Eighteen-ninety-six and all that

J. L. Heilbron and W. F. Bynum

This year's commemorative platter includes ether anaesthesia, smallpox vaccination, radioactivity and several mathematical morsels, as well as an accidental death (Otto Lilienthal) and the mother of all births (the Universe).

THIS year we can offer as anniversary of the year an invention more original in its design and consequences, more necessary to the correct thinking and wellbeing of humankind, more fundamental, inspired — we do not scruple to say awesome — than any other creative expression known to us. It is the act of creation that, on the scientific yet reliable calculation of the learned James Ussher, Primate of Ireland, happened in the year 4004 BC on the evening of 22 October, when God, being at leisure, decided to make a world. This coming October we have the singular opportunity of celebrating the sixtieth centenary of the creation of the Universe. Thinkers stuck in the pre-postmodern style of thought can suppose that the party opens the millionth millennium since the Big Bang.

Wellcome Institute Library

Anniversary of the year: creation of the Universe. From Johann Jacob Scheuchzer's *Physica scara* (1731–1733).

Our anniversaries are arranged as usual, beginning with centennials, sesquicentennials and so on back to 4004 BC, and ending with an anticlimactical list of memorable discoveries made in our century 50, or 50±25, years ago. Also, as usual, ¢ signifies 'centennial'. But for the convenience of those who need it, we depart from our usual custom to supply heading dates AMC (*ab mundo condito*).

5900 AMC (1.0 centenary)

Cleanliness, it is said, is next to godliness. Hence, in this jubilee year, Wilhelm Ludwig Friedrich Krafft's discovery a hundred years ago that soap solutions cleanse by colloidal suspension of offending material may deserve a celebration — and certainly does if combined with a nod to the washing machine (invented 1846, **1.5¢**). It is also said that the world is a stage. So as it spins to its close, it might want to commemorate the installation in 1896 of the first high-tech revolving stage, by Karl Lautenschläger, at the Residenztheater in Munich.

One of the greatest theatres of science, the Institut de France, was the showplace for the most extraordinary discovery of 1896. For several months, Henri Becquerel entertained his colleagues with weekly reports of the darkening of photographic plates through their protective wrappings. The agent of darkness was a beautiful crystal of a phosphorescent salt of uranium exposed to sunlight before being placed with the wrapped film in a closed drawer. The odd experimental design derived from a conjecture by Henri Poincaré that, because X-rays originated in a fluorescent spot on a gas discharge tube, something interesting and invisible might arise from a phosphorescing salt.

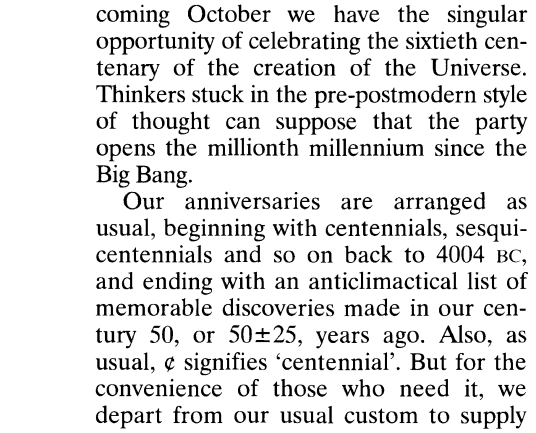
One week the Sun did not shine in Paris. Becquerel nevertheless unwrapped his film (the show must go on), expecting that the week's bulletin would run: "no phosphorescence, no darkening". But the film was as dark as before. He inferred that his specimen radiated spontaneously. 'Becquerel rays' thus made their appearance along with Röntgen rays (last year's anniversary of the year, see *Nature* **373,** 11; 1995), bringing France abreast of Germany in the discovery of odd emanations. Soon France outshone its rival with the detection of '*lumière noire*' by Gustave Le Bon and rays from most yellow-green phosphors by Arsène d'Arsonval. All rays but Becquerel's soon flickered out, however; his, when followed up by Marie and Pierre Curie, brought to light the phenomenon of radioactivity.

