

# Appendices to accompany SCORE's response to the draft National Curriculum for science

Response from the Institute of Physics, the Royal Society of Chemistry, the Association for Science Education and the Society of Biology

8 August 2013

The appendices that follow have been compiled by individual SCORE organisations, with contributions from their members and committees. There may therefore be contradictions between them.

- Appendix 1: Institute of Physics comments on Key Stages 1-3 (pages 2-6)**
- Appendix 2: Institute of Physics Key Stages 1 and 2 (pages 7-22)**
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## **Comments on Physics in the National Curriculum Key Stages 1 to 3**

We have put some comments on the latest draft documents. The points below pull out some concerns about the latest draft.

### **1. Light**

#### ***Years and levels***

Two light statements have been moved down to Year 1 of primary. This seems unnecessary. Throughout the consultation process, we have been saying that it is not necessary to have balances between the sciences in the early key stages. And putting these statements here does not help with coherence.

The statement that starts 'associate' is certainly too advanced for year 1. Again, there have been many discussions about developing the idea of recognising patterns in early key stage 2. Putting this statement in year 1 is undermining the proposals about developing ideas in working scientifically through the key stages.

It is also unhelpful to move the statements at this stage because there are knock-on implications; for example: what to do with the statements that remain in Year 3; and whether to talk about shadows in the seasons topic in Year 1. Having three topics on light in primary is pretty repetitive and potentially off-putting and students will get no sustained, satisfactory story about light. The Year 5 material is too advanced for year 3. So the only possibility is to move the year 3 material to year 5 (which makes sense). But this leaves a large gap between years 1 and 5.

Or, preferably, stick with what we had: leave those light statements in year 3.

#### ***Statement detail***

- Wherever the two statements in Year 1 end up, there needs to be an additional statement that darkness is the absence of light.
- The statement about shiny things that shine in the dark is, at best, misleading. Shiny things do not shine in the dark; luminous things do (and perhaps that's what the author meant).
- Using the ray model to explain images in mirrors is quite tough. Is it really needed (by *\*all\** students)?
- The word specular remains – and is unusual.
- The key stage 3 section on light looks quite old fashioned.

### **2. Waves**

The sound statements have been moved to year 2. This looks fine – especially if it is linked up with the sections on the senses because it is quite a small section as it stands.

### ***Statement detail – key stage 3***

We made a number of comments about statement previously and quite a few of these have not been taken up. Such as:

- Waves on water
- Superposition being too advanced
- Include echoes for sound

### **3. Earth and Space**

The comment about removing the statement on observing the apparent movement of the Sun is pretty depressing. It is not a misconception – the Sun **does** appear to move across the sky. And this is a very valid observation. What are we to say – no it doesn't, your eyes are deceiving you. We have to work with what students observe and how they talk about what they observe. It could be argued that noticing that the Sun appears to move in regular way across the sky (by day and by year) represents the beginnings of looking for patterns in the natural world.

The planets have been added in Year 5. This is a distraction. The point of this section was to look at the model of Earth and Sun that could be used to explain day and night. There is now a lot of stuff to learn. And it doesn't help with understanding the model. If anything, it is a distraction. It would be better to look at the solar system and features of the planets in key stage 3.

It's good to see that there is now a topic on Space in Key Stage 3. However, there is nothing about the solar system (see above). And nothing about the seasons.

### ***Statement detail***

- Year 1 statement should be 'local' weather conditions (see previous comments).
- Key Stage 3 could have a statement about the seasons and the tilt of the Earth.
- In key stage 3, Earth, Sun and Moon are usually upper case.

### **4. Forces and motion**

There are no longer any statements about movement in Year 2. The movement statement has been absorbed into the topic on materials. And it's not clear why.

The statements about the model for poles of a magnet have been moved from key stage 3 to key stage 2. Again, this goes against discussions we had about waiting until key stage 3 to introduce predictive models. It is quite possible that key stage 2 pupils can be drilled in the rules of magnetic

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attraction and repulsion. However, it is less likely that they will appreciate that this is a model that allows to make predictions (the idea of prediction is pretty advanced). So it will be a lost opportunity to develop one of the big ideas of science for the sake of introducing content earlier.

It looks like this is a new statement: “understand that force and motion can be transferred through mechanical devices such as gears, pulleys, levers and springs.” I’m really not sure what it is getting at or what its purpose is. “Transferred” seems an odd word – would we say “my spring transferred motion to a model car”. And what is this statement expecting children to be able to do? Do they need to know, for example, that gears and levers are force multipliers? And how and when will they build on that idea? So, as well as it not being clear what this statements means, it is not clear what educational purpose it is serving.

Pressure and stress. It would be good to have these clearly separated. Pressure is what acts in liquids and acts in all directions. Stress is a vector that measures the force/area between or at a solid surface. At the moment stress (at a solid surface) is not covered.

### **Statement detail**

- The key stage 3 bullet with the unit newtons in it has been corrected to give it an uppercase. The correction is incorrect. The unit the newtons (N) – lower case for the word, upper case for the symbol. And the natural philosopher was Newton (upper case).
- Key stage 3 formula should be *average* speed (text says average but formula drops it).

## **5. Electricity (and magnetism)**

There is a new statement about circuit diagrams and symbols in year 6. Is there a good reason for asking for circuit diagrams and symbols at this stage? It would seem to be something that links in with the idea of topographical maps in maths or geography. So it should appear in physics after they have studied those ideas in maths.

### **Statement detail**

- Resistance (idea of) as ratio of voltage to current should be qualitative only at key stage 3.
- The statement on electrical power is way to advanced for key stage 3. It is well into k3y stage 4.
- There is a bracketed “quantitative” after the statement about the difference in resistance between conducting and insulating materials. Should this be ‘qualitative’? Apart from anything else, it would be resistivity rather than resistance. And what quantities, exactly, would be compared?
- Good that domestic ring main has gone. And some of the statements have been clarified.
- Electrons are still mentioned in static electricity. Is this where the electron is introduced?

## 6. Matter – key stage 3

There remains a lot of duplication between the matter topic in physics (key stage 3) and various chemistry topics. For example, the states of matter, particle model and diffusion. They only need to be covered in one place or the other.

As commented before, they are using the concept of density. But at no point have they been introduced to what the idea of density is. And certainly the formula has not appeared.

### ***Statement detail***

- The anomaly of the ice-water transition is very hard to do satisfactorily at this level.

## 7. Energy – key stage 3

The Institute provided a set of statements for key stages 3 and 4 which were intended as a guide. Some aspects of these statements have been included. However, they have been changed quite a lot (losing the coherence and consistency that had been achieved with Key Stage 4).

However, most worryingly, the key stage 4 statement on calculations has been included at Key Stage 3. It may be that it has found its way there mistakenly. This is way too advanced for key stage 3. I am pasting in below the key stage 3 statements again below.

Also, ideas about energy pervade many areas of physics and the other sciences; it is important that statements referring to energy are consistent across the science subjects;

Many important ideas relating to energy and systems – including ideas about difference, change and dissipation – cannot be developed satisfactorily in a stand-alone topic; they need to be addressed and developed coherently as they arise in other topics over the years. Again, a commentary would be helpful.

### *Energy statements for Key Stage 3.*

#### **Using fuels in the domestic context**

- comparing energy values of different foods (from labels) (kJ)
- relating this to amounts of energy needed to do various things
- fuels and energy resources;
- domestic fuel bills, fuel use and costs;
- comparing power ratings of appliances in watts (W, kW);

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- comparing amounts of energy transferred (J, kJ, kW hour).

### **Changes in systems**

- energy as a quantity that can be quantified and calculated; the total energy has the same value before and after a change;
- how to look at the starting condition and the final condition of a system and describe increases and decreases in the amount of energy associated with its movement, its temperature, its position in a field, its elastic distortion and its chemical composition;
- using physical processes and mechanisms, rather than energy, to explain the intermediate steps that bring about those changes.

### **Simple machines**

- levers and gears as examples of simple machines that transfer energy by doing work;
- simple machines allow us to exert a bigger force but at the expense of having it move less (and vice versa); you can increase force or displacement but not their product;
- $\text{work} = \text{force} \times \text{displacement}$  (measured in joules).

### **Transfer of energy because of a temperature difference**

- heating: that when there is a temperature difference between two objects, the hotter one will transfer energy to the cooler one;
- reaching equilibrium: that the transfer of energy will tend to reduce the temperature difference until they are at the same temperature;
- maintaining a temperature difference for longer by putting an insulator between the hotter body and the cooler one; this reduces the rate at which energy is transferred;
- ways of maintaining a temperature difference by transferring energy to the hotter body at the same rate as it is heating the colder one.

