Primary Curriculum Review

Primary Science Curriculum

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Rationale

1. Throughout I have assumed we are dealing with intelligent and motivated pupils. I expect more of them than is perhaps the norm at present. I make no apologies for this. Delivering this curriculum might look like a daunting task to the primary teacher. However, I believe I have given pointers to many basic experiments which can help illuminate the ideas covered and give a real sense of the experimental nature of the subject. It is in the spirit of Robert Boyle's assertion that as scientists "we assent to experience, even when its information seems contrary to reason"[1]. If you can't show it, you can't prove it.
2. I have put the key figures back into science and taken a semi-historical approach to developing key concepts. I am particularly concerned to locate the progression from the Ancient Greeks through to the Renaissance and onto modern times where appropriate. I wish I had been taught who the Ancient Greeks were and what they knew about the world. I have also where possible put key British figures in science back into their place in history.
3. Some concepts act as a vital intellectual framework upon which a more complex understanding can flourish. They are introduced at an unashamedly early age. Atoms and molecules together with elements and compounds are essential concepts if any understanding of matter is to be taught. Difficult though they are when these ideas are re-introduced at the secondary level it will allow for a far deeper grasp of chemistry to develop rather than the empty use of the term "particles" that has become an excuse for not needing to understand anything more at KS3.
4. Evolution and genetics are similarly crucial to modern biology and horrendously misunderstood by most teenagers. I hope to redress that balance in favour of a basic grasp of the subject which can then lead to a far more nuanced understanding of modern biology and its applications.
5. I have avoided introducing alternative theories or ethics as far as possible within this curriculum. This can and will of course be supplemented by teachers at their own discretion and I have no illusions about the mixed response to some of the content by teachers let alone pupils. However, I feel I have presented a coherent and sound foundation for understanding the principles of modern science which in itself leaves little room for doubt. The problem is then for the child to reconcile their own beliefs with what science teaches us about the natural world.
6. I have a particular interest in engineering which could be called idiosyncratic if you like. We have never held engineering in high esteem in this country in my life time so I have introduced it through Leonardo da Vinci and his machines and a particular emphasis on flight. These are both crucial elements of the curriculum.
7. This curriculum almost certainly requires a new type of text book. Knowledge not skills is prioritised and so we need a reference for the pupils that puts the knowledge back in. I used "The Family Scientist" by Judith Hann as an inspiration for a lot of the experimental work

[1] Quoted in 'Science a history', John Gribbin, 2002.

suggested. Written in the 1970s it has a naive and refreshing character. Hann mixes historical narrative with easy to carry out practical demonstrations. This should be the spirit with which any new text book is approached.

8. Nowhere in this curriculum do I pretend to know how science works or to illuminate a single method for science. To do so would be absurd and to ignore the history of science itself. Instead, through an appreciation of the engagement with ideas through history and the development of modern theories about the universe and human origins etc. I hope to set the pupil of on a path of discovery. As Niels Bohr said of his theory of the atom, “if quantum mechanics hasn’t profoundly shocked you, you haven’t understood it yet”.

Year 1

Age 5

Physics	i)	Making magnetic games - fridge snakes and ladders etc[2] Idea of magnetic attraction.
	ii)	Liquids keep the same volume - pouring from one container to another[3].
	iii)	Recording height over the course of a year allows introduction to charting changes[4].
	iv)	Using kitchen scales to measure mass of food in recipes etc. Bathroom scales to measure pupil's mass[5].
Chemistry	i)	Liquids - not all liquids are water! Different transparent liquids - clear vinegar, clear perfume, ethanol or similar - liquids as examples of different substances.
	ii)	We can use all our senses to observe the properties of different substances. Sight is not enough with the liquids mentioned taste and smell are important. Learn how to make accurate observations.
	iii)	Gases in the air. Basic composition of the atmosphere.
	iv)	States of matter - water freezes and boils. Water expands when it freezes - coke can in the freezer – icebergs.
Biology	i)	Living things grow - planting seeds and helping them grow - cress in cotton wool and water.
	ii)	What makes the seeds grow best? Light/ dark/ cold/ hot? Try it out and compare the results. Doing experiments.
	iii)	A simple habitat – e.g. school garden or pond. What lives there? Observing, collecting and describing plants and animals.
	iv)	Use a magnifying glass[6] to look at insects and try to identify them e.g. ants, woodlice etc. Identifying trees by their leaves using a key. Recognising common birds and butterflies.