One element of the Becquerel rays, named 'beta' by their discoverer, Ernest Rutherford, turned out to be electrons. So did the agent responsible for the production of spectral lines, according to the analysis of Hendrik Antoon Lorentz of the splitting of lines in a magnetic field accomplished by his younger colleague Pieter Zeeman. Zeeman had persevered in his effort to influence light magnetically under the inspiration of Michael Faraday, who, 50 years earlier (1845, almost **1.5¢**) had rotated the plane of polarization of light in a magnetic field. Lorentz and Zeeman shared the second Nobel prize for physics, in 1902; Becquerel received his in 1903, with the Curies.

Another high flyer of the time was the American engineer, astronomer and physicist Samuel Pierpont Langley (died 1906, **0.9¢**), who successfully tested his steam-driven airplane over the Potomac River — until it crashed 1.2 km after take-off. Langley walked away. He was luckier than his fellow aeronaut Otto Lilienthal, who died in 1896 from injuries sustained in a glider accident.

Lilienthal's death and other vital statistics might have been recorded on machines sold by the Tabulating Machine Company, founded in 1896 by Herman Hollerith, whose punch cards, and the devices to read them, had revolutionized the 1890 census in the United States. TMC's descendant, IBM, is still with us.

Is it worthy of remark that, a hundred years ago, Jacques Hadamard proved that, if x is a very large number, the number of primes less than x is around $x/\log x$, said to be "the most important result ever obtained in number theory"; that Svante Arrhenius discovered the principle of the greenhouse effect and thus explained the ice ages; that Charles Edouard



Science Museum/Science & Society Picture Library

A Hollerith printing, listing and tabulating machine.

Guillaume, director of the International Bureau of Weights and Measures, invented invar, a metal that scarcely dilates with heat; that Franz Exner, of Vienna, described his new method of measuring atmospheric electricity in fine weather; that Roland von Eötvös, of Budapest, published his first definitive measurements of gravity that later assisted the invention of general relativity; and that the German company Carl Zeiss took up the suggestions of Horatio S. Greenough, an American in Paris, and marketed the first stereo-microscope?

We think we know that in 1896 the longest refracting telescope in the world, 21 metres in length, went into operation at Treptow near Berlin, outdoing Chicago's Yerkes Observatory (18 m) in "licking the Lick" (15 m), California's first major scientific instrument. The licked Lick thereupon published the first photographic atlas of the surface of the Moon.

The application of these instruments had what may now seem to many people the desirable consequence of having no dangerous technological spin-off. In this they differed from the X-ray tube, which in 1896 was first used in therapy as well as diagnosis. The dangers and benefits are represented perfectly by the rationale and performance of the first therapeutical intervention, by a Dr Freund, who, reasoning from the destruction of hair on skin irradiated by Röntgen rays, used them to depilate a hirsute girl, "with complete success". At the same time, a Russian company marketed a substitute for stone, wood and metal called uralite, which could be sawn and nailed and resisted heat, fire, frost and acids. It was made of asbestos pressed with other minerals into sheets; like the cosmetic application of X-rays, uralite was intended to improve, not shorten, the lives of its consumers.

Neither X-rays nor asbestos injured Emil Heinrich du Bois-Reymond, a fierce pioneering physiologist, author of the positivistic war cry, "*Ignoramus, Ignorabimus*"; Armand-Hippolyte-Louis Fizeau, the collaborator of Jean Bernard Léon Foucault, of the pendulum, in proving, long after everyone believed it, that light moves more slowly in water than in air; William Robert Grove, a barrister by trade, the inventor of a standard electric cell and one of the many legislators of the law of the conservation of energy; Friedrich August Kekulé, a student of architecture turned chemist, discoverer of the key to the structure of organic compounds, the benzene ring; and Alfred Bernhard Nobel, captain of industry, inventor of dynamite and smokeless powder, and champion of peace, science and literature "of an idealist tendency"; nevertheless, they all died, 100 years ago.

Daguerreotype of the second operation in which ether was used as an anaesthetic (17 October 1846) — the photographer was too squeamish to take pictures during the first operation, the day before. Warren stands in the right foreground; Morton is at the head of the operating table, centre rear of the photograph, wearing a checked vest.

