Department for Education: National Curriculum for science: Key Stages 1 and 2 – Draft

Response by the Wellcome Trust

July 2012

Key Points

1. There is an urgent need to increase the value placed upon science in primary schools. One way to achieve this will be by ensuring appropriate assessments that provide a level of rigour to give science equal importance with mathematics and English.

2. The national curriculum should not be overly prescriptive on *how* to teach science. While we welcome the level of detail in the proposals, the curriculum should set out *what* to teach, but it should be left to teachers to decide *how* best to teach it.

3. More emphasis should be placed upon training teachers to have the knowledge and confidence to teach young people scientific concepts in innovative and engaging ways.

4. Care must be taken when simplifying difficult concepts so that they are kept scientifically accurate. In some instances, the draft curriculum has introduced unhelpful and unnecessary inaccuracies which could potentially create misconceptions in young peoples' learning of scientific concepts.

5. We are encouraged by the increased emphasis on practical learning: experimentation is after all the essence of science. It will be important to ensure that schools have the necessary resources and that teachers receive the necessary training and support to implement the practical curriculum effectively.

6. The Department for Education (DfE) will need to carefully consider what is taught at Key Stage 3, given the possible removal of a National Curriculum at secondary level as recently proposed by the Secretary of State, and the introduction of some topics previously taught at that level into this primary curriculum.

INTRODUCTION

7. The Wellcome Trust is committed to supporting science education and works to ensure all young people develop the science skills and knowledge necessary to live and work in an ever more scientific time. Our Education Strategy[1] for 2010-2020 places "science 5-14" as a key priority area in our remit. We are therefore pleased to respond to this pre-consultation on the National Curriculum for science in primary schools (referred to as 'primary science curriculum' throughout).

8. Primary education is crucial in supporting scientific literacy and inspiring young people to continue studying science subjects at a higher level. It is the basis of equipping young

[1] Wellcome Trust Education Strategy 2010–2020 (2010) "Inspiring Science Education: Extraordinary Opportunities"
http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_publishing_group/documents/web_document/wtx064002.pdf

people with the understanding necessary to make informed decisions about the impacts of scientific and technological developments on their lives, as well as engaging and inspiring them to continue with science and hopefully add to the next generation of scientists.

9. We have been actively involved in debates on the National Curriculum, in particular facilitating a symposium in 2010 on the National Curriculum for science, and responding to the Department for Education (DfE) consultation in 2011[2]. The report of the symposium[3] sets out five key messages for consideration in the development of a new curriculum:

    i. The aims and purpose of a National Curriculum for science must be clearly articulated and adhered to;

    ii. The body of core knowledge should be clearly defined but not over-prescriptive;

    iii. Assessment should be designed as an integral part of the National Curriculum development;

    iv. New developments should be carefully piloted and rigorously evaluated before being refined and rolled out nationally; and

    v. Implementation of a new National Curriculum must be carefully planned to ensure that all parties involved (including teachers, inspectors, parents and pupils) understand how it should be applied.

10. Although outside the remit of this consultation, given recent proposals that include the possibility of removing the National Curriculum from 11 to 16, the DfE must think very carefully about continuity from primary to secondary education. If there is to be no National Curriculum at Key Stage 3, and no examination specifications to drive learning at this level, it will be crucial that teachers have clear guidance on what they are expected to teach. A National Curriculum from 5 to 14 would avoid this issue.

ASSESSMENT

11. Young people's interest in science is often sparked in primary schools, yet a survey by the Wellcome Trust and the National Science Learning Centre suggests that many primary schools have experienced an erosion in the status of science in recent years[4]. This follows the removal of compulsory national science tests at age 11, and is linked to the long-term weakness of primary teachers' knowledge and confidence in science, as observed in our 2005 report '*Primary Horizons: starting out in science*'[5].

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[2] http://www.wellcome.ac.uk/stellent/groups/corporatesite/@policy_communications/documents/web_document/WTVM050997.pdf

[3] Wellcome Trust (2010) Summary report of the seminar "Leading Debate: 21 Years of the National Curriculum for Science" http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtx063344.pdf

[4] Wellcome Trust (2011) Primary Science Survey Report. http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtvm053596.pdf

[5] Wellcome Trust (2005). *Primary Horizons: starting out in science*. http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtx026636.pdf

12. While we would not wish to see national testing of science reinstated at this level, because of the tendency to "teach to the test", there is an urgent need to address the status of science in primary school. High quality teaching and rigorous assessment is key to this. Assessments should be developed that support learning and assess the things that are considered important for young people to know, understand and be able to do, encompassing the full breadth of the science curriculum.

