SCI-PHILATELY

A SELECTIVE HISTORY OF SCIENCE ON STAMPS

About the Exhibit

This project started many years ago in a kitchen sink. The sink has changed, but the activity endures. Stamps have been a source of fascination and enjoyment for many children and adults alike, including the elite and powerful, presidents and kings. These tokens of payment for the service of communication between people have evolved over the last 150 years from drab bits of paper into sometimes large and gaudy message boards for anniversaries, propaganda or celebrations. While 50 years ago heads of state were the norm and only a handful of scientific events or personages appeared on postage stamps, more recently the topic science has become a collectible commodity along with dogs, birds, space exploration, dinosaurs and Disney characters. The image of Einstein has become commonplace, and in an effort to corner valuable revenue some developing countries have launched series of stamps celebrating recent Nobel laureates (none of them their own), taking a lead from the excellent Swedish Nobel stamp program. As more countries are commemorating their famous sons and daughters, it becomes possible to fit together pieces of the great mosaic of the history of science, still with many gaps, to be sure. Some of the most satisfying stamps are not the ones displaying portraits, but those presenting ideas and experiments. such as the photoelectric effect, cloud chamber photographs, or the solar absorption spectrum.

The stamps presented here are from my personal collection and as such are an incomplete reflection of the range of published science-related postal materials. The large and fruitful area of space exploration deserves a separate exhibit, as does the diverse, fascinating field of technology. About half of the stamps on view here were shown in 1991 in the *Science & Engineering Library*, *University at Buffalo*, under the title *Sci-Phi* as an example of non-book related science instruction, and also in a 1992 poster session of the *Western New York Library Resource Council, Promoting Scientific Literacy: the Non-Book Approach to Library Exhibits*. Most recently, several of these intangible chapters presented here were printed out and shown at a Stamp Exposition during the *Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy(Pittcon)* in Orlando, Florida in March 1999. The availability of scanning technology and web browsers now makes this material widely accessible to all who have access to the internet. As has been widely pointed out in articles in *The Journal of Chemical Education*, postage stamps can serve as starting points for engaging student interest in science, or initiating classroom discussion and projects. For others with an interest in science, professionally or not, these miniatures can be sufficient in themselves as objects of enjoyment and wonder, reminders of the marvels of the natural world and its laws.

I am indebted to colleagues in the *Science & Engineering Library* and to John Naylor for reading this text and providing useful editorial comments. I am particularly grateful to Scott Hollander and Carole Ann Fabian for editing the scanned images and launching this document on the web. Three web sites inspired me with the extraordinary quality of their scanned stamp images:

- *A Philatelic History of Radiology Pictures of Famous Images of Mathematicians on Postage Stamps* http://
- jeff560.tripod.com/stamps.html
-

The owners of the latter two web sites, Dr Joachim Reinhardt and Jeff Miller, permitted me to refer viewers to highly detailed scans of some stamps as they appear on their pages.

Maiken Naylor
October 2011

Astronomy & Cosmology I

A reference to Aristotle is essential in a history of science, though impossible in a few sentences without being banal. This greatest of all Greek philosophers, who flourished in the 4th century BC, exerted an all-encompassing influence on the development of western thought. He introduced the systematic study of logic which he applied to his teachings. In his biological writings he presented a classification system of animals that was not fully replaced until the time of Linnaeus. All branches of knowledge were classified: physics, methaphysics, rhetoric, poetics. His picture of a perfect, unchanging, spherical universe centered on the earth placed a long-lasting damper on western understanding of the workings of the physical world, particularly the motions of the stars and planets. To the four supposed elements making up the universe, earth, water, air, and fire, he added a fifth, invisible element, the ether. This ether, made necessary because "nature abhorrs a vacuum", was an inpalpable fixture for over 2000 years until its existence was disproved by the Michelson-Morley experiment. His teachings, lost to western Europe during the dark ages, were reintroduced after contacts with the Arab world increased. The Scholastics reconciled Christian dogma with Aristotle's ideas, which virtually became dogma in secular learning. This discouraged independent scientific observation, inquiry, and experiment, even though Aristotle himself had been an interested observer of the natural world.

A 32 cm bronze disc with inlays of gold was found in 1999 near Nebra in Germany. It dates from approximately 1600 BC and is the oldest representation of the cosmos known today, showing the sun, a crescent moon, and stars, including the Pleiades. It is thought to be an astronomical clock designed to help synchronize the lunar calendar with the solar calendar. The twelve month lunar calendar is shorter than the solar calendar by 11 days, and every two or three years a month has to be inserted to stay in step with the solar year. According to Babylonian calculations, a thirteenth month should be inserted when a crescent moon and the Pleiades take on positions as shown on this disc, a fact known and used by the Bronze Age people as well.

Aristarchus of Samos (3rd century BC) considered the sizes and distances of the sun and the moon, and was the first to try to calculate the distances of these bodies geometrically . Furthermore, he advanced the theory that the sun was at rest at the center of the sphere of fixed stars, and that the earth and planets revolved around the sun. The apparent motion of the stars was due to the daily rotation of the earth. Copernicus was familiar with Aristarchus' theory of the universe, which at the time, however, did not find favor with the ancient philosophers.

Hipparchus (2nd century BC), the

greatest astronomer of the ancient world, is thought to have invented the astrolabe. He continued the work of Aristarchus in calculating the distance of the moon by measuring its parallax against the sphere of fixed stars. His result of 30 earth diameters is correct. From his observations he produced the first star catalogue, grading the stars by brightness. He also discovered the precession of the equinoxes.

Zhang Heng (78-139) was a Chinese astronomer, geographer, and mathematician. He constructed a celestial globe, believing that the world was round, "The sky is like a hen's egg, and is as round as a crossbow pellet; the Earth is like the yolk of the egg, lying alone at the centre. The sky is large and the Earth small." He also created a primitive, but very fanciful seismograph. His approximation of pi was the square root of 10.

Ptolemy (2nd century AD) was a famous astronomer, mathematician and geographer whose geocentric view of the universe was dogma in western thought until 1200 years later, when Copernicus was able to offer a competing heliocentric model which accounted just as well for many of its inconsistencies with observations. Ptolemy synthesized and extended the star catalogue of Hipparchus and much of Greek astronomy in his *Almagest.*

A Chinese astronomer and Buddhist monk of the Tang dynasty, **Zhang Sui** (683-727), was the first to describe proper stellar motion, or the apparent motion of stars across the plane of the sky relative to more distant stars. In Western astronomy, Edmond Halley is credited with this discovery in 1718 for some stars from Ptolemy's catalogue.

Ulugh Beg (1394-1449) was the grandson of Tamerlane, the Turkish conqueror of a large empire stretching from the Mediterranean to India. While acting as a ruler under his grandfather and father, the prince was an astronomer and builder of

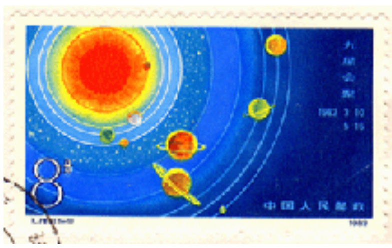
observatories in their capital city of Samarkand, where a stellar catalog was produced, the first since Ptolemy's and before Tycho Brahe. Permanent astronomical instruments of huge dimensions were constructed, since telescopes had not yet been invented. The most direct influence of the Samarkand Observatory was some centuries hence on the Indian Maharajah Jai Singh (1686-1743) who constructed five observatories, or Jantar Mantars, as shown on the Jaipur stamp below:

Nicolaus Copernicus (1473-1543), a Polish astronomer, proposed a heliocentric theory of the universe in which the planets orbited the sun, rather than the earth. It marked the end of the world with man and the earth at its center. Ironically, Copernicus appears here on a Vatican stamp for a theory that flew in the face of established religion in his time. Although known portraits of Copernicus are full face, one modern artist's conception shows a thoughtful man in profile. The French stamp shows a picture of the universe as Copernicus envisioned it -- the six known planets circling the sun. Silhouettes of the Polish churches from whose towers Copernicus made his observations are in the foreground. The souvenir sheet on the left shows the Copernican world view from a beautiful celestial atlas made by Andreas Cellarius, *Harmonia Macrocosmica*, 1661, This planisphere shows the solar system updated from Copernicus' time; the four moons of Jupiter are clearly visible. Venus appears to be obscured by the vertical stamp perforations; on other editions of this work the planets are shown in somewhat shifted positions. This universe is flanked by two figures: at right Copernicus himself, and at left Aristarchus of Samos, the earlier proponent of the heliocentric theory, here lending weight to Copernicus' theory.