5850 AMC (1.5 centenary)

Eben Frost and Gilbert Abbott, patients of William Morton, a dentist, and John Collins Warren, a surgeon, had good reason, in 1846, to sing the praises of Charles Thomas Jackson, who had proposed the use of ether as an anaesthetic; which was altogether more effective than the method recommended 200 years earlier (1646, **3.5¢**) by Marco Aurelio Severino, who chilled the site of surgery with snow or ice. The patients survived their operations; Morton and Jackson eventually died bitter and insane. Nevertheless, we should all sleep easier because of what one surgeon dubbed this 'Yankee dodge'.

Another discovery of high drama took place in the heavens, when Johann Gottfried Galle turned his telescope to the point specified by the calculations of Urbain Jean Joseph Le Verrier (who was here behind, but independent of, John Couch Adams), and found the planet Neptune. The business took place almost at telegraphic speed: Le Verrier published his elements on 31 August, Galle found their (and Adams's) planet on 24 September. For our money, however, the real romance in the sky that year was the detection by Macedonio Melloni of the warmth of moonlight.

There is little enough warmth even in the sunlight of the Faroe Islands, whence the Danish government despatched a young medical graduate, Peter Panum, in 1846. His investigation of a measles outbreak (6,000 cases with 106 deaths) among the islanders is a classic epidemiological account of the behaviour of herd diseases in isolated populations.

One of the best scientific investments of all times was made in 1826 (**1.7¢**). James Louis Macie Smithson, an insignificant English chemist, left to the United States a bequest of £100,000, "to found at Washington, under the name of the Smithsonian Institution, an Establishment for the increase and diffusion of knowledge among men". The nonplussed but grateful nation did as required and, on 3 December 1846, appointed Joseph Henry, a physicist from Princeton (founded 1746, **2.0¢**), the first head of the institution. It now has a dozen museums and galleries, a zoological garden, an observatory, a printing press and lord knows what else.

Mary Evans

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

Smithsonian Institution: "Establishment for the increase and diffusion of knowledge among men".

The seed of another investment, which has not been so happy for mankind, was planted by Christian Friedrich Schönbein's discovery of guncotton. The improvement of what we now call conventional explosives went on apace, culminating in the inventions of the melancholic Nobel, who, as previously announced, died a hundred years ago (1896, **1.0¢**).

Let us not omit inventions that tend toward comfort. All praise belongs to Robert W. Thomson, a British manufacturer, who gave the world more pleasure than all the courtesans of Europe by his invention of an inflatable rubber rim for wagon wheels; Thomas Hancock, in the same trade, obtained a patent for moulding rubber articles for other uses; Alexander Bain eased the lives of telegraph operators with punched-paper tape; and Wilhelm Eduard Weber gave his colleagues, in his profound *Electrodynamische Maassbestimmungen*, a way to extend the familiar Coulomb distance forces to electricity in motion, sparing them for two generations the *Kopfzerbrechung* needed to follow Faraday.

We should note some comings and goings. This year 150 years ago saw the births of Antonio Abetti, Italian astronomer notable for his determination of the positions of asteroids (see under **5750** AMC) and comets; Magnus Gustaf Mittag-Leffler, Swedish mathematician and publicist for mathematics, on whose account, it is unreliably reported, Nobel refused to establish a prize for mathematics; Karol Stanislaw Olszewski, Polish

chemist, a co-inventor of the first successful process for liquefying air; Edward Charles Pickering, called to direct the Harvard Observatory in 1876 (**1.2¢**), a tireless photographer of stars, whose observations of the spectrum of 'hydrogen' (in actual fact helium) figured prominently in the favourable acceptance of Bohr's quantized atom; Ira Remsen, chemist and educator, an important instrument of the spread of the German research ethic to the United States, and, as a recorded talking head, the keynote speaker of the current controversial Smithsonian (founded 1846, **1.5¢**) exhibition "Science in American Life"; Emil Gabriel Warburg, German experimental physicist, discoverer of magnetic hysteresis, and an important force in the politics and pedagogy of German science; and the American Medical Association, an organization whose concern for the health of patients has been equalled only by its regard for the welfare of its members.

Against these we must set the deaths of Benjamin Waterhouse, American exponent of vaccination (see under **5800** AMC) and equally ardent opponent of alcohol and tobacco; and of Friedrich Wilhelm Bessel, who, after completing his apprenticeship as an accountant at the age of 22, began, in 1806 (**1.9¢**), to fashion himself into a most exact astronomer. Among his more famous works were the study of mathematical forms in the theory of gravitational perturbations (Bessel functions) and the detection of stellar parallax, which, like Fizeau and Foucault's measurement of the speed of light in water (see under **5900** AMC), proved what everyone already believed, in this case that Copernicus was more nearly correct than Ptolemy.

