List mania

F A Muller

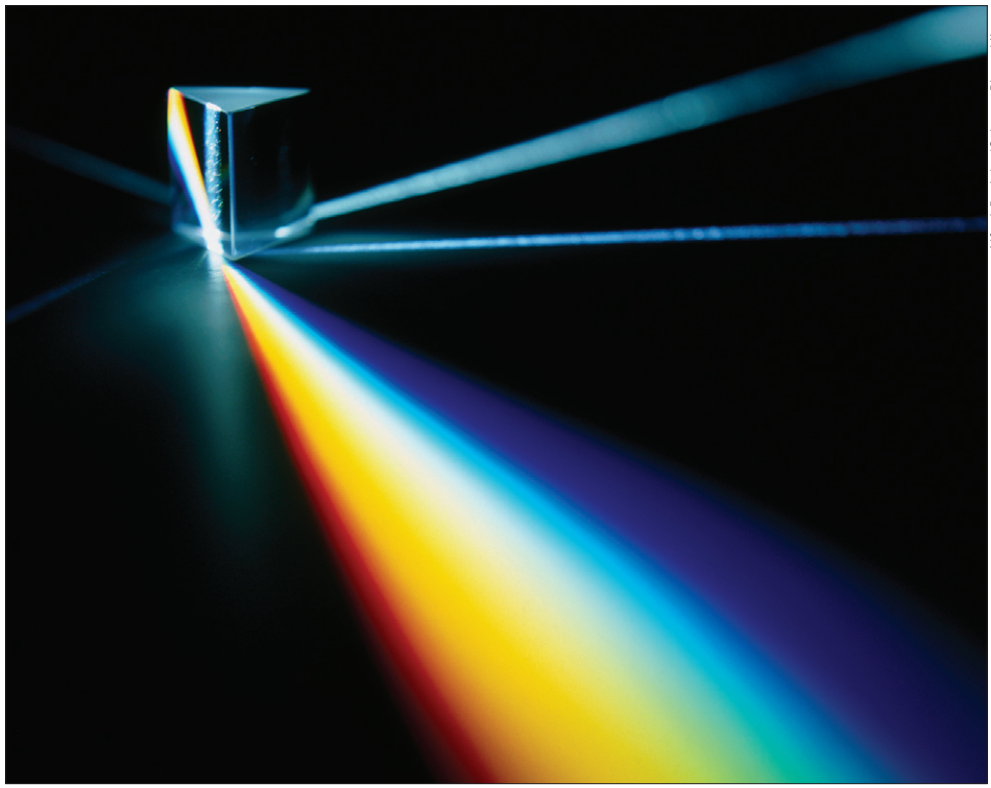
From
Physics World
August 2008

ISSN: 0953-8585

Institute of Physics Publishing
Bristol and Philadelphia

F A Muller

List mania



Alfred Pasieka/Science Photo Library

Shine on
Newton's work on light and colour using prisms is a perennial favourite in lists of the greatest ever experiments.

The Ten Most Beautiful Experiments
George Johnson
2008 The Bodley Head
£14.99/$22.95hb
208pp

"Science in the 21st century has become industrialized," writes George Johnson in the introduction to his new book *The Ten Most Beautiful Experiments*. "The experiments so often celebrated in the newspapers – sequencing the genome, proving the existence of the top-quark, discovering a new planet by analyzing the wobble of a distant star – cost millions of dollars," he continues. "They generate terabytes of data to be analyzed by supercomputers…[and] are carried out by research teams that have grown to the size of corporations." But, Johnson then points out, until very recently the most earthshaking science came from individual pairs of hands. His book pays tribute to those hands and the minds that guided them.

Six years ago *Physics World* columnist Robert Crease invited readers to send in their candidates for the most beautiful experiment in physics to the magazine. About 200 readers responded (*Physics World* September 2002 pp19–20) and a year later Crease published *The Prism and the Pendulum: The Ten Most Beautiful Experiments in Science*, which described the 10 most popular (*Physics World* October 2003 pp45–46). Crease confidently leapt from physics to the whole of science in spite of the fact that all 10 were physics experiments. However, Johnson, who is a US-based science writer, was dissatisfied with Crease's top 10 and decided to draw up his own list, casting the net wider.