Tycho Brahe (1546-1601) was the last and greatest of the naked-eye astronomers, rivalled only perhaps by Hipparchus. His book on his observations of an exploding star, De Nova Stella, gives us the word "nova." His many painstaking observations were passed on to his assistant Kepler, who used them to derive his three laws of planetary motion in a heliocentric universe, while Tycho himself had remained an adherent of the Ptolemaic geocentric world view. For over 20 years Tycho made observations from his castle Uraniborg on the island of Ven, given him as a fief by the king to keep the famed astronomer in Denmark. The layout of the castle was geometric and perfectly aligned with the compass. His instruments, built to his own specifications and design, were large scale to provide greater accuracy than achieved before. The stamps on the right were a joint issue of Denmark and Sweden. One shows a plan of Uraniborg and its grounds, the other, one of Tycho's instruments. On the stamp appears the longest word I have ever seen on a stamp: ekvatotialarmillarinstrument. Identified as a sextant in Scott, it is almost certainly the great equatorial armillary sphere (1585) . It consisted of one single declination circle, 272 cm in diameter, and a semicircle representing the equator, 350 cm in diameter. Full descriptions of all his instruments and the castle can be found on the Official Tycho Brahe web site.

Johannes Kepler (1571-1630) was a German mathematician who is remembered for his three laws of planetary motion, derived empirically from Tycho Brahe's data and observations, describing the solar system with the sun at the focus of elliptic planetary orbits. In his work, he used an early calculating machine (right) invented by his friend Wilhelm Schickard (1592-1635), some 15 years before Pascal built his own. In his writings on conic sections Kepler added the word "focus" to mathematical language.

They burned **Giordano Bruno** at the stake in Rome in 1600. He was a Neapolitan natural philosopher and Dominican priest who had unacceptable views on matters of religious doctrine and was a proponent of a cosmology which included not only Copernicanism but an infinite universe of matter composed of atoms, and stars which were individual suns, each with planets. Bruno traveled widely, teaching in Geneva, Paris, London, Frankfurt and Prague, unable to find a permanent appointment because of his difficult personality and unorthodox message. He ran afoul of the Inquisition first in Venice and then in Rome, where he was condemned as a heretic, and did not recant when given the chance. The trial record and charges against him are lost, but Copernicanism was not yet a punishable offense (until 1664). Galileo at his 1631 trial had a chance to deny the motion of the earth and wisely chose house arrest for his final years over a more dire fate.



This colorful Chinese stamp approximates our current view of the solar system, even showing the asteroid belt between the orbits of Mars and Jupiter. It was issued in 1982 to mark a rare alignment of the planets twice during that year, in in March and May. The nine planets clustered into a relatively small fan-shaped area on the same side of the sun, in arcs of 96 and 105 degrees. The average cycle for such an event is 179 years, and the next one is estimated to happen in 2357. This clustering, or conjunction, is also called **syzygy,** a word worth remembering for a game of Scrabble.

A conjunction of planets is said to occur at their closest approach where the planes of their orbits intersect. When earth and either of the interior planets, Mercury or Venus, are in conjunction and are aligned with the sun, it is possible see the interior planet move across the disc of the sun and a transit takes place. During a normal conjunction the interior planet is seen to move above or below the sun. The mechanism is the same as for a solar eclipse, when the moon moves between the earth and the sun, but since it is nearer to the earth than Venus or Mercury it subtends a much larger angle and obscures the face of the sun entirely. The transits of Venus occur regularly in pairs separated by eight years and repeat the cycle over 243 years. The most recent observed transit was in 2004, the next will be in 2012. Measurements of the solar parallax at widely separated locations during transit can be used to calculate the distance from earth to sun, and in 18th century Europe expeditions were mounted to observe the rare phenomena of the transits of 1761 and 1769. Captain James Cook was dispatched to the South Pacific Ocean by the Admiralty in Great Britain for this purpose and his success in 1769 is noted on the New Zealand stamp. **Maximilian Hell** (1720-1792), a Jesuit astronomer based in Vienna, observed this transit in Lapland (now in Norway), following an invitation from the king of Denmark.

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Astronomy & Cosmology II

Galileo Galilei (1564-1642), first to devise and use a telescope for astronomical observations, discovered the moons of Jupiter, and the motion of sunspots across the solar disc - sign of a less than perfect sun, which also rotated! His many observations confirmed the Copernican theory of the motion of earth and planets around the sun, and brought him in conflict with the Inquisition; for such heresy he spent his last years under house arrest. Here he is honored on Italian and Czech stamps: eppur si muove!

Johann Hevelius (1611-87) was a wealthy brewer in Danzig who dedicated his life and fortune to the study of astronomy. He built enormously long telescopes and other outsize apparatus on the roof of his house (Newton's reflecting telescope had not yet been invented). He mapped and named craters and mountains on the moon and in 1647 published *Selenographia*, the first illustrated work of astronomy dealing exclusively with the moon. He also published a stellar atlas, *Firmamentum Sobiescianum*, observed and mapped nebulosities including the Andromeda nebula, and recorded several decades of sunspot observations. These Polish stamps show Hevelius from a portrait in *Selenographia* superimposed on a chart of constellations, and also with his six foot radius brass sextant on the roof of his house. His celestial atlas *Uranographia* of 1690 may be viewed on the website of the Brera Astronomical Observatory.

Newton's law of universal gravitation applies not only to apples falling from trees, but also describes the relationship of mutual attraction between planets and celestial bodies in the universe. (See also Mathematics and Computation I.)

German musician **Friedrich Wilhelm Herschel** (1738-1822) is

best remembered as Sir William Herschel, famed astronomer and maker of sought-after reflecting telescopes. Ably assisted by his sister Caroline who was an astronomer in her own right, he discovered the planet Uranus, two of its moons Oberon and Titania, two moons of Saturn, and infrared radiation. His biggest telescope measured 40 feet in length and is shown on the stamp, where Herschel stands to the left of Francis Bailey and his son John Herschel. The Mali stamp compares the relative sizes of Uranus and Earth, indicating that Uranus' diameter is four times that of the earth.

Since Newton's time the heliocentric system of Copernicus and Kepler in which the earth and the other planets moved in elliptic trajectories around the sun was generally accepted by astronomers. Observed irregularities in the orbit of Uranus led the French astronomer **Urbain Le Verrier** (1811-1877) to suspect the presence of a planet as yet undiscovered, whose gravitational pull on Uranus caused the discrepancies in orbit. He communicated his calculations to the German astronomer Johann Gottfried Galle (1812-1910), who observed the new planet, Neptune, just where Le Verrier had predicted.