[2] Rapid Electronics 37-2007 A4 self-adhesive magnetic sheet @ £1.55
[3] Use kitchen measuring jug marked in ml.
[4] Tape measure in m and cm from DIY store
[5] Kitchen scales available as digital in g and bathroom scales in kg.
[6] Natural History Museum Pocket Microscope £7.39 from Amazon.

Year 2

Age		Age 6
Physics	i)	The earth our planet – introduce science of geology. Features of the surface of the Earth - oceans, deserts, mountains, cities and human populations, ice sheets. Earth source of many raw materials. Panning for gold.
	ii)	Temperature - human body temperature - use a child's medical thermometer[7] - temperature during the day - outside/inside - forehead thermometer[8].
	iii)	Volume - measure the rain fall over a month - introduction to meteorology - air pressure as indicator of weather changes.[9] Ideas of high and low pressure.
	iv)	Clouds - describe the various types of clouds and if we can use this to help predict the likelihood of rain or temperature - satellite images used to further our study of the weather.
Chemistry	i)	Combustion and the importance of oxygen - burning. Candle puts itself out under a glass jar. Combustion products. H_2O, CO_2, CO and soot. Oxygen needed to burn. Experiments with air – candle burning uses up oxygen in a glass beaker causing water to rise up inside it[10].
	ii)	Water cycle - weather driven by the Sun - changing state of water. Humidity water in the air.
	iii)	Basic composition of the atmosphere. Rusting wire wool (soaked in vinegar) will take out all the oxygen from air trapped in a glass in a matter of hours.[11] Relates back to the composition of air i.e. air is roughly 20% oxygen.[12] Why is the sky blue?[13]
	iv)	Ancient Greek idea of four elements and Robert Boyle's attempt to discover the real elements from which everything is made. Air is not one element! Today we have over 100 elements some of which are man-made.
Biology	i)	How can we tell if something is alive? MRS GREN – spell it out!! Movement, respiration, sensitivity, growth, reproduction, excretion and nutrition.
	ii)	Human body - digestive system - food types and diet - waste system - excretory system. Major organs involved.
	iii)	Food fuel for life - what do animals eat? Carnivores, Herbivores and Omnivores. Who eats who? Which one are we. Food webs and food chains in simple habitats.
	iv)	Plants make their own food - leaves as food factories. Do experiments to prove plants don't need food. Do experiments to prove that plants need sunlight. Plants grow towards light and seeds germinate to allow stem to find light.

[7] Laser IR thermometer £14.45 – point and click - unit of temperature to be used is Celsius.
[8] Forehead thermometer strip around £4 - http://www.thermometerspecialist.co.uk/index.php?app=ecom&ns=prodshow&ref=11-465-3&sid=6f92w4quq3nzcp8a6v828q17h5cktu7m
[9] Digital barometer available at around £40.
[10] Robert Boyle and John Mayow did similar experiments in the 17th century.
[11] See 'The Family Scientist', Judith Hann p180.
[12] Joseph Priestly discovered oxygen in 1774.
[13] Einstein solved it in 1911 – Rayleigh Scattering of light by Oxygen and Nitrogen molecules in the air.