13. It is not clear how pupils will be assessed under this primary science curriculum, although we assume this will be done through teacher assessments. While we support this approach, we urge the DfE to consider ways of supporting and standardising teacher assessment in science at this level, so that it has a degree of externality that is valued as equivalent to that of the other core subjects, mathematics and English. This could be through providing standard ways of assessing learning, for example using practical work and presentations, and exemplars of work that has already been assessed and awarded a particular standard. The ideal would be for these exemplars to arise from the professional teaching community, but it cannot be expected that this will happen without some prompting. Some ideas for the development of appropriate assessments are outlined in the recent report by the Nuffield Foundation[6].

CONTENT

Level of detail

14. The primary science curriculum should set out the key concepts of what we want young people to learn during primary education. This would help teachers to see the teaching of individual parts of the curriculum as part of a bigger picture of what young people should have learnt by the end of primary school.

15. We welcome the level of detail that is contained in this proposed primary science curriculum. This will be helpful for teachers who do not have science expertise. However, in this regard, there is a danger that the notes and guidance in this document could overly influence classroom practice and become a prescriptive scaffold for teaching. Teaching must go further than this, and there is a vital need for continuing professional development for primary teachers so that they have the skills and confidence to teach this material in innovative and engaging ways (this is discussed further in paragraphs 27-28).

16. We were surprised by the amount of emphasis regarding *how* to teach science topics. We believed that the objective of the DfE was to provide a National Curriculum that would give the teachers more flexibility in *how* they teach scientific concepts to young people. We urge the DfE to review the document in light of this, and instead of being prescriptive on how, put more emphasis on the training and support for teachers to implement the National Curriculum in a way that is best for their students.

17. Further, the notes and guidance rely heavily on examples of practical observation and description in the local environment. Engaging teaching and learning requires a variety and diversity of practical approaches to test and develop scientific concepts. We believe

[6] The Nuffield Foundation (2012). *Developing policy, principles and practice in primary school science assessment.* http://www.nuffieldfoundation.org/sites/default/files/files/Developing_policy_principles_and_practice_in_primary_school_science_assessment_Nuffield_Foundation_v_FINAL.pdf

some other examples of practical work, that can be done within the classroom, should be provided in this document.

18. Younger learners should have ample opportunities to develop and test their ideas, even if their methodologies are not yet sophisticated enough to conform to the principles of a "fair test", as they should in later years.

Inaccuracies

19. We are keen to see teachers stretch and challenge their pupils. However, we believe that some concepts in this primary science curriculum have been oversimplified incorrectly due to the introduction of more difficult content. This is dangerous, as oversimplifying complex scientific concepts has introduced inaccuracies, which can lead to misconceptions in young peoples' learning of science. If this level of topic is to be taught, it must be simplified in the correct way for the level of learner.

20. For example in the Year 3 Programme of Study the following is stated 'Ensure pupils understand that it is the material from which an object is made that determines whether it will float or sink', this is not scientifically accurate. Although we think that children of this age can (and should) explore floating and sinking through experimentation and play, we believe the curriculum should avoid oversimplified, and therefore incorrect, explanations of complex concepts. Teaching of the rule stated above, by teachers who may not be subject specialists, will introduce a misconception that is later hard to counter.

21. The above is only one example and we urge the DfE to examine the content in the primary science curriculum so that it is at the appropriate level and does not engender misconceptions of scientific method or fact. In this light we expect that the DfE will seek expert subject advice from the relevant professional bodies and learned societies to thoroughly scrutinise this document in detail before implementation. This should include the Institute of Physics, Royal Society of Chemistry, Society of Biology and Association for Science Education.

Science - not physics, chemistry and biology

22. We fully support the promotion of separate sciences at secondary level. However, we do not believe it is necessary to separate out the sciences at primary level. In any case, a considerable amount of the content provided in the document is not specifically relevant to any one of the three subjects, for example most of the chemistry content is actually material science. We therefore recommend that the DfE simply refers to "the sciences" rather than physics, chemistry and biology separately.