Teenager **Friedrich Georg Wilhelm von Struve** (1793-1864) left Germany with his family to avoid Napoleonic conscription, settling in Estonia, then a part of the Russian empire. He studied astronomy at Tartu University(Dorpat), becoming a professor and director of the observatory. There he studied double stars and was the first to measure the parallax of Vega. In 1839 he founded the Pulkovo Observatory near St. Petersburg at the behest of Czar Nicholas I. Over the years 1816-1855 he established the Struve Geodetic Arc to measure the size and shape of the earth. This series of triangulation stations extends from Norway to the Black Sea, passing through Tartu Observatory.

The return of Halley's comet in 1986 was an event that captured the imagination and

also occasioned an outpouring of philatelic materials around the world. The British possession St Helena was the first to weigh in with a set that commemorates astronomer **Edmund Halley's** (1656-1742) visit in 1677 to that remote island in the South Atlantic to prepare the first stellar atlas of the southern hemisphere. Most spectacular in this spectacular in this set is the contemporary reproduction of the comets image from that comic strip of the Norman Conquest of England in 1066, the Bayeux Tapestry, while Halley's sextant on the stamp below could pass for a quadrant. But only a few years after this visit, Halley speculated that the comet of 1682 had actually been observed before at regular intervals. He calculated the orbit of this comet now named for him, and correctly predicted its return in 1758, in a first application of Newton's laws of motion. The comet has returned twice this century, in 1910 and 1986, or "twice in a lifetime" for a

lucky few. The Australian stamp at upper right shows a plot of the earth's and the comet's trajectories around the sun over the image of a large radiotelescope. Britain was also among the nations to mark the comet's return with commemorative stamps and investigated it via the space probe Giotto. Notice how Orion appears "upside down" to observers in Antarctica for British Antarctic Territories.

The PRC stamp at right shows the comet streaking from right to left over the curved earth and over some mysterious symbols, whose meaning is explained below in notes to the Stamp Index.

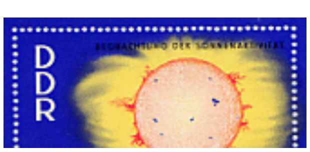
The Jesuit Pietro Secchi (1818-1878), an Italian astronomer, was the first to apply spectroscopy and photography to astronomy, taking spectra of the stars and photographs of the sun during eclipses. His compilation of stellar spectra led to the classification of the well-known spectral types of stars. As longtime director of the Gregorian University Observatory in Rome, he introduced the newest equipment for his studies.

The International Geophysical Year 1957 is noted on the U.S. stamp below with solar flares and a nod to Michelangelo's creation of man from the Sistine Chapel. Solar flares are best observed during a total solar eclipse, as is the corona (center). The corona extends thousands of miles, 30 solar radii, beyond the surface of the sun and changes in shape with sun spot activity. It is highly ionized and reaches temperatures of more than one million degrees K.

A solar eclipse takes place when the new moon passing between the sun and the earth blocks the solar radiation and casts its shadow on the earth. It can be total, partial, or annular. Total eclipses here commemorated were observed in Mexico in 1970, and the Philippines in 1995. The solar eclipse of August 1999 cut a swath from the extreme eastern shore of Canada across the Atlantic Ocean, then Great Britain and Central Europe, and was thus viewed by millions of enthusiastic observers. Postal entities followed the cue and issued many stamps and special cancellations. Shown here is a French stamp of totality, with a splendid corona framing the eclipsed solar disk. The progression of the phenomenon is shown counterclockwise from the upper right corner of the stamp. The new monetary unit of the European Union, the Euro, has also crept into the upper right corner. An earlier eclipse stamp from Mexico in 1942 honors the inauguration of the astrophysical observatory in Tonanzintla that year. Among the more interesting

stamps featuring the eclipse of August 1999 is from Romania. It

has a tag with a diagram, not drawn to scale, showing the alignment of sun, moon, and earth necessary to produce an eclipse. The stamp itself shows the corona of an eclipsed sun, and in a rectangle a map of Romania with the projected swath of the eclipse across it. The legend "total solar eclipse" and the date appear in English on the tag and in Romanian on the stamp itself, while the date of issue is 1998 - earlier than the event perhaps in anticipation of philatelic demand. The USPS in 2000 issued a minisheet called *Exploring the Solar System* of five $1.- pentagonal stamps showing various aspects of the sun, including the eclipse below, right.



Sunspots appear as dark spots on the glowing disk of the sun, near the sun's equator, and they seemingly travel across the disk over a period of days. They were probably already observed by the ancient Chinese who did not known what to make of them. When telescopes became available in Western Europe, in the 17th century, astronomers such as Galileo, Scheiner, Herriot, and Goldsmid observed them more systematically and sketched

Galileo, Scheiner, Harriot, and Goldsmid observed them more systematically and sketched their shape and position on the solar surface. Galileo determined that they were part of the solar surface from observing their changing shape as they disappeared beyond the solar limb. Counting them over periods of centuries has shown that their numbers increase and decrease over a period of eleven years, which is known as the solar cycle. The periods of high solar activity correspond to times of maximum sunspots, when solar flares explode near sunspots whose magnetic fields become unstable. Ionized gases are flung into space in a coronal mass ejection and cause geomagnetic storms and auroras near the earth, interrupting satellite and other electromagnetic communications. The period of minimum sunspots is known as a solar minimum, when activity is much reduced. The years 1964-65 were designated as the Year of the Quiet Sun, as commemorated on the DDR stamp at left.

During the *International Geophysical Year*, advances in rocketry both in the United States and the Soviet Union had made it possible to explore space beyond the earth's atmosphere. The Explorer spacecraft, launched in 1958, was designed by **James van Allen** (1914-2006) to measure the distribution of charged particles encircling the earth by means of a Geiger counter. Earlier, in 1957, *Sputnik I* likewise explored these regions which were found to be torus-shaped and were subsequently called the van Allen belts. Energetic particles streaming from the sun are captured in the earth's magnetic field and constrained to spiral along the field lines emanating from both poles. Our magnetosphere is not symmetrically shaped, being deformed by pressure from the solar wind and elongated in the other direction (see solar wind stamp above). Continuing satellite exploration has found that the other planets are also magnetized and exhibit radiation belts. **Hannes Alfven** (1908-1995) a Swedish Nobel laureate in Physics (1970) contributed much to the understanding of the behavior of the radiation belts, auroras, and effects of magnetic storms on the earth's magnetic field, and the plasmadynamics of the galaxy.

The auroras near the north and south magnetic poles, bright pulsating bands in the night sky at altitudes ranging from 70 to 300 km, are due to high energy particles originating from solar flares on the sun, which then collide with atmospheric molecules, causing them to emit light. Most of these charged particles are deflected by the earth's magnetic field, which protects the atmosphere from being destroyed by the energetic

the energetic particle flux. The Aurora Australis and Antarctica are shown on a 1965 stamp, commemorating a Japanese scientific expedition. The distortion of the earth's magnetic field, or magnetosphere, described above by the so-called solar wind is shown in a stamp from the British Antarctic Territory on the left. The Aurora Borealis also appears on a Soviet stamp honoring the International Geophysical Year 1957-1958. Last but not least, the small stamp from Greenland packs a mighty punch, showing a northern lights display between the Big Dipper and Polaris.