		Year 3
Age		Age 7
Physics	i)	Magnetism - make a compass/Earth's magnetism/magnetic materials and magnetic force.
	ii)	Static electricity - making something static/sticking together/lightning conductors.[14]
	iii)	The Earth in space - solar system and beyond - know the planets and their orbits around the Sun. How to recognise a planet in the night sky. Planets have moons. Life on Mars - old ideas and new ideas? Seasons. Sunrise, sunset and pathin the sky. Daylight hours. Solar eclipse.
	iv)	Making machines that move - cotton reel tank, steam engine, rubber powered airplane - creating a driving force/source of energy - solar cell and electric motor.
Chemistry	i)	Cooking as chemistry - heat causing chemical changes. Making toffee. Grilling food. Permanent change. How long does it take to boil an egg? Carry out experiment to see what happens to white of an egg as temperature increases. Is white of an egg better to eat 76 C rather than 100 C?[15]
	ii)	Starch test with dilute iodine solution. Allows identification of starch in food stuffs. Energy from food. Investigate the calorific value of different foods.[16]
	iii)	Mixing and separating substances - oil in water - volumes don't add up? Milk as a suspension. Sand and salt. Sand and iron filings. Aluminium and steel.[17]
	iv)	Dissolving solids in liquids - soluble solids in water - salt, sugar etc. Where does it go? Volume, mass? Temperature and solubility (sugar not salt) using sugar lumps.
Biology	i)	Classifying plants and animals - simple classification based on ideas already covered or class comes up with. How could you tell if you have discovered a new species?
	ii)	Study a habitat and develop a classification system of your own. Pond life could be a good one.[18]
	iii)	Plants basic structure. Differences between plants. Link to classification above. Allows for plenty of nature trails in the spring summer and autumn. Growing flowering plants to help us identify various parts of plants.[19]
	iv)	New species found in the recent period. Rain forests as abundant sources of biodiversity. Recent extinctions and the causes.

[14] Benjamin Franklin and the lightning conductor.
[15] Experiment from 'The Family Scientist'p???
[16] Dilute iodine solution might cause some difficulties.
[17] Use dissolving and evaporating with salt and sand and magnets with metals.
[18] Create your own key using simple external characteristics.
[19] This should allow for some imaginative work.

		Year 4
Age		Age 8
Physics	i)	Sound - making musical notes - vibrations/pitch and amplitude - transmission of sound through materials other than air - sound proofing - echoes.
	ii)	Making a torch - current electricity basic circuit elements - dangers of mains electricity - making magnetism - build basic electromagnet.
	iii)	The Moon - remote telescope to map the Moon[20]. Apollo missions and man's exploration of space. How we know the Moon isn't made of cheese. Phases of the Moon. Lunar eclipses and the blue moon.
	iv)	Floating and sinking - density as a measure of how tightly packed a substance is - Galileo's thermometer and Archimedes[21] solution to the discovering if a crown was pure gold or not. Archimedes Principle. Density as mass per unit volume in g/cm^3 or g/ml especially water as a reference point for floating/sinking.
Chemistry	i)	Growing crystals - substances from solutions. Salt, sugar and copper sulphate. Idea of saturated solutions.[22] Links to blood as a transport medium in animals.
	ii)	Making new substances - colourful chemical changes - use of copper compounds to illustrate new substances formed - colour and sediments.[23]
	iii)	Chromatography - separating mixtures – water soluble black ink pens are good - use coffee filter paper cut into strips - rubbing alcohol for the more adventurous.
	iv)	Atomic hypothesis - what is stuff made of? Ancient Greeks - Democritus 460 BC everything is made of atoms and vacuum. Renaissance - Robert Boyle revived the notion of atoms in the 'Sceptical Chymist' 1661. Father of modern chemistry he set to discover new elements. Gruesome experiments to prove air is needed to live.
Biology	i)	Blood and circulation in humans - blood carries gases to and from cells to allow respiration to happen. Blood carries sugars to and from cells as fuel for respiration.
	ii)	Respiration - why animals breathe. Comparison with combustion. Need for Oxygen and release of CO_2. Plants need to respire too.
	iii)	Evolution - a history of life on Earth - time line.[24] Fossils and fossil hunting. Why some species survive and some die out. The voyage of the HMS Beagle and Darwin's discoveries on the Galapagos islands and elsewhere.
	iv)	The skeletal and muscular system in humans and animals - links to fossil remains and identifying and classifying animals. Vertebrates and invertebrates. Fossils of ammonites and dinosaurs. Leonardo da Vinci's drawings[25]. Use of X-rays.

