourable solids e.g. flour, salt, rice, sand. • Explore liquids with different viscosities e.g. ketchup, water, treacle, shower gel. • Experience cooking and food preparation that involve change of state e.g. boiling something in water, melting and refreezing e.g. butter or chocolate, and irreversible changes, e.g. making a cake. • Take part in local and national campaigns promoting community engagement in repairing, reducing, recycling and reusing materials responsibly. • Get involved in local clean up initiatives in local parks, beaches, neighbourhoods etc. • Take part in improving local air quality and awareness through walk-to-school initiatives, cycling, and the use of public transport, etc.	**What to include** • Properties of materials: solid, liquid, gas, hardness, transparency, conductivity (electrical, thermal), magnetic, flexibility, elasticity, permeability, absorbency, porosity, mass in relation to size. • Terminology relating to measurement of temperature: what temperatures constitute “hot”, “cold”, “warm” in different circumstances. • Terminology relating to changing state: freezing, melting, boiling, condensing, evaporating. • Terminology relating to making and separating mixtures: dissolving, sieving, filtering. **What not to include** • Density, technical engineering language to describe properties, standard units for hardness, viscosity and conductivity. • Sublimation, other states of matter, particles and particle theory. • Terminology relating to measurement of energy: therm, joule, calorie. • Convection, radiation. • Energy or energy transfers.

7. The PCAG Knowledge Maps

PCAG Knowledge Map: Physics

Understanding for global citizenship	The scientific knowledge children need by age 11...	Equity and inclusion: essential experiences that all children must have by age 11
• Responsible uses of electricity. • Local and global consequences of using a particular source to generate electricity.	**Electricity** • Simple circuits- how they are constructed. • Different ways that electricity can be generated.	• Safely use electrical appliances and battery operated toys or objects. • Take part in 'switch off days' and energy saving campaigns.
• The importance of light for survival of life on earth. • The negative impact of light pollution. • The effects of UV light on humans.	**Light** • Sources - natural and artificial. • How we see objects. • Reflection and shadows.	• Experience complete darkness, and observe shiny and reflective objects in different light intensities. • Explore shadows and notice how they change during the day.
• The importance of sound for survival, communication and wellbeing. • The negative impact of sound pollution.	**Sound** • Vibrations and sources of sound. • Pitch and volume. • Sound insulation.	• Experience making sounds and music with different objects and instruments. • Listen to a musical performance, either live or on a video. • Listen to a range of sounds and music in different environments.

The conceptual boundaries
What to include • Exploration of simple circuits, including multiple components. • Terminology relating to electrical conductivity: conductor, insulator. • Terminology relating to current and the need for a complete circuit: flow and charge. • Terminology relating to voltage: push. **What not to include** • Measurement of current. • Measurement of voltage. • Terminology relating to naming series and parallel circuits. • Resistance. • Energy, energy transfers, or power, other than in everyday use. • Electrons in relation to current. • Standardised circuit diagrams.
What to include • Terminology relating to objects and light: shadow, opacity, translucency, transparency. • That we see when light enters our eyes. • That we see an object when light from a source is reflected from the object into our eyes. • Simple arrow drawings showing the direction of light from a source or an object to our eyes. **What not to include** • Complex light reflections and drawings of these. • Refraction, prisms and white light splitting into a spectrum. • Angles of incidence and reflection. • Light waves. • Energy or energy transfers.
What to include • Terminology relating to production of sound: vibration, pitch, volume. **What not to include** • Terminology relating to production of sound: frequency, amplitude. • Sound waves. • Energy or energy transfers.

7. The PCAG Knowledge Maps

Understanding for global citizenship	The scientific knowledge children need by age 11...	Equity and inclusion: essential experiences that all children must have by age 11
• The importance of understanding forces for: • engineering; • impact of and mitigation of natural disasters.	**Forces** • Types of force - push and pull. • Resistance forces - air, water and friction. • Contact and non-contact forces - gravity, magnetism and electrostatic.	• Go to a playground and explore motion on swings, slides, roundabouts. • Play with a magnet and explore what is attracted to it. • Play with magnets or magnetic toys to feel attraction and repulsion. • Rub a balloon on their hair and stick it to a wall, or notice sparks when they take off a jumper. • Play with toy cars on a ramp and different surfaces. • Drop objects to explore how they fall in air and water. • Feel the resistance of air and water as they move their hands or bodies through it. • Play with objects in water, including pushing floating objects underwater. • Build things, using a range of materials, including making a lever and pulley.
• Understanding the Earth's place in the universe. • The importance of caring for our planet.	**Earth and the Universe** • The solar system within the universe. • Day and night. • Space exploration.	• Observe the Moon on different days/nights. • Notice the position of the Sun at different times of the day. • Use hand lenses and binoculars. • Watch videos of a space rocket taking off, moon landings and other space related film footage.

The conceptual boundaries

What to include
- Terminology relating to forces experienced in action: gravity, resistance, friction, buoyancy.

What not to include
- The difference between mass and weight.
- Explanations of balanced and unbalanced forces, e.g. how aeroplanes stay in the air.
- Explanations about the speed at which objects fall.
- Arrow diagrams to represent forces acting in different directions.

What to include
- The evidence for how we know that the Earth is rotating on its own axis.

What not to include
- Explanations for the phases of the Moon.
- An explanation for the seasons in relation to the tilt of the Earth.

Contact details for the individual organisations

Association for Science Education
info@ase.org.uk

The Association for Science Education (ASE) is an active membership body that has been supporting all those involved in science education from pre-school to higher education for over 100 years; members include teachers, technicians, teacher educators, researchers and others involved in science education. We play a significant role in promoting excellence in teaching and learning of science in schools and colleges. Working closely with the science professional bodies, industry and business, we provide a UK-wide network bringing together individuals and organisations to share ideas and tackle challenges in science teaching, develop resources and foster high quality Continuing Professional Development. We are a Registered Charity with a Royal Charter, owned by our members and independent of government. We seek to create a powerful voice for science education professionals in order to make a positive and influential difference to the teaching and learning of science throughout the UK and further afield.

Institute of Physics
education@iop.org

The Institute of Physics is a charity registered in England and Wales (no. 293851) and Scotland (no. SC040092).

The Institute of Physics (IOP) is the professional body and learned society for physics in the UK and Ireland. It seeks to raise public awareness and understanding of physics, inspire people to develop their knowledge, understanding and enjoyment of physics and support the development of a diverse and inclusive physics community. As a charity, it has a mission to ensure that physics delivers on its exceptional potential to benefit society.

Royal Society of Biology
Education.policy@rsb.org.uk

The Royal Society of Biology (RSB) is a single unified voice for biology: advising government and influencing policy; advancing education and professional development; supporting its members, and engaging and encouraging public interest in the life sciences. The RSB represents a diverse membership of individuals, learned societies and other organisations. Individual members include practising scientists, pupils at all levels, professionals in academia, industry and education, and non-professionals with an interest in biology.

The RSB seeks to support biology education at all levels, and actively engages with education policy through formal consultation responses, convening special interest groups and collaborating and coordinating with other science organisations.

Royal Society of Chemistry
educationpolicy@rsc.org

We are an international organisation connecting chemical scientists with each other, with other scientists, and with society as a whole. We use the surplus from our global publishing and knowledge business to give thousands of chemical scientists the support and resources required to make vital advances in chemical knowledge. We develop, recognise and celebrate professional capabilities, and we bring people together to spark new ideas and new partnerships. We support teachers to inspire future generations of scientists, and we speak up to influence the people making decisions that affect us all. We are a catalyst for the chemistry that enriches our world.