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Astronomy & Cosmology III

The **Hertzsprung-Russell** diagram shown on the Mexican stamp at left is a graphic relation of the absolute magnitude of stars to their spectral class or temperature. Such classification aims at grouping like stars together in a meaningful way so that each star does not have to be described anew individually. Attempts at classification were already made by Secchi, who grouped stellar spectra into four classes, depending on the absorption lines seen, and were continued by the Danish astronomer **Ejnar Hertzsprung** (1873-1967) and independently by the American astronomer **Henry Norris Russell** (1877-1957) after whom the resulting composite graph is named. The main sequence of stars runs from the upper left corner where the hottest, brightest stars are placed (blue giants) to the lower right, where the smallest, dimmest stars reside (red dwarfs). Our sun, a yellow star, falls about into the middle of this sequence, which can also be viewed in time as the evolution of a star from its hot, bright, early stages to cooler, dim, late stages. In the upper right corner are very bright giants or supergiants who are however rather cool, as evidenced by their red color (Betelgeuse).

Hello! It is cold outside, 3 degrees! Three degrees Kelvin, that is, in intergalactic space. This surprising discovery was made by researchers **Arno Penzias** (1933-) and **Robert Wilson** (1936-) at Bell Labs in New Jersey, with a receiver originally built for satellite communication. They found that cosmic microwave radiation of uniform strength was received from all directions, and it was supposed that this radiation was the remains of the Big Bang. The shape of the spectrum is indeed like that of a black body with a temperature of 3 degrees Kelvin, supporting the Big Bang theory of creation rather than the steady state hypothesis. Penzias and Wilson shared one half of the 1978 Nobel physics prize for this discovery; the other half went to Piotr Leontevitch Kapitsa (1894-1984), for his discoveries in the area of low temperature physics. A Swedish stamp has not yet been issued in his honor.

Subramanian Chandrasekhar (1910-1995) shared the 1983 Nobel prize for physics for his theoretical studies of the physical processes relating to the structure and evolution of the stars, particularly white dwarfs, stars at the evolutionary end of stellar development. Chandrasekhar calculated that white dwarfs cannot have a mass greater than 1.4 solar masses without collapsing into an even denser state, a neutron star. The expression for this critical mass is shown on the stamp at left.

William A Fowler (1911-1995) shared the 1993 Nobel physics prize with Chandrasekhar for important astrophysical discoveries in his theoretical and experimental studies of nuclear reactions in the formation of the chemical elements in the universe, from the mostly hydrogen and helium created in the Big Bang.The chart of nuclides on the stamp shows stable heavy nuclei between hafnium and lead.

Georges Edouard Lemaitre (1894-1966), a Belgian cosmologist, astrophysicist and priest, was interested in the problem of the creation of the universe and proposed a theory of an expanding

interested in the problem of the creation of the universe and proposed a theory of an expanding universe based on his solutions to Einsteins equations of general relativity. He envisioned a primal atom containing all the matter in the universe, which exploded at some point 10-20 billion years ago, hurtling elementary particles and photons outward, where they cooled and condensed eventually to form the light elements, heavy elements, molecules, and finally galaxies. The Big Bang theory, as it was derisively called by Fred Hoyle, a proponent of a steady state theory of the universe, is supported by many independent astronomical observations, starting with Hubble's observations of receding galaxies and the discoveries of Penzias, Wilson, and Fowler, above.

Radioastronomer **Antony Hewish** (1924-) and his graduate student Jocelyn Bell discovered radio sources in space that were called pulsars, because of their regular emission of pulsed energy. This confirmed the existence of neutron stars, extremely dense collapsed stars at the center of the pulsars which are highly magnetized. He shared the 1974 Nobel prize in physics with **Martin Ryle** (1918-1984), who was recognized for his achievements in radiotelescope construction. Known as the aperture synthesis technique, this method employs several small telescopes deployed over a distance of about three miles whose positions are mutually adjustable and who act as one enormous composite telescope of corresponding size. The Ryle stamp shows two symbolic radiotelescopes receiving radiation from a radiogalaxy. The Hewish stamp shows a stylized pulse signal superimposed on the Crab Nebula, a supernova remnant which was first observed by Chinese astronomers in the 11th century, and which has a pulsar emitting energy bursts across the whole spectrum at its center. The five stamps of this stunning 1987 Swedish set vary in color from a deep blue to black, like the night sky.

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Astronomy & Cosmology IV

Long before the invention of the telescope, people of ancient civilizations observed, cataloged and named visible, bright objects in the sky: planets, stars, comets, and constellations -- groups of stars seemingly always occurring together in the same spatial configuration, and recurring year after year with the seasons. Along the ecliptic, the plane of the earth's orbit around the sun (or the apparent motion of the sun among the stars for an observer on earth), twelve constellations are observed which give the names assigned to them in antiquity to the signs of the Zodiac, probably by the Mesopotamians two millennia BC. By "fleshing out" the shape of a bear, bull, or ram around the major stars in a constellation, ancient observers populated the heavens with creatures and objects more meaningful to the mortal imagination than these actual random groupings of stars many lightyears apart . The recognition of constellations as such by an observer makes it easier to locate other celestial objects like planets, comets, or distant galaxies within the constellation's area against the sphere of fixed stars.

Swedish Post issued this interesting booklet of stamps showing constellations of the zodiac inside images of their mythological bodies. Issued without denomination, each triangular stamp covers the minimum domestic letter rate. Constellations that appear on other stamps on these pages are the following: Omega, Orion, Leo, Cygnus, Ursa Major, Ursa Minor, and the Pleiades.

In the northern hemisphere voyages of exploration and trade were undertaken initially without the aid of compass or maps. Ancient mariners sailed usually within sight of land, which was possible around the Mediterranean, and in the Baltic Sea. Added directional help came from the Pole Star, Polaris, so called because it is near the north celestial pole. The elevation of this star over the horizon provided a measure of latitude; the higher Polaris, the more northerly the location. Polaris is also known as the Lodestar, as associated with a lodestone. This naturally occurring magnetic material could be used to make a primitive compass by magnetizing iron needles, which, when freely suspended, would align themselves with the magnetic field of the earth and point northward.

The Faroes Island stamp shows a Viking ship and the constellations Ursa Major (the Big Dipper) and Ursa Minor (the Little Dipper). Polaris is the last star in the handle of the Little Dipper, or in the tail of the small Bear.

In the absence of telescopes, ancient observatories were necessarily large in order to afford the naked eye observer a chance to detect small changes in the locations of celestial bodies. The Mayans and even earlier the Babylonians made astronomical observations, the Egyptians had a calendar based on movements of the sun. Stonehenge, a series of large concentric stone circles in England, is believed to be an observatory built between 1000 and 3000 years BC. The monolithic structures that remain are shown in the British stamp at left, which also contains a vignette of stellar navigation similar to the Faroe stamp above.

Giant telescopes such as at Mt. Palomar and radio telescopes at Joddrell Bank in England, at Nancay in France, and the Arecibo 305 Meter Radio Telescope in Puerto Rico, now explore space far beyond the universe imagined by Copernicus and Kepler. But with the deployment of satellite-launched telescopes such as the Hubble Space Telescope above at right, astronomy

has taken an even greater leap forward. No longer limited by absorption of light by atmospheric molecules, distortions due to dust and the glare of earthly lights, telescopes can now explore all kinds of radiation emitted from deep in the galaxy and beyond. We are no longer limited to the visible spectrum impinging on our retinas as

our surrogate detectors record bursts of x rays and gamma rays from exploding stars. The splendid set of German semi-postal stamps of 1999 depicts the Cosmos and presents the cutting edge in astronomical observation. Three Max Planck Institutes in Germany produced the photos on which the stamps are based. The first shows the Andromeda nebula in the spectrum of 6 cm radiowaves, with a picture of this galaxy in visible light in the background. Next, there is a section of the Milky Way at 11 cm wavelength in Cygnus, including a background picture of the constellation

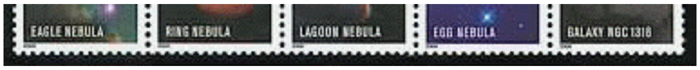
from ***Uranographia***, Bode's stellar atlas of 1801, the last of its kind. Then there are the remains of a supernova in Vela, taken with the X-Ray Telescope ROSAT orbiting the earth. The dramatic collision of fragments of the comet Shoemaker-Levy 9 with Jupiter were documented from the Calar Alto Observatory in Spain with the infrared MAGIC camera. The successive shots were made into a video clip which in turn was used to produce the hologram. On the right of the picture the planet Io is disappearing, while the impact explosion is at the bottom of the planetary disk. Cooperation with NASA on the Compton Gamma-Ray Observatory led to a view of the whole sky in gamma radiation (last stamp). The CGRO is also pictured, as is a section of the Milky Way in the background. The addition of holograms on two of these stamps seems like a bit of overkill or icing on the cake,

depending on your point of view...