**Working scientifically**

| Key Stage 1 programme of study (statutory requirements)   | Notes and guidance (non-statutory)  |
|---|---|
| <p><b>Working scientifically</b></p> <p>During Years 1 and 2, pupils should be taught to use the following practical scientific methods, processes and skills through the teaching of the programme of study content:</p> <ul style="list-style-type: none"> <li>▪ asking simple questions <u>and recognising that they can be answered in different ways</u></li> <li>▪ observing closely, using simple equipment</li> <li>▪ performing simple tests</li> <li>▪ identifying and classifying</li> <li>▪ using their observations and ideas to suggest answers to questions</li> <li>▪ gathering and recording data to help in answering questions.</li> </ul> | <p><b>Working scientifically</b></p> <p>Pupils in Years 1 and 2 should explore the world around them and raise their own questions. <u>They should</u> experience <u>different types of scientific enquiries, including practical activities, and</u> begin to <u>recognise</u> ways in which they might answer scientific questions. They should <u>use simple features to compare</u> objects, materials and living things and, with help, decide how to sort and group them, observe changes over time, <u>and, with</u> guidance, they should begin to notice patterns and relationships. <u>They should ask people questions and use simple secondary sources to find answers.</u> They should use simple measurements and equipment (e.g. hand lenses, egg timers) to gather data, carry out simple tests, record simple data, and talk about what they have found out <u>and how they found it out.</u> With help, they should record and communicate their findings in a range of ways and begin to use simple scientific language.</p> <p>These opportunities for working scientifically should be provided across Years 1 and 2 so that the expectations in the programme of study can be met by the end of Year 2. Pupils are not expected to cover each aspect for every area of study.</p> |

**Comment [A1]:** There is nothing about experiencing phenomena which should be at the heart of primary – and certainly key stage 1 - science.

Year 1

|  |   |
|--|---|
| <p><b>Light</b></p> <p><b>Pupils should be taught to</b></p> <ul style="list-style-type: none"> <li>observe and name a variety of sources of light, including electric lights, flames and the Sun</li> <li>associate shadows with a light source being blocked by something</li> </ul> | <p><b>Light</b></p> <p>Pupils should explore materials to raise questions that will help them to understand the differences between materials that are transparent, translucent and opaque (though these words do not need to be used at this stage). They should observe shadows being formed in everyday contexts, such as when they play outside or shine torches indoors.</p> <p><b>Note:</b> Pupils should be warned that it is not safe to look directly at the Sun, even when wearing dark glasses.</p> <p>Pupils might work scientifically by exploring shiny things and grouping them according to whether they shine in the dark or not. They can go on a shadow hunt and think about what is similar about the places where shadows are found (that is, that there is a light source and something is blocking it.).</p> |
| <p><b>Seasonal changes</b></p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>observe changes across the four seasons</li> <li>observe and describe local weather associated with the seasons and how day length varies.</li> </ul>                         | <p><b>Seasonal changes</b></p> <p>Pupils should observe and talk about changes in the weather and, the seasons</p> <p>Pupils might work scientifically by: making tables and charts about the weather; and making displays of what happens in the world around them, including day length, as the seasons change.</p>   |

- Comment [A2]:** CMT "associate" does seem advanced at this age.
- Comment [A3]:** CMT. We don't really see why it is necessary to move these statements back to year 1. We agree that the physics in the statements isn't overly difficult. However, they don't really lead anywhere. It would be possible to include them with the Seasonal changes below.
- Comment [A4]:** CMT. Notwithstanding those concerns there needs to be a statement that says "darkness is the absence of light".
- Comment [A5R4]:** It is also odd that there isn't a statement that 'we see using our eyes' – the equivalent of the hearing and ears statement in year 2.
- Comment [A6]:** CMT We don't really know what this means but it looks wrong. Shiny things are **not** shiny in the dark. Does it mean to group things by whether they are luminous or shiny?? In which case 'shiny' is the wrong word.
- Comment [A7]:** First bullet point 'observe the apparent movement of the sun during the day' deleted because it is not necessary and could lead to misconceptions. N&G have been redrafted to reflect this amendment.
- Comment [A8]:** CMT. Neither of those are the case. It is almost the beginnings of scientific observation of the physical world around them. It is a really important observation that the Sun **appears** to move across the sky. This is not the same as saying it does move across the sky. This is part of the problem of putting these things so ea...
- Comment [A9]:** CMT. Given that they have done shadows, they could look at the movement and length of shadows across the day and the seasons.
- Comment [A10]:** CMT. See previous draft



Year 2

| Uses of everyday materials  | Uses of everyday materials  |
|---|---|
| <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>identify and compare the uses of a variety of everyday materials, including wood, metal, plastic, glass, brick, rock, paper and cardboard</li> <li><u>comparing how things move on different surfaces</u>.</li> </ul> | <p>Pupils should identify and discuss the uses of different everyday materials so that they become familiar with how some materials are used for more than one thing (metal can be used for coins, cans, cars and table legs; wood can be used for matches, floors, and telegraph poles) or different materials are used for the same thing (spoons can be made from plastic, wood, metal, but not <u>normally from</u> glass; tables can be made from plastic, wood, metal, but not <u>normally from</u> paper). <u>Pupils should discuss, describe and compare the movement of a variety of objects and, where appropriate, themselves, through actions such as sliding, rolling, falling, flying, walking and running, on different surfaces.</u></p> <p>Pupils might work scientifically by: comparing the uses of everyday materials in and around the school with materials found in other places (at home, the journey to school, on visits, and in stories, rhymes and songs); observing closely, identifying and classifying the uses of different materials, and recording their observations. Pupils should be encouraged to think about unusual and creative uses for everyday materials. <u>They could ask questions about the movement of objects such as toy cars on different surfaces; comparing them, by measuring how far they go; ordering their findings and recording their observations and measurements, for example by constructing tables and charts, and drawing on their results to answer their questions.</u></p> |

**Comment [A11]:** CMT. OK. But it is a bit bare. It's not very clear that this section is about movement. And do they really go together? Materials and movement??

Appendix 2

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| <p>Sound</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"><li>▪ observe and name a variety of sources of sound, noticing that we hear with our ears</li><li>▪ recognise that sounds get fainter as the distance from the sound source increases</li></ul> | <p>Linked with work in music, pupils should explore various ways of making sounds, for example using a range of musical instruments to make louder and softer and higher and lower sounds.</p> <p>Pupils might work scientifically by: comparing different sound sources and looking for patterns; carrying out tests to find the best places to locate fire bells in school.</p> |
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**Comment [A12]:** Moving this section has **not** helped with coherence. What is it being coherent with? And what is the point of having such a small section. But it isn't doing any harm – except that it means the next two sections become rather repetitive.

**Working scientifically**

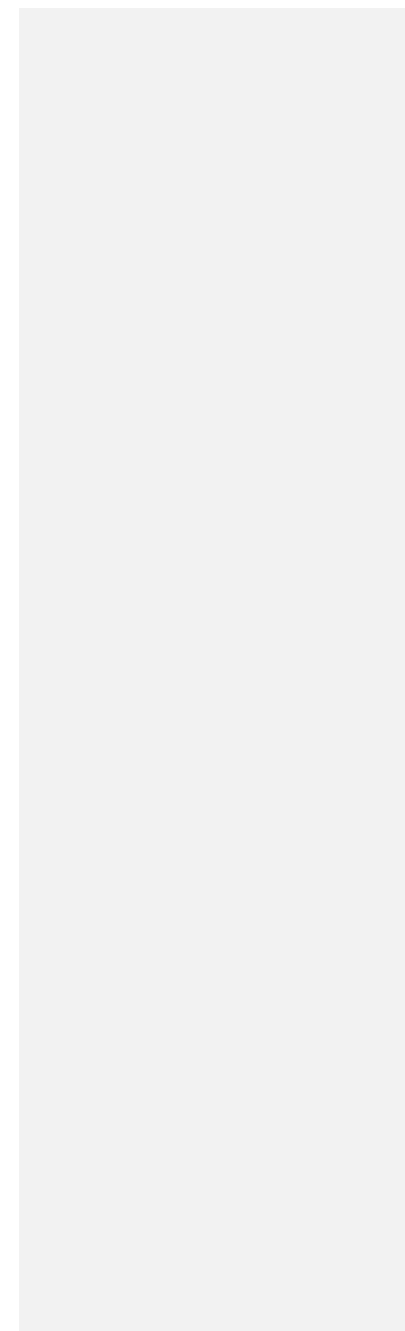
| Lower Key Stage 2 programme of study (statutory requirements)  | Notes and guidance (non-statutory)  |
|--|---|
| <p><b>Working scientifically</b></p> <p>During Years 3 and 4, pupils should be taught to use the following practical scientific methods, processes and skills through the teaching of the programme of study content:</p> <ul style="list-style-type: none"> <li>▪ asking relevant questions <a href="#">and using different types of scientific enquiries to answer them</a></li> <li>▪ setting up simple practical enquiries, comparative and fair tests</li> <li>▪ making accurate measurements using standard units, using a range of equipment, including thermometers and data loggers</li> <li>▪ gathering, recording, classifying and presenting data in a variety of ways to help in answering questions</li> <li>▪ recording findings using simple scientific language, drawings, labelled diagrams, <a href="#">keys</a>, bar charts, and tables</li> <li>▪ reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions</li> <li>▪ using results to draw simple conclusions and suggest improvements, new questions and <a href="#">predictions for setting up further tests</a></li> <li>▪ identifying differences, similarities or changes related to simple scientific ideas and processes</li> <li>▪ using straightforward scientific evidence to answer questions or to support their findings.</li> </ul> | <p><b>Working scientifically</b></p> <p>Pupils in Years 3 and 4 should <a href="#">be given a range of scientific experiences to enable them to</a> raise their own questions about the world around them. They should start to make their own decisions about the most appropriate type of scientific enquiry they might use to answer questions; recognise when a simple fair test is necessary and help to decide how to set it up; talk about criteria for grouping, sorting and classifying; and use simple keys. They should begin to <a href="#">look for</a> patterns <a href="#">and decide</a> what data to collect to identify them. They should help to make decisions about what observations to make, how long to make them for and the type of simple equipment that might be used. They should learn how to use new equipment, such as data loggers, <a href="#">appropriately</a>. They should collect data from their own observations and measurements, using notes, simple tables and standard units, and help to make decisions about how to record and analyse <a href="#">this</a> data. With help, pupils should look for changes, patterns, similarities and differences in their data in order to draw simple conclusions and answer questions. With support, they should identify new questions arising from the data, <a href="#">making predictions for new values within or beyond the data they have collected</a> and <a href="#">finding</a> ways of improving what they have already done. They should also recognise when and how secondary sources might help them to answer questions that cannot be answered through practical investigations. Pupils should use relevant scientific language to discuss their ideas and communicate their findings in ways that are appropriate for different audiences.</p> <p>These opportunities for working scientifically should be provided across Years 3 and 4 so that the expectations in the programme of study can be</p> |