Mathematics

23. It is important that understanding of mathematics goes hand in hand with science. We expect that DfE is ensuring alignment across science and mathematics, and that both curricula inform each other and equally prepare students to learn at the same level in both subjects.

Biographies

24. Biographies can often provide rich and engaging, real-life context for learning. In science, they can convey the process of scientific discovery and even supply role models. However, the rationale for why these people are named in this primary science curriculum is not always clear, especially given that the suggested person is sometimes

not primarily associated with the subject matter. For instance, we were pleased to see Charles Darwin highlighted in the primary science curriculum. However, his name not placed in the context of evolution. Evolution is an important scientific concept which we believe should have a strong place in this primary science curriculum, and one that could certainly be enriched by discussing the life and work of Charles Darwin.

25. We recommend that DfE look more closely at appropriate biographies that put science into context in an interesting way and provide role models that all students can relate to. We have provided some examples to supplement those already in the document (Annex A).

RESOURCING AND IMPLEMENTATION

26. The document sets out a number of ways to try and put scientific learning into practice (although as mentioned we would like to see a greater variety of these). While we are encouraged by the increased emphasis on practical work, the examples noted in the document, such as using data loggers or boiling water in a safe way so that its temperature can be taken, may require equipment that many primary schools may not currently have. Extra resources must be made available to schools so that all primary schools are able to teach the breadth of the proposed curriculum.

27. It is not yet clear how this primary science curriculum will be transferred into practice in the classroom. We have noted our concerns that the guidance notes may lead some teachers just to follow the document to the letter, as they may not have the skills or vision to introduce innovative and engaging ways to teach young people science. It is therefore important that primary teachers have the necessary subject-specific knowledge and expertise. Many studies have identified these attributes as important influencers on pupil responses to science during primary and early secondary education[7]. Implementation of this primary science curriculum will therefore require high-quality support and ongoing professional development to help teachers provide the best possible science education for our young generations.

28. The Trust is currently developing a programme of continuing professional development to train primary science coordinators, who do not have a science background, to become inspirational science specialists with the necessary subject knowledge, pedagogical knowledge and leadership skills to develop science throughout their school. We hope that the course will impact on the status of science throughout the school, the skills of the teacher involved and their peers, and the attainment and aspirations of pupils. The impacts of the programme will be rigorously assessed through a randomised controlled trial. If positive impacts are seen, it is hoped there will be national roll-out of the programme so that every school can have access to a highly trained primary science specialist. This model for training could support the implementation of the new primary science curriculum across the country. Without such in-depth training, the new curriculum cannot have the transformative effect that it aspires to.

[7] Tymms, P. & Gallagher, S. (1995) Primary Science: an exploration of differential classroom success. Research in Science & Technological Education, 13 (2), 155 – 162; Osborne, J. F., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: a focus-group study. International Journal of Science Education, 23(5), 441-468;

EVIDENCE BASED EDUCATION

29. However well informed, when introducing new reforms to the education system, it is important to evaluate the impact on young peoples' learning. We believe the ideal approach to introducing a new primary science curriculum would be through a phased implementation. It would then be possible to gather some information on how the curriculum is being received by teachers, how it is affecting pupils and enable a more iterative process for improvement. However, realising that this is not the intention of DfE, we urge the Department to collect information on the impact of this curriculum as soon as possible following implementation, to inform its improvement over time.

ANNEX A – further examples of scientists, with some rationale for their inclusion, to supplement the people named in the primary science curriculum.

Year 2 Animals including Humans, Year 3 Animals including Humans

1. **Dr Elsie Widdowson** FRS ,was a British scientist responsible for overseeing the government mandated addition of vitamins to food and war-time rationing in Britain during World War II. She graduated with a PhD in chemistry from Imperial College, London in 1928; her thesis was on the carbohydrate content of apples. Widdowson and her scientific partner, Robert McCance, headed the first mandated addition of vitamins and mineral to food. Their work began in the early 1940s, when calcium was added to bread. The two were also responsible for formulating the war-time rationing of Britain during World War II. In1940 she coauthored *The Chemical Composition of Foods* in with Professor McCance. Their work became known the basis for modern nutritional thinking.