The centenary of the Tokyo Astronomical Observatory was the occasion for the issue at left, in 1978. It shows a huge reflector pointing through the opening of the dome in the direction of the constellation Orion which is, with the Big Dipper and Cassiopeia, one of the most distinctive constellations in the northern sky. The left shoulder of the great hunter is marked by the supergiant red star Betelgeuse, which is so large that it would encompass the solar system including the orbit of Mars. A whimsical feature of this stamp is that Betelgeuse is actually shown as red, not distinguishable as such on this page, but check the enlargement,

Images of galaxies and nebulae taken with the Hubble telescope appear below on a set issued by the USPS. Each stamp bears a brief description on the back:

Eagle nebula: a dramatic region of star formation featuring pillars of dust and gas
Ring nebula: a barrel of gas cut off by a dying star similar to our sun
Lagoon nebula: a cradle of star formation with giant clouds of dusty gas
Egg nebula: beams of light from a dying sun-like star emerging from a dark dust cloud
Galaxy NGC1316: the aftermath of a collision between two galaxies is shown here, with the remains of the smaller one drifting before the glowing core of NGC 1316.



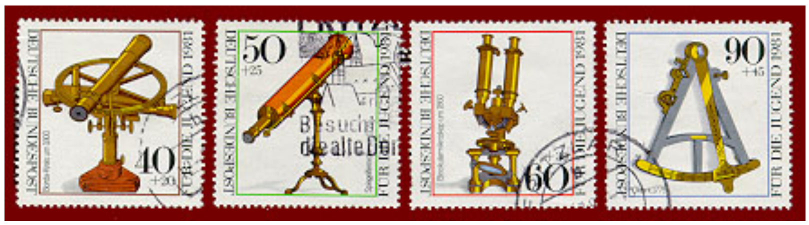
The Hubble telescope also produced this spectacular image of the planet Saturn, which is featured on a British stamp that was part of their Millenium series.

These Australian stamps issued in 1992 are part of a minisheet celebrating the International Space Year. Shown are the Helix Nebula, the Pleiades, and Spiral Galaxy NGC2997.

As we see in this chapter, photographs or radiographs now appear regularly on stamps instead of artists' conceptions of astronomical objects. Perhaps the earliest such photographic records are on the beautiful 1942 set from Mexico, issued on the occasion of the inauguration of the astrophysical observatory in Tonanzintla that year. They are, in order: the Horsehead Nebula in Orion; a total solar eclipse; the beautiful spiral galaxy M51in Canes Venatici, known as the Whirlpool Galaxy; spiral galaxy M104 in Virgo, the Sombrero Galaxy; planetary nebula M57 in Lyra, the Ring Nebula (s.a. above in the US set of Hubble stamps). The set is completed with a stamp showing the Herzsprung-Russell diagram, which appears at the beginning of the previous chapter.

The Kant-Laplace hypothesis is a theory of the origin of the solar system proposed independently by two of the mostfertile minds of the Enlightenment. It explains many of the facts observed. The German philosopher and natural scientist **Immanuel Kant** (1724-1804) in his Natural History and Theory of the Heavens,1755, and years later French astronomer and mathematician **Pierre Laplace** (1749-1827) suggested that the solar system developed from a rotating hot gas cloud (nebula) which condensed while cooling, thereby also increasing its angular momentum. Gravity shrank it towards the center (now the sun) vertically, while masses were flung out into orbit horizontally, creating the planetary system. Planets in turn developed their own moons by the same mechanism. These satellites all spin in the same direction as the original nebula, and travel in approximately the same plane of the original rotation (the ecliptic).

Instruments & Measurements



In the centuries succeeding Galileo, optical instruments proliferated and increased in precision, making possible scientific discoveries beyond the capabilities of the naked eye, from the galactic to the microscopic. Shown above are specimens from the late 18th and 19th centuries: a Borda reflecting circle, reflecting telescope, binocular microscope, and octant.

Jean Charles de Borda (1733-1799), a French mathematician and nautical astronomer, devised many instruments, among them a reflecting circle. Together with Delambre and Mechain, Borda used this to measure the length of an arc of a meridian between Dunkirk and Barcelona in 1790 . Borda, whose most significant work was done in hydraulics, strongly supported the introduction of the metric system and originated the word "metre" for its basic unit of length.

The Royal Microscopical Society of Great Britain celebrated its 150th anniversary in 1989 with a set of stamps picturing objects magnified from 5 to 600 times: shown here are a blue fly, snow flake, blood cells, and a microchip.

The metric system originated in France around the time of the French revolution and was officially adopted in 1795. Louis XVI authorized the formation of a commission, of which Lagrange was a member, to reform weights and measures. Based mainly on decimal units, it has been adopted as the standard system of measurement in science and commerce throughout the world, except in a handful of countries, including the United States, where it is legal and encouraged, but not mandatory. The meter is the international unit of length; the General Conference on Weights and Measures in Paris in 1875 was the occasion for the Treaty of the Metre signed by 18 nations, including the U.S. The meter was originally defined as one ten-millionth of the length of a quadrant meridian. In 1960 a wavelength of Krypton 86 radiation was used to redefine the meter; the original platinum-iridium meter is still preserved in Paris. Since 1983, it is defined as the length traveled by light in vacuum during 1/299792458 of a second. The second, another standard, is defined as the time required for 9,192631770 vibrations of a microwave emission line between the two hyperfine ground levels of the cesium 133 atom. The advantage of these standards lies in that they form a common basis for all scientific measurements, and that they are founded on immutable physical properties of the cesium atom.

Stamps observing the centenary of the Metric Treaty were issued by many countries: Sweden displays a simple tape measure; the French stamp shows not only the signatories to the Metric Treaty, but also a Kr 86 atom surrounded by the symbols of the metric units. The number 1,650763.73 between amplitude peaks refers to the wave number of the Kr radiation standard. The Swiss stamp shows a stylized platinum bar and characteristic Krypton radiation.

Many countries have used the metric system for over a hundred years; Brazil since 1862, and Mexico since 1857. Others have adopted it more recently: Japan in 1959, Korea in 1964.


Metrication reached much of the English-speaking world in the 1970's, including former British colonies in Africa: Kenya, Uganda, and Tanzania. A set of four stamps illustrates the conversion between metric and other units currently in use; volume for gas at the pump, distance on the road, weights at the store, and temperature outside. Shown here is the temperature conversion stamp which graphically gives equivalent readings on the Fahrenheit and Celsius (here called Centigrade) scales for representative temperatures such as the freezing and boiling points of water, and the ambient outdoor temperature of 80 degrees F given as 27 degrees C, but rounded up from the actual conversion value of 26.5. Unfortunately, there is no stamp with a portrait of Daniel Gabriel Fahrenheit (1686-1736), a famous German instrument maker, who invented the alcohol and mercury thermometers, and who flourished in the Netherlands. He chose as the zero for his scale the temperature of a mixture of equal parts of ice and salt. The freezing point of water was then 32 degrees, and the boiling point of water 180 degrees higher, or 212 degrees. The Fahrenheit scale is still in use in the United States.