**Comment [A13]:** There should be a statement about looking for patterns. They have to be able to identify patterns before they can make predictions.

**Comment [A14]:** This seems very early.

Appendix 2

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|  | met by the end of Year 4. Pupils are not expected to cover each aspect for every area of study. |
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Year 3

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|---|--|
| <p><b>Rocks</b></p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>compare and group together different kinds of rocks on the basis of their <a href="#">appearance and</a> simple physical properties</li> <li>describe in simple terms how fossils are formed when things that have lived are trapped within rock</li> <li><a href="#">recognise that soils are made from rocks and organic matter.</a></li> </ul> | <p><b>Rocks</b></p> <p>Linked with work in geography, pupils should explore different kinds of rocks and soils, including those in the local environment.</p> <p><a href="#">Pupils might work scientifically by: observing rocks, including those used in buildings and gravestones, and exploring how and why they might have changed over time; using a hand lens or microscope to help them to identify and classify rocks according to whether they have grains or crystals, and whether they have fossils in them. Pupils might research and discuss the different kinds of living things whose fossils are found in sedimentary rock and explore how fossils are formed. Pupils could explore different soils and identify similarities and differences between them and investigate what happens when rocks are rubbed together. They can raise and answer questions about the way soils are formed.</a></p> |
| <p><b><u>Light</u></b></p> <p><u>Pupils should be taught to:</u></p> <ul style="list-style-type: none"> <li><a href="#">notice that light is reflected from surfaces</a></li> <li><a href="#">find patterns that determine the size of shadows.</a></li> </ul>  | <p><b><u>Light</u></b></p> <p><a href="#">Pupils should explore what happens when light reflects off a mirror or other reflective surfaces, including playing mirror games to help them to answer questions about how light behaves.</a></p> <p><b>Note:</b> <a href="#">Pupils should be warned that it is not safe to look directly at the Sun, even when wearing dark glasses.</a></p> <p><a href="#">Pupils might work scientifically by: looking for patterns in what happens to shadows when the light source moves or the distance between the light source and the object changes.</a></p>   |

**Comment [A16]:** Really. Are they going to be using light boxes and tracing rays as they reflect of mirrors? That is way too advanced. Maybe this means they will explore what happens when you look in a mirror???

**Comment [A15]:** CMT. This section looks very strange now. There's not much to it. I'd suggest combining it with the following section on light in year 6. Where they can, in one go, bring together the ideas of shadow size and light travelling as straight rays. There really is no need to repeat something on light every two years. Indeed, it is off-putting.

| Forces and magnets  | Forces and magnets  |
|---|---|
| <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>▪ notice that some forces need contact between two objects <a href="#">but magnetic</a> forces <a href="#">can</a> act at a distance</li> <li>▪ observe how magnets attract or repel each other and attract some materials and not others</li> <li>▪ <a href="#">compare and group together a variety of everyday materials on the basis of whether they are attracted to a magnet, and identify some magnetic materials</a></li> <li>▪ <a href="#">describe magnets as having two poles</a></li> <li>▪ <a href="#">predict whether two magnets will attract or repel each other, depending on which poles are facing.</a></li> </ul> | <p>Pupils should observe that magnetic forces can <a href="#">act</a> without direct contact, unlike most forces, where direct contact is necessary (for example, opening a door, pushing a swing). <a href="#">They should explore the behaviour and everyday uses of different magnets (for example, bar, ring, button and horseshoe).</a></p> <p>Pupils might work scientifically by: <a href="#">exploring</a> the strengths of different magnets and finding a fair way to compare them; sorting materials into those that are magnetic and those that are not; <a href="#">looking for patterns in the way that magnets behave in relation to each other and what might affect this, such as the strength of the magnet or which pole faces another;</a> <a href="#">identifying how these properties make magnets useful in everyday items and suggesting creative uses for different magnets.</a></p> |

**Comment [A17]:** CMT. We had quite long discussions about why this should come later. It is a predictive model and it feels too early to understand that idea in Year 3. Clearly **some** children will be able to follow the rule. But they will not understand where it has come from or the role of modelling in this rote rule-following exercise. I.e. it is not scientific.

Year 4

| States of matter   | States of matter   |
|--|--|
| <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>▪ compare and group materials together, according to whether they are solids, liquids or gases</li> <li>▪ observe that some materials change state when they are heated or cooled, and measure <a href="#">or research</a> the temperature at which this happens in degrees Celsius (°C)</li> <li>▪ identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature.</li> </ul> | <p>Pupils should explore a variety of everyday materials and develop simple descriptions of the states of matter (solids <a href="#">hold their shape</a>; liquids form a pool not a pile; gases escape from an unsealed container). Pupils should observe water as a solid, a liquid and a gas and should note the changes to water when it is heated or cooled.</p> <p><b>Note:</b> Teachers should avoid using materials where heating is associated with chemical change, for example, through baking or burning.</p> <p>Pupils might work scientifically by: grouping and classifying a variety of different materials; exploring the effect of temperature on substances such as chocolate, butter, cream (for example, to make food such as <a href="#">chocolate crispy cakes</a> and ice-cream for a party). <a href="#">They could research the temperature at which materials change state such as when iron melts or when oxygen condenses, using and applying what they have learnt in mathematics.</a> They might observe and record evaporation over a period of time, such as a puddle in the playground or washing on a line, and investigate the effect of temperature on washing drying or snowmen melting.</p> |

**Comment [A19]:** 'Hold their shape' substituted for 'can be held in your hands' to improve accuracy and clarity, as well as safety (it isn't a good idea to hold every solid in your hand).

**Comment [A18]:** To widen the knowledge acquired since there are so few changes of state whose temperature can be safely and accurately measured in a primary classroom.

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| <p><b><u>Sound</u></b></p> <p><u>Pupils should be taught to:</u></p> <ul style="list-style-type: none"><li>▪ <u>identify how sounds are made, associating some of them with something vibrating</u></li><li>▪ <u>find patterns between the pitch of a sound and features of the object that produced it</u></li><li>▪ <u>find patterns between the volume of a sound and the strength of the vibrations that produced it.</u></li></ul> | <p><b><u>Sound</u></b></p> <p><u>Pupils should explore and identifying the way sound is made through vibration in a range of different musical instruments from around the world; and find out how the pitch and volume of sounds can be changed in a variety of ways.</u></p> <p><u>Pupils might work scientifically by: finding patterns in the data (for example, blowing across the top of bottles, changing the length and thickness of elastic bands). They might make earmuffs from a variety of different materials to investigate which provides the best insulation against sound. They could make and play their own instruments by using what they have found out about pitch and volume.</u></p> |
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**Comment [A20]:** CMT. See comment in previous response.



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| <p><b>Electricity</b></p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>▪ identify common appliances that run on electricity</li> <li>▪ construct a simple series electrical circuit, <a href="#">identifying and naming its basic parts, including cells, wires, bulbs, switches and buzzers</a></li> <li>▪ identify whether or not a lamp will light in a simple series circuit based on whether or not the lamp is part of a complete loop with a battery</li> <li>▪ recognise that a switch opens and closes a circuit and associate this with whether or not a lamp lights in a simple series circuit</li> <li>▪ recognise some common conductors and insulators, and associate metals with being good conductors.</li> </ul> | <p><b>Electricity</b></p> <p>Pupils should construct simple series circuits, trying different components, such as bulbs, buzzers and motors, and including switches, and use their circuits to create simple devices. Pupils should draw the circuit as a pictorial representation, not necessarily using conventional circuit symbols at this stage; these will be introduced in Year 6.</p> <p><b>Note:</b> Pupils might use the terms current and voltage, but these should not be introduced or defined formally at this stage. Pupils should be taught about precautions for working safely with electricity.</p> <p>Pupils might work scientifically by: observing patterns, for example that bulbs get brighter if more cells are added, that metals tend to be conductors of electricity, and that some materials can and some cannot be used to connect across a gap in a circuit.</p> |
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**Comment [A21]:** Bullet point expanded with requirements for identifying and naming transferred from Y6 because pupils cannot construct a circuit without being able to identify and name its basic parts.