[20] http://www.schoolsobservatory.org.uk/ free resource to take pictures with the Liverpool Telescope.
[21] On Floating Bodies, Archimedes, 287-212 BC solves the problem and explains many features of floating bodies.
[22] Crystal garden using water-glass and small amounts of metal salts. Uses sodium silicate solution which is rated as harmless - http://www.mistralni.co.uk/msds/sodiumsilicatesolutionq7079ccsmsds.pdf
[23] This very much depends on Health and Safety considerations.
[24] Suggested resource supplied.
[25] http://www.gfmer.ch/International_activities_En/Leonardo_anatomical_drawings.htm

		Year 5
Age		Age 9
Physics	i)	Light and colour - reflection – make a kaleidoscope and periscope. Refraction – bending light in water, apparent depth in water[26]. Dispersion of white light[27] - white as a mixture of all colours of light - spectrum - colour triangle - use in TV / computer / printed page[28].
	ii)	Flight - from kites[29] and hot air balloons[30] to jets[31] and rockets. Frank Whittle and Hans von Ohain and the jet engine[32]. A history of flight. How do we stay in the air? Principle of the aerofoil and the generation of lift force – demonstrate with two ping-pong balls hung close together by thread.
	iii)	Stars - looking at the night sky, constellations and telescopes[33] - the Sun our star – some of our nearest stellar neighbours – Proxima Centauri and Alpha Centauri, Barnard's Star and Sirius. The Pole star Polaris and how to find it using the Great Bear Ursa Major. Making and using a planisphere in the winter night sky. Comets and asteroids debris from the formation of the solar system.
	iv)	Machines that make things easier to do – simple treatment of levers, pulleys and gears - idea of force multipliers. Leonardo da Vinci's systematic description of the elements of mechanics – essentially the invention of engineering as a modern science[34]. Archimedes explained the principle of the lever and the Archimedes Screw.
Chemistry	i)	Elements and compounds - indivisible units of a substance. Common compounds and their elemental constituents - the idea of a chemical formula. H_2O and CO_2 molecule models made from ping-pong balls and pipe cleaners or similar.
	ii)	Violent and slow chemical changes - rusting and matches. Explosives as very fast reactions. History of dynamite and the Noble prize[35].
	iii)	Acids and examples of chemical reactions - coke on coins. Vinegar on alkali[36]. Make an indicator from red cabbage[37]. Test tooth paste for acidity.
	iv)	Chemical decomposition - electrolysis of water (simple to do with a 6V battery and slightly acidic water) and baking soda thermal decomposition in cooking[38].

[26] Laser pointers (low power) used with water filled container with a few drops of milk added.
[27] Isaac Newton, Opticks, 1704- 60 degree glass prism very useful to replicate Newton's original experiment.
[28] Use magnifying glass or microscope.
[29] Quite easy to make a simple kite as a cheap project – dowel and bin liners plus a simple design will do.
[30] Montgolfier brothers 4th June 1783, first manned flight.
[31] de Havilland Comet first commercial jet airliner first flew in 1949 – still flying as the Nimrod for the RAF until this year. Hawker Siddeley Harrier first vertical takeoff and landing plane, first flew in December 1967 withdrawn from service in 2011. Concorde first and only commercial supersonic airliner first flight 2 March 1969 withdrawn 2003.
[32] http://www.bbc.co.uk/history/historic_figures/whittle_frank.shtml and http://en.wikipedia.org/wiki/Hans_von_Ohain
[33] Galileo Galilei, The Starry Messenger, 1610 – observed the Moon, the stars and the 4 Galilean moons of Jupiter.
[34] Museo Leonardo da Vinci, Florence, Italy - http://www.mostredileonardo.com/site.asp?idSito=1&idLingua=10&idPagina=222
[35] Alfred Nobel invented dynamite in 1866 and gave us safe and power full explosives.
[36] Use sodium bicarbonate here too.
[37] Simple instructions - http://chemistry.about.com/od/acidsbase1/a/red-cabbage-ph-indicator.htm