Charles-Edouard Guillaume (1861-1936) was a Swiss scientist who worked at the International Bureau of Weights and Measures for over fifty years, where he was responsible for calibration of thermometers and studies of thermal expansion of the standards of length, such as the International Meter. His discovery of a steel-nickel alloy called invar that was impervious to temperature changes advanced the development of precision instruments significantly. For this discovery and its many applications he received the 1920 Nobel prize in physics.

A joint issue of France and Finland commemorates simultaneous 1736 French expeditions to the equator in South America and the polar regions of Lapland to determine the shape of the earth, generally acknowledged to be spherical. **Charles LaCondamine** (1701-1774) in Peru and **Pierre Maupertuis** (1698-1759) in Lapland surveyed the curvature of the meridians and found that the earth was somewhat flattened at the pole, and more curved at the equator, giving it the shape of an oblate spheroid.

This confirmed Newton's theory put forth in the *Principia* that the centrifugal force of the rotating earth caused it to be distended at the equator, where the speed of rotation was greatest, and flattened at the poles, where the speed was zero - as indicated on the Finnish stamp. **Anders Celsius** (1701-1744), the Swedish astronomer, was also a member of the northern expedition. He was the inventor of the centigrade thermometer, which divides the range in temperature between the freezing and boiling points of water into 100 degrees. These divisions are now called degrees Celsius.

The question of the size of the earth continued to occupy the scientific minds of the 18th century, and soon after the measurement of the arc of a meridian by Delambre, Borda and Mechain in 1790, an even more ambitious project was conceived, this time in India. In 1799, Colonel William Lambton proposed a plan of a mathematical and geographical survey right across the subcontinent along the 78th E meridian, ostensibly to fix the location of some important points in the country, to aid surveyors in their work and to serve as reference points in a lattice for more detailed mapping. The method used was to be triangulation, and the survey was later called the Great Trigonometric Survey. Begun in 1802, by the time of Lambton's death in 1823 the Great Arc of the measured meridian extended for nearly 700 miles, or 10 degrees. Colonel George Everest took over the survey and completed the longitudinal aspects in 1866.

British interest in lands beyond the Indian borders resulted in surveys carried out by Indian surveyors trained by the British, since the border countries did not allow foreigners to enter. These native surveyors were known as pundits, or men of learning. Two such pundits are honored on the sheetlet comemmorating the Great Arc; they are Nain Singh, who explored and mapped the trade route between Nepal and Tibet and determined the altitude of Lhasa; and Radhanath Sidkar, who determined the altitude of the highest peak in the mountain range, which was later named Everest. The center stamp shows a series of stylized triangles covering the subcontinent

The zero meridian passing through Greenwich, England, has been used by international agreement since 1884 as the prime meridian for indicating longitude east and west on the earth, a reference for navigators and map makers. These British commemoratives show progressively smaller areas crossed by this imaginary line.

Since prehistoric times, calendars were devised to keep track of time - days, seasons, years. The Julian calendar introduced by Julius Caesar, based on the solar year and containing leap year, was succeeded by the Gregorian calendar, after minute discrepancies had accumulated over the centuries. Early Central American calendars had 18 months of 20 days, plus five days of bad luck. An Aztec calendar stone was the symbol of the 1968 Olympics in Mexico City.

The compass, a primary aid to navigation, has been known since ancient times; the one depicted on the Chinese stamp was used in the 3rd century BC. The modern compass rose is displayed on a German Red Cross commemorative.

This elaborate device is a **seismograph**, the work of Zhang Heng, an early Chinese astronomer. Inside the round jar is a pendulum which moves when an earthquake occurs, transferring its motion to one of eight rods, which in turn prods one of the eight dragons clinging to the outside of the jar. The dragons hold round balls in their mouths, disgorging them when struck. At the base of the jar sit eight toads with open mouths, ready to catch the dropping balls. The general direction where the earthquake took place is thus determined by the the toad holding a ball in its mouth. The name for this device is *didongy*.

Navigation on charted or uncharted seas depended crucially on accurate, dependable time pieces in order to determine a ship's position based on the positions of celestial bodies. Many major disasters at sea were caused by faulty navigation due to inaccurate clocks that could not keep perfect time on pitching seas and in changing atmospheric conditions. The British Admiralty's Board of Longitudes offered a huge monetary prize for the successful development of a naval chronometer to determine longitude to within 60, 40, and 30 geographical miles at sea. **John Harrison** (1693-1776), a horologist, rose to the challenge and produced a series of five superb chronometers between 1736 and 1773, as the Board hedged on the reward, asking for more improvements. Harrison finally received his prize only after the intervention of King George III.

Rene Laennec (1781-1825) was a French physician who now would be called an internist. He studied diseases of the liver and the chest and invented the stethoscope when he rolled up a piece of paper, placed one end of the tube against a patient's chest, the other to his ear, thus avoiding direct contact with the patient. Acoustic waves travel through the hollow tube directly to the ear rather than being dispersed into the air.

Instruments Index

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Mathematics & Computation I

The beginning of mathematics was primitive man's discovery of counting; adding one and one to make two is pictured on this stamp. Upon seeing two birds, an Egyptian makes the cerebral leap to count them on his fingers. (Detail) This stamp is the first in a set of ten issued by Nicaragua in 1970 which features important mathematical formulas that changed the face of the earth. Besides showing the law, equation, or formula, the name of its originator, and an application, the reverse of each stamp is printed with a brief paragraph in Spanish explaining the significance of the formula and its far-reaching applications in modern life. Presumably the user can ponder this educational message while licking the stamp; whether the recipient would

appreciate it or be aware of it is another matter. The illustrations contain a wealth of interesting detail, and the sci-philatelic sleuth can enjoy identifying the many clues and their relationship to the original formula.

The Inca civilization of the 15th century, centered in Peru, did not have a written language, but kept records (and count) of items on an array of colored, knotted cords called quipu. Color, type of knot, spacing and placement of the cords were all meaningful and part of a code that was used to send information on production, census, resources, and taxes owed or collected to distant parts of the empire. Runners carried the quipi which were then decoded at their destination.

A well-known theorem in geometry is named after Pythagoras, who flourished in the 6th century BC, and was a teacher in Samos, Babylon, and Egypt: the sum of the squares of the sides of a right triangle equals the square of the hypotenuse. Actually, the so-

called Pythagorean triples were known already in Babylonian times. The striking design of the Greek stamp is a visual representation of the theorem. (Detail)

Archimedes of Syracuse, the great mathematician of the 3rd century BC, considered one of his most important accomplishments to be the proof of the relationship between the volumes of a sphere and a circumscribed cylinder: the spherical volume is 2/3 that of the cylinder. He asked that a sphere and cylinder be placed on his tomb, where they were seen by Cicero in 75 BC. This Italian stamp commemorates the World Mathematical Year 2000 with just such a sphere and cylinder. For some of Archimedes' many other accomplishments see Archimedes.

Tsu Ch'ung Chi (430-501) was a Chinese mathematician and astronomer. His approximation of pi was 355/113, which is correct to six decimal places. In astronomy, he arrived at the precise time of the solstice by measuring the sun's shadow at noon on days around the solstice.