**Comment [A22]:** CMT. That's helpful.

**Working scientifically**

| Upper Key Stage 2 programme of study (statutory requirements)  | Notes and guidance (non-statutory)  |
|--|---|
| <p><b>Working scientifically</b></p> <p>During Years 5 and 6, pupils should be taught to use the following practical scientific methods, processes and skills through the teaching of the programme of study content:</p> <ul style="list-style-type: none"> <li>▪ planning <a href="#">different types of scientific enquiries to answer questions</a>, including recognising and controlling variables where necessary</li> <li>▪ taking measurements, using a range of scientific equipment, with increasing accuracy and precision</li> <li>▪ recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, <a href="#">and</a> bar and line <a href="#">graphs</a></li> <li>▪ using test results to make predictions to set up further comparative and fair tests</li> <li>▪ using simple models to describe scientific ideas</li> <li>▪ <a href="#">reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of results, in oral and written forms such as displays and other presentations</a></li> <li>▪ identifying scientific evidence that has been used to support or refute ideas or arguments.</li> </ul> | <p><b>Working scientifically</b></p> <p>Pupils in Years 5 and 6 should use their science experiences to: explore ideas and raise different kinds of questions; select and plan the most appropriate type of scientific enquiry to use to answer scientific questions; recognise when and how to set up comparative and fair tests and explain which variables need to be controlled and why. They should use and develop keys and other information records to identify, classify and describe living things and materials, and identify patterns that might be found in the natural environment. They should make their own decisions about what observations to make, what measurements to use and how long to make them for; choose the most appropriate equipment to make measurements and explain how to use it accurately. They should decide how to record data from a choice of familiar approaches; look for different causal relationships in their data and identify evidence that refutes or supports their ideas. They should use their results to identify when further tests and observations might be needed; recognise which secondary sources will be most useful to research their ideas and begin to separate opinion from fact. They should use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas and should talk about how scientific ideas have developed over time.</p> <p>These opportunities for working scientifically should be provided across Years 5 and 6 so that the expectations in the programme of study can be met by the end of Year 6. Pupils are not expected to cover each aspect for every area of study.</p> |

**Comment [A23]:** To improve clarity

**Comment [A24]:** 'and models' deleted because you don't use models to record data. The fifth bullet point refers to models more clearly.

**Comment [A25]:** Two bullet points have been conflated into one because they are both about the same thing and the order of the bullet points has been made more logical, with reporting and presenting findings near the end.

Year 5

|   |  |
|---|--|
| <p><b>Earth and space</b></p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>describe the movement of the Earth, <del>and other planets,</del> relative to the Sun in the solar system</li> <li>describe the movement of the Moon relative to the Earth</li> <li>describe the Sun, Earth and Moon as approximately spherical bodies</li> <li>use the idea of the Earth's rotation to explain day and night.</li> </ul> | <p><b>Earth and space</b></p> <p>Pupils should be introduced to a model of the Sun and Earth that <a href="#">enables them to explain</a> day and night. Pupils should learn that the Sun is a star at the centre of our solar system and that it has eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune (Pluto was reclassified as a 'dwarf planet' in 2006). They should understand that a moon is a celestial body that orbits a planet (Earth has one moon; Jupiter has four large moons and numerous smaller ones).</p> <p><b>Note:</b> Pupils should be warned that it is not safe to look directly at the Sun, even when wearing dark glasses.</p> <p>Pupils should find out about the way that ideas about the solar system have developed, understanding how the geocentric model of the solar system gave way to the heliocentric model <a href="#">by considering the work of scientists such as Ptolemy, Alhazen and Copernicus,</a></p> <p>Pupils might work scientifically by: comparing the time of day at different places on the Earth through internet links and direct communication; creating simple models of the solar system; constructing simple shadow clocks and sundials, calibrated to show midday and the start and end of the school day; <a href="#">finding out why some people think that structures</a> such as Stonehenge <a href="#">might have been</a> used as astronomical clocks.</p> |
|---|--|

**Comment [A26]:** CMT. The planets has been added and could represent a lot of content. As previously submitted, it would be better to concentrate on just the Sun, Earth and Moon at this stage.

Adding the planets

- could cause confusion because there are lots of new ideas at once
- is way beyond their comprehension (size of solar system etc
- is done without any direct supporting observations so is, in a sense, unscientific
- doesn't seem necessary for everyone to study (although some might, of course).
- Strongly suggest leaving the planets out.

|  |   |
|--|---|
| <p><u>Forces</u></p> <p><u>Pupils should be taught to:</u></p> <ul style="list-style-type: none"> <li>▪ <u>explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object</u></li> <li>▪ <u>identify the effects of air resistance, water resistance and friction, that act between moving surfaces</u></li> <li>▪ <u>understand that force and motion can be transferred through mechanical devices such as gears, pulleys, levers and springs.</u></li> </ul> | <p><u>Forces</u></p> <p><u>Pupils should explore falling objects and raise questions about the effects of air resistance. They should experience forces that make things begin to move, get faster or slow down. Pupils should explore the effects of friction on movement and find out how it slows or stops moving objects, for example by observing the effects of a brake on a bicycle wheel. They should explore the effects of air resistance by observing how different objects such as parachutes and sycamore seeds fall. Pupils should explore the effects of levers, pulleys and simple machines on movement. Pupils might find out how scientists such as Galileo Galilei and Isaac Newton helped to develop the theory of gravitation.</u></p> <p><u>Pupils might work scientifically by: exploring falling paper cones or cup-cake cases, and designing and making a variety of parachutes and carrying out fair tests to determine which designs are the most effective. They might explore resistance in water by making and testing boats of different shapes. They might design and make artefacts that use simple levers, pulleys, gears and/or springs and explore their effects.</u></p> |
|--|---|

**Comment [A27]:** CMT. Need to say that gravity, like magnetism, is a force that does not need contact. It acts at a distance. I.e. reinforce work from earlier year. Previously, they were introduced together.

**Comment [A28]:** An interaction acts between two objects. A force acts on one object. So it doesn't make sense to say a force acting between the Earth and the falling object.

**Comment [A29]:** CMT This looks like a new statement. And seems quite advanced for this year group. I'm not actually sure what it means that force and motion can be transferred through a spring. And what are they expected to do with the gears. As ever, they can only know these things rather than understand them.

Year 6

|   |  |
|---|--|
| <p><b>Light</b></p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>understand that light appears to travel in straight lines</li> <li>use the idea that light travels in straight lines to explain that objects are seen because they give out or reflect light into the eye</li> <li><a href="#">explain that we see things because light travels from light sources to our eyes or from light sources to objects and then to our eyes</a></li> <li>use the idea that light travels in straight lines to explain why shadows have the same shape as the objects that cast them, and to predict the <a href="#">changes in</a> size of shadows when the position of the light source changes.</li> </ul> | <p><b>Light</b></p> <p>Pupils should explore the way that light behaves, including light sources, reflection and refraction. They should talk about what happens and make predictions. They should experience a range of examples of interesting aspects of light such as rainbows, colours on soap bubbles, objects looking bent in water and white light being split by prisms.</p> <p>Pupils might work scientifically by: deciding where to place rear-view mirrors on cars; designing and making a periscope and using the idea that light appears to travel in straight lines to explain how it works. They might investigate the relationship between light sources, objects and shadows by using shadow puppets.</p> |
|---|--|

**Comment [A30]:** CMT. Suggest moving the small section on light in year 3 to here so that it makes a complete and coherent section.

**Comment [A32]:** It's not really clear what the purpose is for all of this.

**Comment [A33]:** They will not be offered any explanation for this. So it should be omitted.

**Comment [A31]:** Seems good.

|   |   |
|---|---|
| <p><b>Electricity</b></p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> <li>▪ associate the brightness of a lamp or the volume of a buzzer with the number and voltage of cells used in the circuit</li> <li>▪ compare and give reasons for variations in how components function, including the brightness of bulbs, the loudness of buzzers and the on/off position of switches</li> <li>▪ use recognised symbols when representing a simple circuit in a diagram.</li> </ul> | <p><b>Electricity</b></p> <p>Building on their work in Year 4, pupils should construct simple series circuits, to help them to answer questions about what happens when they try different components, such as switches, bulbs, buzzers and motors. They should learn how to represent a simple circuit in a diagram using recognised symbols.</p> <p><b>Note:</b> Pupils are expected to learn only about series circuits, not parallel circuits. Pupils should be taught to take the necessary precautions for working safely with electricity.</p> <p>Pupils might work scientifically by: systematically identifying the effect of changing one component at a time in a circuit; designing and making a set of traffic lights, a burglar alarm or some other useful circuit.</p> |
|---|---|

**Comment [A36]:** CMT Or it should come out of the N&G – which would be better. I don't really see the advantage of using circuit symbols at this point. Also, which symbols do they need to learn. As an example of coherence, have they studied ideas about topology and topography in maths. If not, then they certainly should **not** be using topographical ideas to draw circuits in science.