Biology

i) Complex classification - Carl Linnaeus Swedish botanist who invented the naming system for plants and animals still used today. Know basic structure of naming system for some common plants and animals.
ii) Habitats, adaption, survival and extinction - why did the dinosaurs die out? The tree of life - we are not related to monkeys and apes but we do have a common ancestor. Endangered species today. Conservation and loss of habitat. Learning from our mistakes - the Cane toad introduced Queensland Australia.
iii) Reproduction in animals and plants - sexual reproduction in plants and animals. Egg and sperm cells share information in the chromosomes. What determines if you are a boy or a girl?
iv) Death, decay and disease - microbes the cause of disease. Germ theory of disease. History of the Broad Street Cholera outbreak in London[39]. Importance of clean water. Pasteurisation of milk. Florence Nightingale and the treatment of soldiers. Importance of hospital hygiene. Alexander Fleming and penicillin.

[38] Some baking powder contains only sodium bicarbonate.
[39] http://en.wikipedia.org/wiki/Broad_Street_cholera_outbreak

		Year 6
Age		Age 10
Physics	i)	Motion - how fast can I go? How long would it take to walk around the world? How long to fly to the Moon? Measuring time accurately enough to get speed - Olympics fast man on record - hundredths of a second[40]. Human reaction time and limits of accuracy of measurement. Speed = distance / time should be used.
	ii)	Why everything that goes up must come down - gravity[41]. Forces of nature. Overcoming gravity - projectiles[42]. Investigating projectiles how to reach a particular distance – use a child's bow and arrow.
	iii)	The discovery of galaxies[43], the known universe and the big bang - gravity the most important force in the universe – basic description depends on masses and distance between them[44]. A history of the universe. How the solar system was formed.
	iv)	Heat and energy - joules experiments. Conservation of energy. Why we need new sources of energy. Heat degradation and the futility of tidying up your room – it only makes more mess somewhere else. Impossibility of perpetual motion machines?
Chemistry	i)	Metals and non-metals properties similarities and differences. Magnetic, electrical properties, appearance, and mechanical properties of some common metals and non-metals.
	ii)	Chemical reactions - new substances from the same constituents. Give partial simple word equations for simple reactions - combustion and acid/metal reactions – at least common products of reactions.
	iii)	Energy from chemicals - lemon battery to power a led. Heat from fuels - ethanol burner. Heat from food. Calorific content of food – labels.
	iv)	Atoms and the periodic table of elements - first 10 elements as well as some other famous ones. Comparing chemical properties. Mendeleev's approach to describing the elements.
Biology	i)	Cells and microscopes[45] - the building blocks of life[46]. Basic constituents of a cell. Relationship to respiration, reproduction and ageing. View flakes of skin under microscope[47].
	ii)	Genetics[48], inheritance and mutation - the blind watch maker - the mechanism behind evolution. Selective breeding and genetic engineering two approaches to improving on evolution. GM crops and their uses.

[40] Basic stopwatch £3.95, http://www.ravencourt.com/raven-product-details.asp?productID=Z382
[41] Isaac Newton
[42] Galileo's inclined plane experiment, http://galileo.rice.edu/lib/student_work/experiment95/inclined_plane.html - correcting Aristotle, precursor to Newton.
[43] Edwin Hubble
[44] Principia, Isaac Newton, 1687
[45] Micrographia, Robert Hooke, 1665 http://www.gutenberg.org/files/15491/15491-h/15491-h.htm credited with discovery of the cell.
[46] Matthais Jakob Schleiden and Theodor Schwann developed the cell theory in 1839 – cells come from pre-existing cells. First to observe the sperm cell penetrating the egg cell of a sea anemone.
[47] Natural History Museum Pocket Microscope, £7.39 from Amazon or USB x400 microscope at £42.25

iii) Human evolution - pre-human ancestors, “out of Africa” thesis and why we don't evolve any more. Should science improve human beings?
iv) The immune system and protection from disease - vaccinations[49] - congenital disease and genetic testing.

[48] Discovery of DNA structure by Crick and Watson in 1953. Human Genome project completed in 2003 http://genome.wellcome.ac.uk/
[49] Edward Jenner and smallpox vaccine 1796.