5800 AMC (2.0 centenary)

We recommend that observance of the second centenary of the publication of Pierre Simon de Laplace's *Système du monde* be joined with celebrations of the anniversary of the year. Laplace makes it clear how the trick of creation was pulled, from the swirling of the primordial nebula down to the formation and shaping of the Earth. And we might in the interest of universalism include a notice of the birth of the never-sufficiently-to-be-praised Johann Christian Poggendorff, the least of whose services to science was editing the *Annalen der Physik* for more than 50 years. Poggendorff belongs with the *Système du monde* because of his creation of the bible of historians of the physical sciences, his immortal (it is still being published) *Biographisch-Literarisches Handwörterbuch zur Geschichte der exakten Wissenschaften*.

In this year Carl Friedrich Gauss was not born, but born again, by his discovery of the constructibility (by straight edge and compass) of the regular 17-gon, a point missed by all the geometers of Greece, and of everywhere else; for, on the strength of this performance, he decided to devote his life to mathematics. Among others born (for the first time) in 1796 were Sadi Carnot, whose inspired and perplexing theory of the perfect engine later stimulated invention of the concept of entropy and the second law of thermodynamics; Baden Powell, an expert on optics, an important spokesman for British science and, through his son Robert, first Baron Baden-Powell, the grandfather of all boy scouts; and Lambert-Adolfe-Jacques Quetelet, the Belgian astronomer and statistician father of *l'homme moyen*.

Further to statistics, David Rittenhouse, pioneering US colonial astronomer and clockmaker, Johann Daniel Titius, inventor in 1766 (**2.3¢**) of the Titius–Bode law of

Mary Evans

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

Pierre Simon de Laplace: exposed the trick of creation in his *Système du monde* (1796).

planetary distances, and Johan Carl Wilcke, omni-competent Swedish experimental natural philosopher, translator and editor of Franklin's *Letters on Electricity*, died.

This toll, which could be lengthened, should not depress friends of good health. The year 1796 saw the publication of Christoph Wilhelm Hufeland's *Makrobiotik, oder die Kunst, das menschliche Leben zu verlängern*, which recommends daily air baths, thus evaporating the advice given two years earlier by the physician Samuel Gottlieb von Vogel, who preferred sea baths; and Edward Jenner recommended the bucolic pleasure of cowpox as a protective against smallpox. Jenner's vaccination of James Phipps, on 14 May, was a triumph of folk wisdom placed at the service of preventive medicine. Good health was also a preoccupation of Benjamin Thompson, Count Rumford, an American tory turned Bavarian nobleman, who introduced the potato into central Europe, published recipes for hearty soup, invented the kitchen range, argued for the kinetic theory of heat and, in 1796, to encourage the mind as well as the body, endowed the Rumford prizes for scientific achievement at the Royal Society of London and the American Academy of Arts and Sciences.

5750 AMC (2.5 centenary)

There were a great many books on diverse subjects published in 1746. Among our favourites are Denis Diderot's *Pensées philosophiques*, which says most of what can be said to prove the existence of God from nature; Antoine Deparcieux's *Essai sur les probabilités de la durée de la vie humaine*, which introduced the concept of the life expectancy of the newborn; Pierre Bouguer's *Traité du navire*, the theoretical foundation of naval architecture; and Johann Heinrich Winkler's *Die Stärke der elektrischen Kraft des Wassers in gläsernen Gefässen*, in which, as reported last year, the author described the effects of using his wife to short-circuit a Leyden jar.

While on the subject of fulminations, we should mention John Roebuck's invention of the lead-chamber method for manufacturing sulphuric acid; the publication, by Jean-Etienne Guettard, of a map of the volcanic and other geological features of France; and the death of Colin Maclaurin, Scottish mathematician (Maclaurin's series) and fiery expositor of Newton. Among the births of 1746 were those of Jacques-Alexandre-César Charles, experimental physicist and showman; Giuseppe Piazzi (died 1826, **1.7¢**), founder of the Palermo observatory and discoverer of the first asteroid, which he named Ceres after the patron goddess of Sicily; Benjamin Rush, physician, chemist and educator in the British colony of Pennsylvania; and Jan Hendrik van Swinden, Dutch electrician, magnetizer and meteorologist.