**Comment [A34]:** What reasons can they give. I fear that this will encourage students and teachers to misapply technical terms (such as energy and power) in descriptions that sound like explanations but explain nothing.

**Comment [A37]:** Include a note to teachers to avoid using technical terms in a vague way or to provide children with terms that have not been developed or understood (such as energy, power, current). Students may well use those terms but teachers should not encourage that use.

**Comment [A35]:** For consistency; if the N&G says they should learn how to do so, then the PoS should require it to be taught.

## Physics – Key Stage 3

### Energy

Pupils should be taught about:

#### Changes and transfers

- examples of processes that cause change: with forces (work = force x distance; levers and gears reducing force by increasing distance, changing motion, dropping an object, turning a dynamo to produce light); with matter (releasing a compressed spring, igniting fuel, putting hot and cool objects in contact, metabolism of food), with vibrations and waves (warming by radiation) and with electricity (completing an electrical circuit)

**Comment [CT38]:** A somewhat mangled version of what we submitted. And there are some important bits missing.

#### Energy and fuel

- energy transfer caused by temperature difference, maintaining heating by energy supply to the hotter body
- use of energy in a domestic context, fuel sources and heating
- amounts of energy from different foods (from labels)  
relationship between rate of transfer and amount of energy used

#### Energy calculations

- energy calculations using measures of change in the energy associated with elastic deformation, moving and/or vibrating objects, heating materials, and chemical changes involving fuels
- fuel use and costs (including domestic fuel bills), comparing power ratings of appliances, measured in W, kW; calculating amounts of energy transferred in J, kJ, kW hour.

**Comment [CT39]:** This could be a mistake. But it's clearly KS4.

#### Motion and forces

Pupils should be taught about:

##### Describing motion

- speed and the quantitative relationship between average speed, distance and time (average speed = distance ÷ time)
- the representation of a journey on a distance-time graph  
relative motion: trains and cars passing one another.

##### Forces

- forces as pushes or pulls, arising from the interaction between two objects
- using force arrows in diagrams, adding forces in one dimension, balanced and unbalanced forces
- moment as the turning effect of a force

- forces: associated with deforming objects; stretching and squashing – springs; with rubbing and friction between surfaces, with pushing things out of the way; resistance to motion of air and water
- forces measured in **Newtonsnewtons**, measurements of stretch or compression as force is changed
- force-extension **linear relation** as a special case
- work done and energy changes on deformation**
- non-contact forces: gravity forces acting at a distance on Earth and in space, **forces between magnets**, and with static electricity

**Comment [CT40]:** Lowercase for the unit as a word.

**Comment [CMT41]:** There is an opportunity here (and elsewhere) to **start to** develop the idea of proportionality and how it leads to formulae such as  $F = kx$ .

**Comment [CT42]:** This should be qualitative only. If it is here at all. It's probably better saved for KS4.

**Comment [CT43]:** Wording is a bit odd.

### Pressure in fluids

- atmospheric pressure, decreases with increase of height as weight of air above decreases with height
- pressure in liquids, increasing with depth; upthrust effects, floating and sinking
- pressure measured** by ratio of force over area – acting normal to any surface.

**Comment [CT44]:** It's not clear whether this is still pressure. On its own, this statement could be referring to stress. It is only because it is in this section that it might be intended as pressure in a fluid.

### Balanced forces

- opposing forces and equilibrium: weight held by stretched spring or supported on a compressed surface

### Forces and motion

- forces being needed to cause objects to stop or start moving, or to change their speed or direction of motion**
- change depending on direction of force and its **size**.

**Comment [CT45]:** This looks new. It would be better to stick with just Newton's first law at this stage rather than hinting at acceleration.

**Comment [CT46]:** And also on their inertia. Again, it would be better to stick with N1 and the idea of inertia (but not quantitative).

### Waves

Pupils should be taught about:

#### Observed waves

- waves on **surface of** water as undulations which travel ~~through across the~~ water with transverse motion; these waves can be reflected, and add or cancel – superposition

#### Sound waves

- frequencies **of** sound waves, measured in hertz (Hz); echoes, reflection and absorption of sound
- sound needs a medium to travel, the speed of sound in air, in water, in solids
- sound produced by vibrations of objects, in loud speakers, detected by their effects on microphone diaphragm and the ear drum; sound waves are longitudinal
- auditory range of humans and animals

**Comment [CT47]:** See previous response

#### Energy and waves

- pressure waves** carrying energy, use for cleaning and physiotherapy by ultra-sound; for carrying energy and **information for conversion to electrical signals by microphone**

**Comment [CT48]:** See previous response

**Comment [CT49]:** Prefer rewording because this looks like energy is converted to electrical signals. Which it isn't.



### Light waves

- the similarities and differences between light waves and waves in matter
- light waves travelling through a vacuum; speed of light
- the transmission of light through materials: absorption, diffuse scattering and specular reflection at a surface
- use of ray model to explain imaging in mirrors, the pinhole camera, the refraction of light and action of convex lens in focusing (qualitative); the human eye
- light transferring energy from source to absorber leading to chemical and electrical effects; photo-sensitive material in the retina and in cameras
- colours and the different frequencies of light, white light and prisms (qualitative only); differential colour effects in absorption and diffuse reflection.

### Electricity and electromagnetism

Pupils should be taught about:

#### Current electricity

- electric current, measured in amperes, in circuits, series and parallel circuits, currents add where branches meet current as flow of charge
- potential difference, measured in volts, battery and bulb ratings; resistance, measured in ohms, as the ratio of potential difference (p.d.) to current measured in ohms
- calculations of current, power and energy transfer for series circuits
- differences in resistance between conducting and insulating components (quantitative)

**Comment [CT50]:** Qualitative only. The formula should be reserved for key stage 4.

**Comment [CT51]:** This is very solidly in key stage 4.

#### Static electricity

- separation of positive or negative charges when objects are rubbed together: transfer of electrons, forces between charged objects.
- the idea of electric field, forces acting across the space between objects not in contact

#### Magnetism

- magnetic poles, attraction and repulsion
- magnetic fields by plotting with compass, representation by field lines.
- Earth's magnetism, compass and navigation
- the magnetic effect of a current, electromagnets, D.C. motors (principles only).

### Matter

Pupils should be taught about:

**Comment [CT52]:** This whole section still seems to be repeated in chemistry. It needs to be made coherent with the chemistry content.

**Comment [CT53]:** Also, see previous response for comments that still stand.

### Physical changes

- conservation of material and of mass, and reversibility, in melting, freezing, evaporation, sublimation, condensation, dissolving
- similarities and differences, including density differences, between solids, liquids and gases
- Brownian motion in gases
- diffusion in liquids and gases driven by differences in concentration
- the difference between chemical and physical changes

### Particle model

- the differences in arrangements, in motion and in closeness of particles explaining changes of state, shape and density, the anomaly of ice-water transition
- atoms and molecules as particles

### Energy in matter

- changes with temperature in motion and spacing of particles
- internal energy stored in materials.

### Space physics

Students should be taught about:

- gravity force, weight = mass x gravitational field strength (g), on earth  $g=10$  N/kg, different on other planets and stars; gravity forces between ~~earth~~-Earth and ~~moon~~Moon, and between ~~earth~~-Earth and ~~sun~~-Sun (qualitative only)
- our sun as a star, other stars in our galaxy, other galaxies
- the seasons and the Earth's tilt, day length at different times of year, in different hemispheres.
- the light year as a unit of astronomical distance
- The solar system
- The seasons and tilt of the Earth.

**Comment [CT54]:** New topic. Hooray.

**Comment [CT55]:** More appropriate here than in KS2.

**Comment [CT56]:** Nice use of models to explain something. So worth including.

## Comments from the Royal Society of Chemistry on latest draft Programme of Study

In general in Key Stage 1-2 the notes and guidance could say more about the concepts which are being developed. They include suggestions for activities - some quite random, because of the later additions. There is a danger of the notes and guidance being followed without the teacher or pupil understanding the purpose of the activity. They do not always explain what is important about the topic being covered in terms of developing progression through understanding of key concepts.

As it stands, pupils would experience no chemistry in year 6 - a major problem, so we would like to reinforce the Key Stage approach not the year by year, as this would allow better matching of content over the Key Stage to pupils' development.

More specifically:

### Year 2

Uses of everyday materials:

Addition of new bullet point '**Compare how things move on different surfaces**'

This is very odd here as it's not clear what concepts it is trying to develop – forces? Friction? Indicate it's inappropriate to link materials to movement in this artificial way. We suggest this bullet point about movement comment is removed. Notes and guidance about addition of movement looks odd here and the purpose is confused and unclear. If movement is to be included, it should be clear what concepts are being developed and how there is progression through the years.

### Year 3

Rocks:

**'compare and group together different kinds of rocks on the basis of their appearance and simple physical properties'**

We suggest that the term 'physical properties' is omitted. Very unclear what simple physical properties are apart from appearance – when concept of density and other physical properties have not yet been introduced.

### Year 4

States of matter:

In notes and guidance: **'They could research the temperature at which materials change state such as when iron melts or when oxygen condenses, using and applying what they have learnt in mathematics'**.