Muhammed ibn Musa al-Khwarizmi was a Persian mathematician of the 9th century whose name comes down to us in the word "algorithm." The translation of his arithmetic treatises into Latin in the 12th century brought the advantages of the Indo-Arabic method of positional counting, including the use of zero, to western Europe, where counting tables based on the abacus and Latin numerals were still used. The title of his work *Al-jabr wa'l muqabalah* has become our word "algebra." (Detail)

Fibonacci numbers, a sequence named for Leonardo of Pisa, also known as Fibonacci (1170-1250) , are described in his book ***Liber Abaci*** published in 1202 and were already known to Hindu scholars. This mathematical text also introduced the use of the “Indian method of mathematics”, or Arabic numerals with digits 0- 9, and place value. After the initial values 0 and 1, the subsequent numbers are generated by adding the previous two

numbers, so that the sequence runs 0,1,1,2,3,5,8,13,21… Fibonacci numbers occur in nature, in the arrangement of seeds and petals in flower heads, the swirl of pine cones, and provide optimal packing . The rabbits on the stamp refer to the problem posed to, and by, Fibonacci about the reproductive rate of rabbits and their population growth:

Liber Abaci was a source for Luca Paccioli's writings three centuries later, see below.

Luca Pacioli (1445-1517) (Detail) was an Italian monk and mathematician who in 1494 published an encyclopedic compendium of all that was known in the field of mathematics at the time: Summa de arithmetica, geometria,proportioni et proportionalita. This Italian stamp commemorates the 500th anniversary of this event with a painting based undoubtedly on an original by Jacopo de Barbari of Pacioli surrounded by mathematical figures and artifacts shown here. His work contained many chapters on double entry bookkeeping based on an unpublished manuscript of Benedetto Cotrugli, and elsewhere he drew on the work of many earlier mathematicians, including Fibonacci. His last great work was Divina proportione, (divine proportion, a term coined by Pacioli) or the golden section, known to Greek mathematicians and philosophers. This work was illustrated by his friend Leonardo da Vinci.

Adam Riese (1489-1559) was the most famous and influential German arithmetician of the 16th century, and author of many popular commercial arithmetic books which made use of Indo-Arabic numerals instead of counters.(Detail)



Pedro Nunes (1502-1578) was the foremost mathematician and cosmographer of Portugal during the Age of Discoveries. He wrote extensively on Cosmography, Spherical Geometry, Astronomic Navigation, and Algebra. Three stamps issued by Portugal in 2002 reproduce two of the most important discoveries of Nunes: the loxodromic curve and the nonius. Loxodromic curves appear on the first stamp from the left, both over a globe and on space, and cover part of the second stamp, on which appears a typical face of the epoch. It is not a portrait of Nunes, since no drawing or painting of his face survives. The stamp on the right reproduces an instrument now in the Museum for the History of Science in Florence of nonius scales, as well as a stylized drawing of these scales. Loxodromic curves, also called rhumb lines, are spirals that converge to the poles. They are lines that maintain a fixed angle with the meridians. A ship following a fixed compass direction travels along a loxodromic. Nunes discovered the loxodromic lines and advocated the drawing of maps in which loxodromic spirals would appear as straight lines. This led to the celebrated Mercator projection, constructed along these recommendations. Nonius scales were invented by Nunes in order to allow a more precise reading of the height of stars on a quadrant. The set of concentric scales provides a higher precision than the individual precision of any particular scale. The device was used and perfected at the time by Tycho Brahe, Jacob Kurtz, Christopher Clavius and others. Following these various improvements, the French Pierre Vernier constructed in 1630 a device with one sliding scale over a fixed one, which proved to be a most practical solution. For some centuries, this device was called nonius. During the 19th century, many countries, most notably France, started to call it vernier.(1)

John Napier's (1550-1617) invention of logarithms immensely facilitated mathematical computations before the age of computers. Lengthy multiplications and divisions of large numbers were replaced by the addition or subtraction of their logarithms, which were calculated and conveniently available in tables of great accuracy. The Nicaraguan stamp shows astronomical equipment and the Big Dipper.(Detail) Astronomical calculations benefitted enormously from the use of accurate logarithmic tables. Napier's "bones," or sliding scales, later became the slide rule, an essential tool for engineers and scientists until replaced by the hand-held calculator of the 1970's. On the Romanian stamps of 1957 publicizing a Congress of Engineers and Technicians, calipers and slide rule represent quintessential tools for measurement and calculation.

Simon Stevin (1548-1620) was a Dutch mathematician who is remembered for popularizing the use of decimal fractions in everyday use, and he predicted the use of decimal weights and measures as well as coinage. He experimented with falling bodies and stated that two lead spheres of very different weights fell equal distances in the same period of time, contradicting the Aristotelian dictum that heavier bodies fall faster than lighter ones. This predated Galileo's experiments with falling bodies by some 18 years

Johannes Kepler (1571-1630) was a German mathematician who is remembered for his three laws of planetary motion, derived empirically from Tycho Brahe's data and observations. The laws describe the solar system as having the sun at the focus of elliptic planetary orbits. In his writings on conic sections he introduced the word focus into mathematical language. The second stamp, issued for the International Congress of

Mathematicians in Tokyo in 2000, shows an origami construction of the stella octangula, a composed polyhedron first discovered in by Kepler. It is made up of two interpentrating tetrahedra and its vertices are the vertices of a cube. The stella octangula is also called a stellated tetrahedron, and is the only stellation of the octahedron (s.a. Astronomy and Cosmology I)

Pierre de Fermat (1601-1665), the French mathematician, left mathematical posterity with a tantalizing problem, known as Fermat's Last Theorem, which states that the Pythagorean equation $a^2 + b^2 = c^2$ has no solution for integer values of a, b, and c for any power higher than 2. He professed to have a proof of this theorem but did not have space to write it down in the margin of the text he was then annotating. Not until 1994 was a satisfactory proof published, by Andrew Wiles, who has the distinction to see his name emblazoned on the Czech Republic stamp, while Fermat's enigmatic smile on the French stamp at left reflects perhaps the amusement he would have felt at the feverish attempts of mathematicians to prove him either right or wrong over the last four centuries.

Mathematics & Computation II

Gottfried Wilhelm Leibniz (1646-1716) developed a system of the calculus independently from Newton's, and was unjustly accused of plagiarism by Newton's followers. His notation flourished in Europe and is now generally used, while Newton's was preferred in England. The German stamp shows a page of his manuscripts. Both Newton and Leibniz had "Big Hair." (Detail)

Like Eve and Snow White, **Isaac Newton** (1642-1727) was the alleged victim of an apple, but with more positive results: the law of gravitation which not only applies to apples falling from trees but also describes the relationship of mutual attraction between planets and celestial bodies in the universe. On the 300th anniversary of the publication of his *Principia Mathematica*, Great Britain issued this set of commemoratives. Planetary motion according to the inverse

square law and optical refraction are shown on two of the stamps. Newton is also considered the inventor of the calculus at the same time as Leibniz developed his version of the calculus; understandably, the German stamp honoring

Newton features his *Optics* instead.([Detail]())

Jakob Bernoulli (1654-1705) was a member of the distinguished Swiss family of mathematicians which, together with Euler, brought fame to the city of Basel in the 17th century. He worked closely with Leibniz on the foundations of his calculus, and is here remembered on a Swiss stamp for his Law of Large Numbers, first published in 1713 in his *Ars conjectandi*, a milestone in probability theory. ([Detail]())

Leonhard Euler (1707-1783), a Swiss mathematician, worked in number theory, differential geometry, calculus, differential equations, and is here commemorated with his polyhedron formula:

Number of vertices - number of edges + number of faces = 2

The Swiss stamp on the right shows a bewigged Euler and his formula relating the exponential and trigonometric functions in the complex plane. (Detail)

Christian Goldbach (1690-1764) was a native of Prussia and a minister's son who studied law at university but cultivated wide-ranging interests in many other fields, most importantly in mathematics. He formed acquaintances with many of the leading thinkers of his time, including the Bernouillis, Euler, and Leibnitz, whom he met during his extended travels in Europe, and he maintained an active correspondence that lasted through his lifetime. He served as Secretary of the Academy of Sciences in St Petersburg, and during that time, in 1742, he first communicated to Euler the supposition that any even integer greater than two is the sum of two prime numbers. Additionally, any odd integer is the sum of three primes. Goldbach's conjecture, as it is called, has not been proved absolutely, though it has been found to hold for ever larger numbers. . The most convincing proof so far was provided by the Chinese mathematician Chen Jing-run (1933-1996) in 1965 and is expressed by the inequality at the top of the stamp at left. This stamp was issued in 1999 by China as part of a set of four science and technology motifs and shows the late Chen in profile. For a detailed description of this stamp and

extensive background on the Goldbach conjecture, see [Mathematische Philatelie] under Goldbach-Vermutung.