5700 AMC (3.0 centenary)

Of the making of books there is no end. During 1696 were published Guillaume François Antoine de l'Hospital's *Analyse des inifiniment petits*, the first textbook on the differential calculus, and William Whiston's romance, *A New Theory of the Earth*, to name but two of scientific interest. That same year, we think, John Ray published the first description of peppermint; Johann Bernouilli challenged the mathematicians of Europe with the problem of the brachristochrome, whose solution led to the calculus of variations; and Johann Lotting set up the first ever factory for the manufacture of thimbles.

The three-hundredth anniversary of the death of Jean Richer should not slip by unobserved. Richer was the agent sent by the Paris Academy of Sciences in the early 1670s to the island of Cayenne to make measurements useful to astronomy and geography. While his confrères remained in the relative comfort of Paris, Richer sweltered to measure the refraction of the Sun, the parallax of Mars and the length of a seconds pendulum. His results enabled astronomers confidently to correct their observations for refraction, confirmed that the distance from the Earth to the Sun was much larger than even Kepler had allowed and provided an essential ingredient to Newton's deduction of the size and shape of the Earth.

5650 AMC (3.5 centenary)

All that we can say of AD 1646 is that it was pregnant with things to come, or, to be exact, just finishing being pregnant. We refer to the births of two giants of industrious learning: John Flamsteed, who would become the first astronomer royal of the United Kingdom, and Gottfried Wilhelm Leibniz, who would become the first philosopher, and a not mediocre mathematician, of his age.

5600 AMC (4.0 centenary)

The same must be said about René Descartes, born in 1596, a latter-day Aristotle and Apollonius combined, the inventor of an analytic geometry, an implausible metaphysics and a world full of whirlpools, who inspired (sometimes with horror) all the active philosophers who knew his ideas.

One of his ideas was to base all of physics (which then meant all natural science) on laws of motion of inert matter — an idea that, when reworked in Cambridge, helped to produce the Newtonian system of the world.

5550 AMC (4.5 centenary)

The best bet for a 4.5 centenary is the folio by Georg Agricola containing tracts on mining and metallurgy (forerunners of his great *De re metallica* of 1556 (**4.4¢**)) as well as his *De natura fossilium*. Agricola, a doctor who practised in the mining district of Joachimsthal, could describe in detail the various chemical and mechanical operations of smelting, extracting, assaying and pumping. No mere observer, he put his learning to use investing in mine shares, which made him wealthy. By 'fossils' Agricola meant anything found in the ground, including ingredients of the remedies described in Valerius Cordus's *Pharmacorum conficiendorum ratio*, the first German pharmacopoeia, also published in 1546.

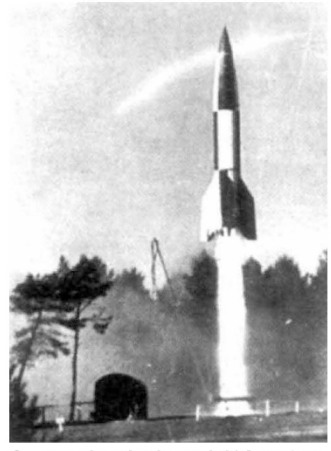
0 AMC (60 centenary)

We know that our choice of 4004 BC for the date of creation might be controversial. People with more imposing natural scientific credentials than Ussher had arrived at other numbers, such as Michael Mästlin, the teacher of Kepler, who insisted on 4075 BC, and Giambattista Riccioli, SJ, whose *Astronomiae reformatae* of 1665 gave 4184 BC as the best weighted average of the sages of the ages. To which we reply that Mästlin and Riccioli were wrong. On their reckoning, the millennium has already come, whereas any fool can see that the old dispensation reigneth still. We acknowledge the possibility that Ussher too made the world too old and that nothing will happen on 23 October next. But who can be sure?

Although we have pressed our researches further into the past than usual, we have found nothing of scientific interest of certifiable and appropriate date worthy of an anniversary between the creation of the world and the fifteenth century of our era. Our remote ancestors were inexcusably and, from a modern point of view, unintelligibly lax in supplying the data necessary to celebrate their discoveries.