#### Appendix 4

We suggest removing this sentence as oxygen condensing is outside pupils' experience, at a level when they have barely understood that air is a gas. Also most of the materials dealt with so far are mixtures which do not have sharp melting points. When pupils start asking what temperature chocolate melts at, there would be a need to introduce the idea of mixtures, compounds and elements. Year 4 is too early for this.

#### Year 5

Properties and changes of materials:

***'explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible, including changes associated with burning and the action of acid on bicarbonate of soda'***

We suggest using the word 'substance' instead of material here.

Notes and guidance ***'They should find out about how chemists create new materials, for example Spencer Silver, who invented the glue for sticky notes or Ruth Benerito, who invented wrinkle-free cotton'***

This really illustrates the importance of starting to use the correct term 'substance' rather than material to avoid confusion. Cotton and wrinkle-free cotton are made of the same material but contain different substances.

#### KS3

Periodic table:

***'the chemical properties of metals and non-metals'***

We suggest changing this to 'physical properties' as it would be much more important and relevant here. Without knowing about electron configurations, the chemical properties of metals and non-metals won't make any sense.

## Comments from ASE on Key Stages 1-3

### Aims (p136)

We are in agreement with the aims as broadly set out at the head of the document. What follows helps to exemplify the first two bulleted aims, but not the third. The proposed curriculum does not equip students with the knowledge to understand the uses and implications of science now and in the future.

### Attainment targets (p137)

The term has been retained but not defined or explained. The curriculum should propose what is taught, why it is taught and how to assess whether students have made the necessary progress. Without knowing what students should be able to achieve at each key stage it is unlikely that teachers will be able to successfully implement the proposed curriculum.

### Principal focus

The document sets out the principle focus of teaching science at key stage 1, lower key stage 2 and upper key stage 2. It does not set out the principal focus at key stage 3. This is a serious omission and adds to the lack of clarity around key stage 3. This is a crucial stage in each student's education, and particularly in science. It is during key stage 3 that students make curriculum choices that have significant impact on their future education and career. It would have been appropriate to include teaching about STEM careers in this key stage.

### Progression and coherence

The content of the curriculum is set out as individual subjects, without links between related areas. It would be helpful to teachers of all key stages to recognise linkages between subjects, and particularly between science and mathematics, technology and English.

Within science, content is presented as separate science disciplines, again leading to a lack of coherence. Use of different terminology, different methods of presentation and failure to link through the big ideas underpinning science lead to further unhelpful compartmentalisation of biology, chemistry and physics.

Progression within each discipline is clearly set out, and yet the appropriate age to introduce new ideas appears to be arbitrary and not supported by science education research. The drive for rigour has resulted in difficult concepts being introduced at too early an age, rather than pushing for a better understanding of foundation principles.

Progression is not clear in working scientifically. We welcome the prominent position given to this underpinning aspect of developing scientific reasoning. However, the failure to ensure consistent use of language and ideas, and the failure to build progression into the transition from key stage 2 to key stage 3 is a serious failing.

### Working scientifically

This important aspect of the curriculum is clearly laid out and coherent at key stages 1 and 2.

The statement on working scientifically at key stage 3 is poor. It has been noted above that there is no clear progression from key stage 2 to 3. In addition there is incorrect use of language (reliability

of methods p171), vague statements lacking in exemplification (evaluate risks, apply sampling techniques etc p171), and a section headed 'Measurement' which contains no content about measurement (p172). A term 'investigations and experiments' has been introduced that fails to distinguish between these two important concepts. The term 'scientific enquiry' used at key stages one and two is quite adequate and should also be used at key stage 3.

The divide between key stage 2 and 3 illustrates the problems of using different groups of drafters to produce different sections of the document. Significant further editing of the whole document is needed to ensure coherence and integrity.

### **Content statements**

Previous comments made in response to earlier drafts on biology, chemistry and physics content have yet to be implemented. In general these content statements are too detailed and prescriptive, and yet lack exemplification to show how the statement contributes to the overall aims of the curriculum.

### **Mathematics in science**

We welcome the greater prominence given to mathematics within the science document, and would like to see more detail to exemplify the methods and approaches to be used at each key stage. There are clear examples of how mathematics could be used within biology, physics and chemistry at key stage 3, but more exemplification is needed to support this change in the curriculum.

The links between the mathematics used in science within each key stage and the mathematics national curriculum need to be made clear.

### **Notes and guidance**

This is a welcome feature within the key stages 1 and 2 sections of the document. However, guidance notes should not specify teaching activities or there will be a risk of these activities taking on an unintentional importance at the expense of others.

In the absence of similar guidance at key stage 3, further exemplification is needed within the programme of study on linking content statements to working scientifically, and mathematics. Physics and chemistry sections contain less exemplification than biology.

### **Impact on teaching and the school curriculum**

The draft science curriculum is a substantial document leaving little opportunity for teachers to develop flexible schemes of learning appropriate to their local situation. This could have negative impact on some groups of students. We would like to see provision made for monitoring impact of the curriculum change and for the curriculum to include a plan for review and development. Changes in the national curriculum need to be better built in to a schools curriculum development cycle.

## **Comments from ASE on latest draft primary science Programme of Study**

These comments draw on responses from members of ASE's Primary Science Committee and NAIGS committee.

Positive changes:

- Generally the balance of topics across the year groups is better in terms of both content and conceptual demand.
- There is generally better progression and coherence in the topics and content across the year groups.
- The links between the content and the working scientifically in each key stage are generally more explicit.
- The changes to the notes and guidance to increase clarity have generally been successful.

However there still remain areas of concern which should be addressed before this draft progresses to the next stage.

### **Year 1**

#### **Light**

There needs to include a bullet point to make it clear that children need to understand that we need light to see and that darkness is the absence of light - and something in Notes and Guidance about experiences of darkness.

### **Year 2**

#### **Uses of everyday materials**

It is difficult to make sense of the combination of materials and forces in this section. We have now lost the basic statement about observing and describing movement and restricted the comparison to movement on different surfaces, presumably to tie it in with materials. However the Notes and Guidance cover objects falling and flying which is important but has no connection with a statement about what happens on surfaces. Suddenly it's all about friction, but as a property rather than a force and we've lost everything else. This whole section is very muddled and will result in children leaving KS1 with no idea that a force is needed to make something move- that a force is a push, pull or twist. The first time they encounter forces will be to compare contact with non-contact forces when they do magnets in Year 4 but they will have nothing to build on. This really must be looked at again and movement separated from materials.

#### **Sound**

We are concerned that there is no statement about sound needing a medium to travel through either here or in Year 4.

## **Year 4**

### **States of matter**

We question whether there should be an inclusion of specific vocabulary around states of matter.

## **Years 5 and 6**

### **Working scientifically**

We would like to see the inclusion of scattergraphs. We know that, with simplified scattergraphs KS1 children can see simple correlations. If there is a reason not to include these in PoS, we would like to see them in the Notes and Guidance.

## **Year 5**

### **All living things**

Explain the differences in the life cycles of etc. What explanation are we looking for? Observe is the term used in the Notes and Guidance and is the more appropriate term.

### **Animals, including humans**

We are concerned that puberty is only referenced in the Notes and Guidance. The fundamental problem with the teaching of puberty is that some schools, under parental pressure, will opt out of teaching it unless it is statutory. This is a matter of entitlement to what all the evidence shows is necessary and beneficial.

### **Properties and changes of materials**

Response to magnets does not belong in the first bullet point. As it reads we are directing teachers to do a comparative or fair test to find out whether a material is magnetic or not. As we are not testing strength of magnets or 'degree of magnetism', it is a simple sorting investigation (is it or isn't it). We are concerned that the statement as written will lead to inappropriate attempts at fair testing.

### **Earth and space**

As apparent movement of the sun has been removed from KS1 it would seem sensible to add it here so that children

- Use the idea of the Earth's rotation to explain day and night and the apparent movement of the sun across the sky

### **Forces**

Has a decision been made not to include comparing and measuring forces, using forcemeters and Newtons?

In the Notes and Guidance there is some overlap with the D&T draft POS and this could be made more explicit as a cross curricular link by rephrasing the final sentence. If children are designing and making then it reads like D&T; in which case they are making products not artefacts. Also simple levers read more like KS1 D&T. In KS2 there is progression to levers and linkages – see <http://dev.data.org.uk/generaldocs/Design-and-Technology-PoS-KS1-3-final-advice-160513.pdf>



## Year 6

### All living things

There is some inconsistency in progression between Year 4 and 6. Is it intended that Year 4 children use two main groups - plants and animals and expand this grouping to three in Year 6 including micro-organisms?

### Animals including humans

Describe the function of the heart etc. not explain.

### Evolution and inheritance

Together the three bullets provide a really clear description of the factors that inform understanding of evolution. We suggest inclusion of a separate statement about evolution.

In general, continuity with the Mathematics PoS needs to be strengthened and made more explicit.

### Progression to KS3

#### Working scientifically

It is hard to see any continuity or progression in Working scientifically - from the simple observation that using models doesn't appear at KS3, to the more significant omission that all the hard work done at KS1 and 2 to clearly identify the different types of science enquiry that children need to be familiar with in order to answer scientific questions is not referred to in any introductory text. No mention is made of building on the skills children will have in terms of knowing which approach to take in order to answer questions, nor that by the end of KS2 they will be able to work autonomously. As it stands, this section could be interpreted that children have no prior experiences in science enquiry. An introductory paragraph, along the lines of that in the primary science PoS, should be included before the detailed bullet statements to ensure that children are given the opportunities to build on their considerable skills and autonomy from their primary science education.