Year 3 Rocks, Year 6 Evolution and Inheritance

2. **Mary Anning** (21 May 1799 – 9 March 1847) was a British fossil collector, dealer, and paleontologist who became known around the world for a number of important finds she made in the Jurassic marine fossil beds at Lyme Regis in Dorset, where she lived, Her work contributed to fundamental changes that occurred during her lifetime in scientific thinking about prehistoric life and the history of the Earth.

   Anning searched for fossils in the area's Blue Lias cliffs, particularly during the winter months when landslides exposed new fossils that had to be collected quickly before they were lost to the sea. It was dangerous work, and she nearly lost her life in 1833 during a landslide. Her discoveries included the first ichthyosaur skeleton to be correctly identified, which she and her brother Joseph found when she was just twelve years old; the first two plesiosaur skeletons ever found; the first pterosaur skeleton located outside Germany; and some important fish fossils. Her observations played a key role in the discovery that coprolites, known as bezoar stones at the time, were fossilised faeces. She also discovered that belemnite fossils contained fossilised ink sacs like those of modern cephalopods.

Year 4 Earth and Space

3. **Valentina Tereshkova** was the first woman in space. She was selected out of more than four hundred applicants, and then out of five finalists, to pilot Vostok 6 on the 16 June 1963, becoming both the first woman and the first civilian to fly in space, as she was only honorarily inducted into the USSR's Air Force as a condition on joining the Cosmonaut Corps. During her three-day mission, she performed various tests on herself to collect data on the female body's reaction to spaceflight. Before being recruited as a cosmonaut, Tereshkova was a textile factory assembly worker and an amateur parachutist. Although Tereshkova experienced nausea and physical discomfort for much of the flight, she orbited the earth 48 times and spent almost three days in space. With a single flight, she logged more flight time than the combined times of all American astronauts who had flown before that date. Tereshkova also maintained a flight log and took photographs of the horizon, which were later used to identify aerosol layers within the atmosphere.

4. **Jocelyn Bell Burnell**, DBE, FRS, FRAS (born 15 July 1943) is a British astrophysicist. As a postgraduate student, she discovered the first radio pulsars with her thesis supervisor Antony Hewish, for which Hewish received the Nobel Prize in Physics. She

was president of the Institute of Physics from October 2008 until October 2010, and was interim president following the death of her successor, Marshall Stoneham, in early 2011. She was succeeded in October 2011 by Sir Peter Knight.

Year 4 Light, Year 6 Light

5. **Abū ʿAlī al-Ḥasan ibn al-Ḥasan ibn al-Haytham,** latinized: **Alhacen** or **Alhazen,** was a Muslim scientist and polymath described in various sources as either Arab or Persian. Alhazen made significant contributions to the principles of optics, as well as to physics, astronomy, mathematics, ophthalmology, philosophy, visual perception, and to the scientific method.

   Born circa 965, in Basra, present-day Iraq, he lived mainly in Cairo, Egypt, dying there at age 74. Overconfident about practical application of his mathematical knowledge, he assumed that he could regulate the floods of the Nile. After being ordered by Al-Hakim bi-Amr Allah, the sixth ruler of the Fatimid caliphate, to carry out this operation, he quickly perceived the impossibility of what he was attempting to do, and retired from engineering. Fearing for his life, he feigned madness and was placed under house arrest, during and after which he devoted himself to his scientific work until his death.

   Alhazen made significant improvements in optics, physical science, and the scientific method, his work on optics is credited with contributing a new emphasis on experiment. The Latin translation of his main work, *Kitab al-Manazir* (*Book of Optics*), exerted a great influence on Western science: for example, on the work of Roger Bacon, who cites him by name. Alhazen proved that rays of light travel in straight lines, and carried out various experiments with lenses, mirrors, refraction, and reflection. He was also the first to reduce reflected and refracted light rays into vertical and horizontal components, which was a fundamental development in geometric optics. Alhazen also gave the first clear description and correct analysis of the camera obscura and pinhole camera. Alhazen was the first to demonstrate this with his lamp experiment where several different light sources are arranged across a large area and was the first to successfully project an entire image from outdoors onto a screen indoors with the camera obscura. He made the observation that the ratio between the angle of incidence and refraction does not remain constant, and investigated the magnifying power of a lens. The correct explanations of the rainbow given by al-Fārisī and Theodoric of Freiberg in the 14th century depended on Alhazen's *Book of Optics*. He wrote as many as 200 books, although only 55 have survived, and many of those have not yet been translated from Arabic.