5950 AMC (0.5 centenary)

The matter is altogether different for our century. The same machinery that guards priority and issues rewards has documented so many memorable events that we can notice only a few of the more characteristic of their era. The application of wartime technology and war-like funding to physical science gave a character to 1946. It saw the adaptation of captured V-2 rockets to solar observation; the start-up of the synchro-cyclotron at Berkeley, finished with money from the Manhattan District (the early US atomic bomb project) according to a design conceived by Edwin M. McMillan during quiet time at Los Alamos; the creation of the ENIAC, the first all-purpose, all-electronic calculator, by John William Mauchly and John Presper Eckert; the turn-on of the first Soviet nuclear reactor, under the direction of Igor Vasilievich Kurchatov; and the rapid development of radio-astronomy, which, still in 1946, secured the discovery, through Martin Ryle, of the first radio galaxy.



Captured and adapted: V-2 rocket.

We also offer a few discoveries and inventions that did not require large machines or big money, but nonetheless were to have important ramifications in the postwar era: Willard F. Libby's introduction of radioactive dating by carbon-14; George Rochester and C. C. Butler's discovery of the first of the strange particles among the products of cosmic rays; Arthur Burks, Herman Goldstine and John von Neumann's foundational theory of computers, their "Preliminary discussion of the logical design of an electronic computing instrument"; and Joshua Lederberg and Edward Tatum's discovery of sexual goings-on in the reproduction of bacteria, reported in *Nature* **158**, 558 (1946).

The Nobel prize for physics went to Percy Bridgman for creating the field of high-pressure physics; that for chemistry to James B. Sumner, John H. Northrop and Wendell M. Stanley for the preparation and crystallization of pure enzymes; and that for medicine to Hermann Joseph Muller for producing mutants with X-rays. It was a sign of things to come — all the winners were American.

5950±25 AMC (0.25¢ and 0.75¢)

Several candidates for anniversarial notice for 1971 are developments of inventions and initiatives of 1946. In space exploration, a descendant of V-2 rocketry, the Soviets successfully docked three cosmonauts at the world's first space station; two American astronauts brought back a sack of rocks from the Moon; the American Mariner 9 went into orbit around Mars two weeks before the Soviet explorer Mars 2 and three weeks before Mars 3 landed on the planet to broadcast unintelligibly for 20 seconds before going dead. On the computer front, Intel introduced the first microprocessor and Texas Instruments the first 'pocket' calculator (weighing just over 1 kg); Niklaus Wirth developed Pascal; and direct-distance dialling came in between Europe and the United States.

The Nobel prize for physics in 1971 was awarded to Dennis Gabor, a native of Hungary attached to Imperial College, London, for his invention of holography; that for chemistry to Gerhard Herzberg, a Canadian, for work on the electronic structure of molecules; and that for physiology or medicine to Earl W. Sutherland Jr, of the United States, for discoveries about the action of hormones.

Canada has further cause to celebrate this year. In 1921, Frederick Grant Banting and his collaborators started their attack on diabetes, which brought the world insulin and Banting and one of his colleagues a Nobel prize; and John Augustus Larson, a medical student, invented the polygraph or lie-detecting machine. We have other contemporary examples of the mechanization of mind: Karel Capek's play *R.U.R.* (*Rossum's Universal Robots*), which introduced the concept and word 'robot' (from the Czech for 'worker'), was first performed; and Hermann Rorschach invented his routinized psychological probe, the inkblot test.

The Nobel prize for physics for 1921 went to nobody (the somebody to whom it went retrospectively the following year, Albert Einstein, was apparently still immature in the eyes of the judges); that for chemistry went to the same party, that is, to nobody (it would go in 1922 to Rutherford's former collaborator Frederick Soddy); and that for physiology or medicine to, yes, nobody (it would fall into the coffers of the prize-awarding body, the Karolinska Institute). Another clean sweep. Nobody then won prizes like Americans. □

J. L. Heilbron is at the Office of History of Science and Technology, University of California, Berkeley, California 94720, USA; W. F. Bynum is at the Wellcome Institute for the History of Medicine, 183 Euston Road, London NW1 2BE, UK.