**Biology:** good links with skeleton and muscles; digestion and nutrition; reproduction and health; interdependence and variation. Challenge and progression is about right.

**Chemistry:** this is a big jump from primary which is a result of the introduction of the particle theory. What is similar is the link between patterns of behaviour; the reactions described and the Earth science. This is suitable progression.

**Physics:** this is also a big jump from primary which is a result of the introduction of the concept of energy. What is similar is the link between forces and motion; sound and light; electricity and magnetism; and Space physics. We question whether the bullet point on P10 of the KS3 POS: 'forces as pushes or pulls, arising from the interaction between two objects' needs to be adapted to ensure progression from KS2.

## Comments from Society of Biology on latest draft primary science Programme of Study

These comments draw on responses from some of the Society's Member Organisations, teachers and other relevant stakeholders. Please note: given the time limitations this is not a comprehensive review.

### General:

- There is generally better progression and coherence in the biology topics and content.
- However, it is still of concern that plants does not appear as a topic post-Year 3 (although 'Animals, including humans' does feature).
- First hand experiences for pupils to experience phenomena (e.g. plants and animals) should be emphasised wherever possible (using a range of senses), alongside the use of secondary data.
- The notes and guidance still contain statements that comment on how teachers should teach, which is not appropriate for a National Curriculum document.
- It's important that a National Curriculum document about scientific knowledge should list living organisms in the correct order in terms of evolutionary development
- The National Curriculum document must also clear up any confusion between trees/plants and humans/animals (i.e. they are not mutually exclusive).

### Of particular note:

- Puberty must be added to the statutory statements at Year 5. The fundamental problem with the teaching of puberty is that some schools will opt out of teaching it unless it is statutory. This is a matter of entitlement to what all the evidence shows is necessary and beneficial.

## Plants

### Year 1: Plants

The Programme of Study should make it clear that trees are plants (in both statutory statements and Notes and guidance – N&G). By listing them separately there is a risk of creating confusion.

- identify and name a variety of common plants, including garden plants, wild plants (including trees) and trees, and those classified as deciduous and evergreen

### Year 2: Plants

- observe and describe how seeds and bulbs grow into mature plants

[From N&G] Pupils should use the local environment throughout the year to observe how plants grow, develop and die (including seeds, bulbs, fruit and vegetables, deciduous and evergreen bushes and trees, and annual, perennial, deciduous and evergreen plants).

**Note:** Seeds and bulbs need water to grow but do not need light; seeds and bulbs have a store of food inside them.

**Comment [GG57]:** Listing 'trees' separately risks implying that trees are not plants. Suggest revising to 'garden plants, wild plants (including trees)' to avoid any misinterpretation.

**Comment [GG58]:** More clarity on what the learning outcome is for this statement would be helpful. E.g. are pupils expected to name different types of garden vs wild plants – or just be able to identify differences (which may not be obvious)? Compared to the similar statement on animals at Year 1, the variety is somewhat limited - suggest expanding (e.g. adding 'ferns' and 'mosses') or possibly revising – e.g. to '...including flowering plants (garden and wild), conifers, ferns and mosses'. Realising and recognising that flowering plants (which include trees), conifers, ferns and mosses are all plants is quite powerful and important.

**Comment [GG59]:** Do we want to include this at Year 1? This might be better introduced at Year 2 when pupils are expected to observe seasonal changes in plants.

**Comment [GG60]:** Consider adding more on life cycle – e.g. plant development and death (to statements elsewhere on once living vs. never living). This would allow a consideration of annuals and perennials to be added and help pupils realise how long some plants have been alive compared with others that die off within a year.

**Comment [GG61]:** As above

**Comment [GG62]:** If this is kept in then it needs to be sorted (currently a muddle). Seeds can grow into trees, fruit & veg is not a helpful distinction at this stage. Suggest revising to something like: Seeds that grow into a variety of plants, including bushes and trees. Bulbs that grow into plants used for flowers (e.g. daffodil) and food (e.g. onion). Flowers that develop into fruits.

**Comment [A63]:** Note: although the majority of seeds do not need light, some do. Revise to 'Most seeds do not need light'

**Year 3: Plants**

- identify and describe the functions of different parts of flowering plants: roots, stem/trunk, leaves and, flowers, bulb, seed, and fruit.

**Animals, including humans**

**Year 1: Animals, including humans**

- identify and name a variety of common animals that are birds, fish, amphibians, reptiles, mammals and invertebrates
- identify and name a variety of common animals that are carnivores, herbivores and omnivores
- describe and compare the structure of a variety of common animals (birds, fish, amphibians, reptiles, mammals and invertebrates, and including pets)

It would also be helpful to provide teachers with guidance to explain the difference between 'germination' and 'growth'.

**Comment [A64]:** When listing animals invertebrates should come before vertebrates; when listing vertebrates the order should be: fish, amphibians, reptiles, birds and mammals. The order is important as it is a strong feature of biology that we order living things according to evolutionary development

**Comment [A65]:** This vocabulary is difficult for Year 1

**Comment [A66]:** See comment on order

**Year 2: Animals, including humans**

- describe the importance for humans of exercise, eating the right amounts of different types of food, and hygiene to the health of the human body.

[From N&G] They should also be introduced to the processes of reproduction and growth in animals.

**Comment [GG67]:** Needs more definition – especially as this isn't really expanded in the N&G

**Comment [GG68]:** 'Process' should be in the plural as growth and reproduction are two different processes.

**Comment [GG69]:** Without 'other' it seems as if humans are separate to animals

**Year 3: Animals, including humans**

- identify that humans and some other animals have skeletons and muscles for support, protection and movement.

**Comment [GG70]:** Puberty must be explicitly mentioned in the statutory statements (not just the non-statutory notes and guidance) to ensure that it is covered – and covered well – at Year 5.

**Comment [A71]:** 'Describe' rather than 'explain'

**Year 5: Animals, including humans**

- describe the changes as humans develop from birth to old age

**Comment [GG72]:** More clarification around this might be helpful in the N&G (as per our comments submitted in the April consultation response). Pupils need to develop a better biological understanding of 'living', 'once-living' and 'never-living'. Living things should not just be defined by a set of characteristics (e.g. MRS GREN), where the absence of any one characteristic implies they're not living (e.g. a car doesn't reproduce, so can't be deemed living) since not all living individuals reproduce (i.e. a worker bee or a mule) and yet they are alive. E.G. A more sophisticated understanding could be based on the idea that all living things 'self-maintain' – they're doing things to keep themselves alive.

**Year 6: Animals, including humans**

- identify and name the main parts of the human circulatory system, and explain the functions of the heart, blood vessels and blood

Working scientifically section of N&G could be further enhanced by suggesting more hands-on practical experiences – e.g. measuring pulse rate before and after exercise.

**Comment [GG73]:** Consider moving this statement from Yr 2 to Yr 4, alongside the relevant section of the N&G (where it could explicitly build on/make links to the classification and identification of living things), and re-naming the Yr 4 topic 'Living things and their habitats'. Moving to a later stage is also important as pupils need a much stronger grasp of this in order to deal with photosynthesis and energy at KS3.

**All living things**

**Year 2: All living things and their habitats**

- explore and compare the differences between things that are living, dead, and things that have never been alive
- describe how animals obtain their food from plants and other animals, using the idea of a simple food chain, and identify and name different sources of food.

**Year 4: All living things (N&G)**

Pupils should begin to put animals into groups such as fish, amphibians, reptiles, birds, and mammals; invertebrates into snails and slugs, worms, spiders, and insects.

**Note:** Plants are more difficult to classify, but can be grouped into categories such as flowering plants (including grasses) and non-flowering plants such as ferns and mosses.

**Year 5: All living things (N&G)**

They should find out about the work of naturalists and animal behaviourists such as David Attenborough and Jane Goodall.

**Year 6: All living things**

- living things into broad groups according to common observable characteristics and based on similarities and differences, including plants, animals and micro-organisms

**Evolution and inheritance**

**Year 6: Evolution and inheritance (N&G)**

Pupils might find out about the work of palaeontologists such as Mary Anning and about how Alfred Wallace and Charles Darwin developed their ideas on evolution.

Pupils might work scientifically by: observing and raising questions about local animals and how they are adapted to their environment; comparing how some living things are adapted to survive in extreme conditions, for example cactusescacti, penguins and camels.

**Comment [GG74]:** Invertebrates should be before vertebrates (but the list of vertebrates is correct).

**Comment [GG75]:** Note: Snails and slugs represent a phylum (Molluscs) Worms represent one phylum of worms (Annelids) but spiders represent a Class of Arthropods. If the spiders and insects are linked then this would be correct as both are classes within the same phylum (Arthropoda).

**Comment [MR76]:** Delete this statement – not necessarily the case at this level and it may be detrimental to suggest that plants are more difficult in case this becomes ingrained! And, from a practical perspective, pupils can more easily line up a group of plants together and make decisions about them than with animals.