Year 5 All Living Things

6. **Dame Jane Morris Goodall**, DBE (born **Valerie Jane Morris-Goodall** on 3 April 1934) is a British primatologist, ethologist, anthropologist, and UN Messenger of Peace. Considered to be the world's foremost expert on chimpanzees, Goodall is best known for her 45-year study of social and family interactions of wild chimpanzees in Gombe Stream National Park, Tanzania. She is the founder of the Jane Goodall Institute and has worked extensively on conservation and animal welfare issues.

   She began studying the Kasakela chimpanzee community in Gombe Stream National Park, Tanzania in 1960. Without collegiate training directing her research, Goodall observed things that strict scientific doctrines may have overlooked. Instead of numbering the chimpanzees she observed, she gave them names such as Fifi and David Greybeard, and observed them to have unique and individual personalities, an unconventional idea at the time. She found that, “it isn’t only human beings who have personality, who are capable of rational thought [and] emotions like joy and sorrow.” She also observed behaviors such as hugs, kisses, pats on the back, and even tickling, what we consider "human" actions. Goodall insists that these gestures are evidence of "the close, supportive, affectionate bonds that develop between family members and other individuals within a community, which can persist throughout a life span of more than 50 years." These findings suggest similarities between humans and chimpanzees exist in more than genes alone, but can be seen in emotion, intelligence, and family and social relationships.

Goodall’s research at Gombe Stream is best known to the scientific community for challenging two long-standing beliefs of the day: that only humans could construct and use tools, and that chimpanzees were vegetarians. While observing one chimpanzee feeding at a termite mound, she watched him repeatedly place stalks of grass into termite holes, then remove them from the hole covered with clinging termites, effectively “fishing” for termites. The chimps would also take twigs from trees and strip off the leaves to make the twig more effective, a form of object modification which is the rudimentary beginnings of toolmaking.

Year 6 Changes That Form New Materials, Working Scientifically throughout

7. **Marie-Anne Pierrette Paulze** (20 January 1758 – 10 February 1836), was a French chemist. Born in the town of Montbrison, Loire, in a small province in France, she is most commonly known as the spouse of Antoine Lavoisier (**Madame Lavoisier**)

   Paulze accompanied Lavoisier in his lab during the day, making entries into his lab notebooks and sketching diagrams of his experimental designs. The training she had received from the painter Jacques-Louis David allowed her to accurately and precisely draw experimental apparatuses, which ultimately helped many of Lavoisier’s contemporaries to understand his methods and results. Furthermore, she served as the editor of his reports. Together, the Lavoisiers rebuilt the field of chemistry, which had its roots in alchemy and at the time was a convoluted science dominated by George Stahl’s theory of phlogiston.

   In the eighteenth century the idea of phlogiston (a fire-like element which is gained or released during a material’s combustion) was used to describe the apparent property changes that substances exhibited when burned. Paulze, educated in English, Latin and French, was able to translate various works about phlogiston into French for her husband to read. Perhaps her most important translation was that of Richard Kirwan's essay 'Essay on Phlogiston and the Constitution of Acids', which she both translated and critiqued, adding footnotes as she went along and pointing out errors in the chemistry made throughout the paper. She also translated works by Joseph Priestley, Henry Cavendish, and others for Lavoisier’s personal use. This was an invaluable service to Lavoisier, who relied on Paulze’s translation of foreign works to keep abreast of current developments in chemistry. In the case of phlogiston, it was Paulze’s translation that convinced him the idea was incorrect, ultimately leading to his studies of combustion and his discovery of oxygen gas.

   Paulze was also instrumental in the 1789 publication of Lavoisier’s Elementary Treatise on Chemistry, which presented a unified view of chemistry as a field. This work proved pivotal in the progression of chemistry, as it presented the idea of conservation of mass as well as a list of elements and a new system for chemical nomenclature. Paulze contributed thirteen drawings that showed all the laboratory instrumentation and equipment used by the Lavoisiers in their experiments. She also kept strict records of the procedures followed, lending validity to the findings Lavoisier published.

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