Not that much wider, however – six of Johnson's 10 beautiful experiments belong to physics, while Luigi Galvani's experiments on animal electricity are on the borderline between physics and physiology. Despite this, only three experiments figure in the lists of both Crease and Johnson. These are Galileo Galilei's experiments with bronze balls rolling on an inclined plane (1604); Isaac Newton's use of prisms to understand colour (around 1665); and Robert Millikan's use of floating oil droplets to measure the charge of the electron (1909). Who would dare to challenge their beauty?

The other seven physics experiments chosen by *Physics World* readers, including Ernest Rutherford's experiments demonstrating that atoms consist largely of empty space (1911) and Claus Jönsson's interference experiments with electrons (1961), are not on Johnson's list. However, it contains three physics experiments that were not in Crease's top 10: Michael Faraday's experiment with polarized light and electromagnets, which demonstrated that light responds to magnetic forces (1850); James Joule's experiment with water and weights, which demonstrated the transformation of mechanical work into heat (1847); and Albert Michelson's use of an interferometer to look for evidence of a luminiferous ether (1881 and 1887, with Edward Morley).

In addition to Galvani's experiments with frogs' legs, the other three experiments on Johnson's list are Antoine-Laurent Lavoisier's experiments demonstrating the existence of oxygen and the non-existence of phlogiston (1777); William Harvey's observations and experiments that unlocked the secrets of the heart (1628); and Ivan Pavlov's elaborate experiments with hundreds of dogs, which showed the existence and extreme malleability of the stimulus-response mechanisms (1890s). Johnson's description of the latter is particularly fascinating and is likely to be less familiar to physicists than the other experiments he includes.

Pavlov was supposed to become a priest in the Russian Orthodox Church, like his father, but then he discovered a Russian translation of Darwin's *On the Origin of Species* and Ivan Sechenov's *Relfexes in the Brain* in his village library. The young Pavlov read about some invigorating ideas, particularly from Sechenov – a radical materialist who argued that the human mind was nothing more than an exceedingly complex machine. Fascinated, Pavlov left the local seminary and headed for St Petersburg, where his brother Dimitry soon joined him. There they studied chemistry under Dmitri Mendeleev, who at the time was devising his periodic table of the elements. Pavlov earned a doctorate in medicine for conducting experiments on how the canine nervous system controlled blood pressure and the heart.

By 1891 Pavlov was considered one of Europe's best animal surgeons and was appointed head of physiology at the newly formed Institute for Experimental Medicine in St Petersburg. There he undertook an impressive sequence of experiments with dogs, which he loved. Pavlov noticed that the dogs produced different kinds of saliva depending on whether food was offered (in which case the saliva contained water for dilution mixed with mucin to lubricate the food for its passage to the stomach) or whether something unsavoury, like salt, mild

acid or mustard oil was offered (in which case the saliva consisted of water only, in order to protect the tongue and wash out the noxious substance). An evolutionary explanation for this was easily devised. Pavlov also found that his dogs stopped drooling after repeated showings of food that was subsequently taken away.

Whether he ever rang a bell in his conditioned-reflex experiments has been doubted; he did, however, use flashes of light, whistles and tuning forks. The dogs' powers of discrimination turned out to be astounding. Johnson tells us that some dogs could "distinguish between a circle and an ellipse, between a metronome beating 100 times per minute versus 96 or 104". They could also apparently distinguish between adjacent notes on a musical scale and different shades of grey. Indeed, the dogs' hearing was so sensitive that a "tower of silence", modelled on seismological laboratories, had to be build in order to screen out interfering noises and tremblings. The dogs were observed remotely through periscopes, as in "a submarine ready for battle", as one visitor reported.