**Comment [G77]:** This builds on nicely from Year 1.

**Comment [MR78]:** Alternative examples we would recommend, that better represent science, include Arthur Tansley (for introducing the concept of ecosystem), or Charles Elton (who turned natural history into the science of ecology by applying the scientific method to study the lives of animals in their natural habitats). Rosemary Grant is widely regarded by ecologists as one of the greatest female naturalists (who is still alive, British - although now in the US - and has spent a lot of time working on Galapagos finches). Would also be helpful to include an environmentalist or botanist. Rachel Carson provides an opportunity to learn about 'Silent Spring' and concern for the environment. If the existing examples are retained then reverse the order (one of them is an animal behaviourist; the other is a great TV presenter).

**Comment [A79]:** Re-order, this should read micro-organisms, plants and animals

**Comment [MR80]:** Pleased to see the addition of Wallace (and therefore breadth), but put Darwin before Wallace

## Comments from the Society of Biology on the latest draft KS3 Programme of Study for biology

These comments draw on responses from some of the Society's Member Organisations, teachers and other relevant stakeholders. Please note: given the time limitations this is not a comprehensive review.

### General:

- There is generally better coherence and sequencing of content within and between the biology topics.
- We are pleased to see many of our comments have been implemented.
- It is a positive improvement that plants are now considered alongside animals. This should help teachers identify the similarities between the systems operating in both.

### Structure and function of living organisms

Students should be taught about:

#### Cells and organisation

- cells as the fundamental unit of living organisms, including how to observe, interpret and record cell structure using a light microscope
- the functions of the cell wall, cell membrane, cytoplasm, nucleus, vacuole, mitochondria and chloroplasts
- the similarities and differences between plant and animal cells
- the role of diffusion in the movement of materials in and between cells
- the structural adaptations of some unicellular organisms the hierarchical
- organisation of multicellular organisms: from cells to tissues to organs to systems to organisms

#### The skeletal and muscular systems

- the structure and functions of the human skeleton, to include support, protection, movement and making blood cells
- biomechanics – the interaction between skeleton and muscles, including the measurement of force exerted by different muscles
- the function of muscles and antagonistic muscles

#### Nutrition and digestion

- content of a healthy human diet: carbohydrates, fats, proteins, vitamins, minerals, dietary fibre and water, and why each is needed
- calculations of energy requirements in a healthy daily diet
- the consequences of imbalances in the diet, including obesity, starvation and deficiency diseases

**Comment [GG81]:** Consider rephrasing to: 'the function of muscles and examples of antagonistic muscle groups'.

**Comment [GG82]:** Consider changing to 'lipids' or 'lipids (fats and oils)'

- the tissues and organs of the human digestive system, including adaptations to function and how the digestive system digests food (enzymes simply as biological catalysts)
- the importance of bacteria in the human digestive system
- ~~healthy plants gain mineral nutrients from soil via their roots and make carbohydrates in their leaves by photosynthesis~~

**Comment [G83]:** This is important to have in this section (i.e. alongside human nutrition). However, it's important not to reinforce prevailing misconceptions among students that plants get their food from the soil (rather than understanding that plants synthesise their 'food' from carbon dioxide in the air and water in photosynthesis). Suggest adding 'and make carbohydrates in their leaves by photosynthesis' to clarify (and link to section on photosynthesis).

### Gas exchange systems

- the structure and functions of the gas exchange system in humans, including adaptations to function
- the mechanism of breathing to move air in and out of the lungs, using a pressure model to explain the movement of gases, including simple measurements of lung volume
- the impact of exercise, asthma and smoking on the human gas exchange system
- the role of leaf stomata in gas exchange in plants

### Reproduction

- reproduction in humans (as an example of a mammal), including the structure and function of the male and female reproductive systems, menstrual cycle (without details of hormones), gametes, fertilisation, gestation and birth, to include the effect of maternal lifestyle on the foetus through the placenta
- reproduction in plants, including flower structure, wind and insect pollination, fertilisation, seed and fruit formation and dispersal, including quantitative investigation of some dispersal mechanisms
- ~~the importance of plant reproduction through insect pollination in human food security~~

**Comment [GG84]:** This is currently duplicated in 'relationships in an ecosystem' section below. Suggest deleting from here and retaining below.

**Comment [GG85]:** There is more to health than drugs (although more detail is provided at KS4/GCSE) – consider revising the sub-title?

### Health

- ~~the importance of medicines on the treatment of disease and~~ the effects of recreational drugs (including smoking, alcohol and substance misuse) on behaviour, health and life processes

**Comment [GG86]:** The current statement does not mention the importance of medicines – is this adequately covered at KS4/GCSE or should it mentioned here as well? More clarification on the breadth required here might also be helpful.

### Material cycles and energy

Students should be taught about:

#### Photosynthesis

- ~~the reactants in, and products of, photosynthesis, and a word summary for photosynthesis~~
- the dependence of almost all life on Earth on the use of sunlight by ability of plants and algae to use sunlight in photosynthesis
- the adaptations of leaves for photosynthesis
- ~~the relationship between the structures and functions of leaves, including chloroplasts and stomata~~

**Comment [GG87]:** More clarity would be helpful here to explain what is meant by 'word summary'. The rationale for changing from 'word equation' is fair, but there is a risk teachers will not understand what it means and may require additional support (ideally in the form of notes and guidance to avoid the content statement becoming overly clunky).

**Comment [GG88]:** More clarity might be helpful regarding what the learning outcome is at KS3 compared with KS4/GCSE (where this is more explicit), in order to provide clearer progression and avoid repetition. Suggest adding 'to produce organic molecules that are a useful energy store'.

**Comment [GG89]:** Delete as this is covered by the statement above on adaptations of leaves.

- the reactants in, and products of, photosynthesis, and a word summary for photosynthesis
- mineral nutrition in plants, to explain the role of nitrates
- chemosynthesis in bacteria and other organisms

**Comment [GG90]:** Suggest a change in order so that this statement comes first in the section

**Comment [GG91]:** Repetition from statement in the 'nutrition' section. Delete from here and retain above.

**Comment [GG92]:** Delete from KS3 and move to KS4/GCSE criteria where students can better understand these topics

**Comment [GG93]:** This statement is less true for plants as much of the ATP and carbon skeletons in plants come from photosynthesis, not respiration. Therefore suggest deleting 'all the'.

**Comment [GG94]:** As above

**Comment [GG95]:** As above

**Comment [GG96]:** Suggest removing the reference to energy and rephrasing to: "in terms of the products formed and implications for the organism."

### Cellular respiration

- aerobic and anaerobic respiration in living organisms, including the breakdown of organic molecules to enable all the other chemical processes necessary for life
- a word summary for aerobic respiration
- the process of anaerobic respiration in humans and micro-organisms, including fermentation, and a word summary for anaerobic respiration
- the differences between aerobic and anaerobic respiration in terms of products formed and implications for the organism, and energy accounting.

### Interactions and interdependencies

Students should be taught about:

#### Relationships in an ecosystem

- the interdependence of organisms in an ecosystem, including food webs and insect pollinated crops as examples
- the importance of plant reproduction through insect pollination in human food security
- how organisms affect, and are affected by, their environment, including the accumulation of toxic materials
- the role of variation in enabling living things organisms with similar requirements to survive in an ecosystem.

**Comment [GG97]:** This may need revising or deleting. It links to the statements below on competition/variation therefore may not be necessary. Niches are too complex to be taught at KS3.

### Genetics and evolution

Students should be taught about:

#### Inheritance, chromosomes, DNA and genes

- heredity as the process by which genetic information is transmitted from one generation to the next
- a simple model of chromosomes, genes and DNA in heredity, including the part played by Watson, Crick, Wilkins and Franklin in the development of the DNA model
- the variation between individuals of different species
- the variation between individuals within a species being continuous or discontinuous, to include measurement and graphical representation of variation
- the variation between species and between individuals of the same species leading to competition which can drive natural selection

**Comment [GG98]:** This section contains several references to species, would it be helpful to include a definition of 'species'? Alternatively, this statement could be changed to "the differences between species" (depending on the intended learning outcome).

**Comment [GG99]:** Suggest revising this as it is currently misleading (e.g. it is limited resources that leads to competition). Limited resources leads to competition, variation between species and between individuals of the same species leads to some organisms surviving at the expense of others (differential survival) which can drive natural selection.

Appendix 8

- changes in the environment may leave individuals within a species, and some entire species, less well adapted to compete successfully and reproduce, which in turn may lead to extinction
- the importance of maintaining biodiversity
- the use of gene banks to preserve hereditary material before a species becomes extinct.

**Comment [GG100]:** Suggest adding 'maintaining' so that teachers cover the importance of biodiversity *and* ways of maintaining it

**Comment [G101]:** This statement may fit better in the section above on 'relationships in an ecosystem' (although the link to gene banks is also important).

**Comment [G102]:** Suggest curtailing this statement to give more freedom to talk about the use of gene banks more widely (the previous version was unduly negative and restricted). E.g. as well as preserving material before extinction, they also allow us to draw on the genetic diversity within it when environmental circumstances mean the crops we have focused on become less well adapted.