The descriptions make easy reading, but there is little analysis of what makes an experiment beautiful

Some dogs were able to categorize 22 different sequences of musical notes into two groups according to whether they were mostly ascending or mostly descending, leading Pavlov to speculate that pattern recognition and concept formation are continuous with each other. The influence of his findings on psychology has been enormous and his realization that the brain and nervous system form a precise, highly adaptable living machine has endured. Pavlov's achievements earned him the Nobel Prize for Medicine and Physiology in 1904.

Johnson's descriptions of the 10 experiments make easy reading, containing neither formulae nor numbers. Unfortunately there is little analysis of what exactly makes an experiment beautiful. Vastly superior in this respect is Romano Harré's *Great Scientific Experiments: Twenty Experiments that Changed our View of the World*, first published in 1981, which is widely available at antiquarian booksellers, and, of course, via the Internet, for a modest price.

F A Muller is a researcher funded by the National Science Foundation (NWO) of the Netherlands and is connected to the Institute for the History and Foundations of Science at the Department of Physics and Astronomy, Utrecht University, e-mail f.a.muller@phys.uu.nl

Between the lines

Take flight
A visual history of the world's first commercial space ship *SpaceShipOne*.

The new space age

In April 2003 the first commercial space ship was revealed to the world. Just over a year later that craft, known as *SpaceShipOne*, completed the first privately funded human spaceflight, and shortly afterwards it won the $10m Ansari X Prize. The history of *SpaceShipOne* began several decades earlier, however, and involves an eclectic list of characters that includes Microsoft co-founder Paul Allen and British entrepreneur Richard Branson. The real star, however, is *SpaceShipOne* designer Burt Rutan, and indeed much of science writer Dan Linehan's new book *SpaceShipOne: An Illustrated History* reads like an extended profile of this remarkable man. Rutan trained as an aeronautical engineer, was then a test pilot for the US Air Force for several years, before leaving to design innovative planes full time. In 1974 he founded the Rutan Aircraft Factory (now Scaled Composites), which has since produced about 50 experimental aircraft. Over 200 pictures and diagrams are complemented by lucid technical descriptions and plenty of personal recollections to make an attractive and readable coffee-table book.

● 2008 Zenith Press £25.00/$34.95hb 160pp

Surviving academic life

"Many scientists – due to a chronic lack of self-knowledge – do not feel any necessity for improving their own communications competences." So states University of Twente physics professor Ad Lagendijk in the introduction to *Survival Guide for Scientists*, and anyone who has sat through a dull talk at a conference will probably agree with him. This book is his attempt to rectify the situation. It is made up of three self-contained guides: how to write scientific texts; how to give presentations; and how to read and write e-mails to colleagues. Each section is organized as a list of short rules, which are all numbered and indexed. The scope is exhaustive, covering everything from how to use a spam filter to making sure that the lighting is appropriate when giving a presentation. As such, this is not a book to be read cover to cover, but, thanks to the comprehensive index system, scientists of all levels of experience should be able to find plenty to benefit their work. At the end of the day, however, much of the advice boils down to Lagendijk's personal opinions about how things should be done, and the reader would do well to bear this in mind.

● 2008 Amsterdam University Press £12.95/$19.95pb 260pp

The mathematical rabbit hole

Lewis Carroll, aka Charles Lutwidge Dodgson, is famous for his children's books *Alice's Adventures in Wonderland* and *Through the Looking Glass*. Less well known is the fact that Dodgson was also a talented mathematician who lectured in mathematics at Oxford University's Christ Church College for 25 years and published works in the fields of geometry, logic and algebra. *Lewis Carroll in Numberland*, by mathematician Robin Wilson, examines Dodgson's life, focusing in particular on his mathematical endeavours. It was clear from an early age that Dodgson was exceptionally gifted, when he produced both poetry and word and number puzzles for his 10 siblings. These passions for writing, maths and logic stayed with him throughout his life, and the *Alice* books are full of mathematical allusions, which Wilson outlines in the introduction to his book. Many of the numerical puzzles that Dodgson authored are also included. While this is not the first book on this topic, Wilson has succeeded in making his short biography accessible to the general reader, and what it lacks in analysis it makes up for in clarity.

● 2008 Allen Lane £16.99/$24.95hb 256pp