Gaspard Monge (1745-1818) was the most influential French mathematician of the late 18th century, but also active in other scientific fields, such as physics and chemistry. He was elected to the Academie des Sciences and contributed many memoirs on diverse subjects such as double refraction, finite difference equations, partial differential equations, meteorology, metallurgy and the composition of nitrous oxide. He was an examiner of naval cadets whose teaching and education he reformed during the French Revolution. The naval colleges were essentially the only schools offering training in the sciences, and to further this type of education Monge was instrumental in the establishment of the the Ecole Polytechnique in 1794, where he was a famous professor. His treatises in descriptive geometry, some of them written for his students and published in the Travaux of the Ecole, contributed to the increased interest in, and flourishing of, that field in the 19th century. Monge participated in Napoleon's campaign in Egypt, where he studied atmospheric effects such as mirages, as well as metallurgy. His important chemical research dealt with the composition of water, which he was able to synthesize at about the same time as Lavoisier. He also achieved the liquifaction of a gas, sulfur dioxide.

Joseph-Louis Lagrange (1736-1813) worked in analysis, number theory, and celestial mechanics. He succeeded Euler at the Academy of Science in Berlin, but then moved on to the Paris Academy of Science. He was a co-founder of the

	Ecole Polytechnique, where he taught analysis. His major work is *Mecanique analytique*, applying analytical methods to the subject of mechanics. (Detail)

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Mathematics & Computation III

The roots of any

algebraic equation are complex numbers which can be depicted as labeling points in what is called the complex plane. Proof of the fundamental theorem of algebra was only one of the many achievements of **Carl Friedrich Gauss** (1777-1855), the "Prince of Mathematics." The Gaussian distribution and the magnetic unit gauss bear his name. (Detail) His construction of an equilateral 17-sided polygon inside a circle with only straight edge and compass, the first such new construction since Greek times, is the subject of this East German stamp.

Augustin Cauchy (1789-1857) was a prolific mathematician whose 200th birthday is commemorated on this French stamp. Besides his portrait, we see the Cauchy integral formula at right: the Cauchy integral of a regular analytic function f(z) of a complex variable is evaluated along a closed, smooth curve L in a domain D. Several paths are indicated, all enclosing the pole a. The value of these contour integrals is f(a) while contour integrals of a function not enclosing a pole are all equal to zero. On the left side of the stamp is another type of Cauchy integral, this time of a real variable, x. The function is a parabola, y=x2, and the definite integral is over the span -1=< x =<+1. It can be written as a limit as the increments along the x axis approach 0. (Detail)

The significant contributions of **Evariste Galois** (1811-1832) to the foundation of group theory were not widely recognized until many years after his untimely death in a duel in 1832. On the eve of his death he entrusted a resume of the mathematical ideas and writings that occopied his mind, including the discovery of the connection of the theory of groups with the solution of equations by radicals, to his friend Auguste Chevalier. Not until 1846 were these collected writings published by Liouville in th e *Journal de Mathematiques Pures et Appliquees*. (Detail)

Nikolai Lobachevsky (1792-1856) was a Russian mathematician who published the first non-Euclidean geometry, which does not make use of Euclid's fifth postulate, but treats Euclidian geometry as a special case. (Detail) The Lobachevskian plane, in accordance with Poincare's conformal mapping, is shown on the Finnish stamp at the head of this chapter. It is presented as interior of a circle, and lines are represented by arcs of circles orthogonal to the main circle .

Janos Bolyai (1802-1860)

was a gifted young Hungarian mathematician who also gave thought to Euclid's geometry and came up with another system of non-Euclidean geometry while still in his twenties. He did not publish this, however, because through his father Farkas Bolyai, a friend of Gauss's, he heard that Gauss had "been there, done that", so to speak, without actually publishing. This claim by the great Prince of Mathematics was enough to discourage young Janos, but his treatise was nevertheless published later by his father in 1832.

Friedrich Wilhelm Bessel (1784-1846) was a German astronomer and mathematician who is

remembered for the functions bearing his name; the Bessel functions of first and second order appear on this German stamp. (Detail) Bessel was the first to measure the parallax of a star (Cygni 61) in 1838, thus making it possible to calculate its distance. Observing the motions of the stars Sirius and Procyon, he deduced that each was orbiting around another, dark star. These dark stars were later found to be white dwarfs.

August Ferdinand Moebius (1790-1868), another astronomer and mathematician, was one of the founders of topology. His Moebius strip is a strip whose ends are joined after giving it a half twist; it has only one side and one edge, and here promotes a mathematical congress in Brazil. (Detail)

Charles Babbage (1792-1871) was responsible for the invention of an early antecedent of the modern computer, the analytical engine. There was much interest in calculating devices in his time, but the technology to make the analytical engine work was not yet available. (Detail)

Niels Henrik Abel (1802-1829) was a

Norwegian mathematician of great talent whose work was in analysis and elliptic functions. He proved that it was impossible to solve algebraically an equation of the fifth degree. Always poor, he died of tuberculosis at an early age, just before the news of an important appointment in Berlin could reach him. (Detail)

Sir William Rowan

Hamilton (1805-1865) was an Irish mathematician who devised a non-commutative four-dimensional algebra of quaternions, or hypercomplex numbers. Their importance lay in their applications in geometry and mathematical physics, leading to vector theory. The Irish stamp at left shows Hamilton's rules for multiplication of quaternions. (Detail)

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SCI-PHILATELY

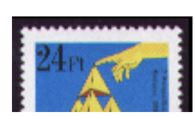
A SELECTIVE HISTORY OF SCIENCE ON STAMPS

Mathematics & Computation IV

Sonia Kovalevskaya (1850-1891) was born into a noble Russian family and due to her gender had to overcome many obstacles in order to pursue her interest in mathematics. Barred from matriculating at Heidelberg, she audited lectures and later studied privately with Weierstrass, receiving a doctorate (in absentia) from Goettingen for an important paper on partial differential equations. Still, academic appointments eluded her. In 1884 she did obtain a position in Stockholm, thereafter winning honors and prizes, including the Prix Bordin in France. (Detail)

Pafnuty Lvovich Chebyshev (1821-1894) was a Russian mathematician working in number theory, particularly with prime numbers. (Detail)

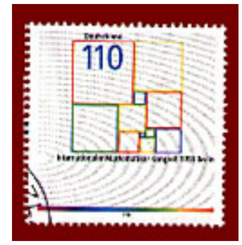
Srinivasa Ramanujan (1887-1920) was an Indian mathematician who was largely self-taught, deriving independently some work of Gauss and Riemann. G.H. Hardy at Cambridge sponsored the brilliant young mathematician, whose notebooks of original discoveries are being published and are a source of inspiration to other mathematicians. (Detail)



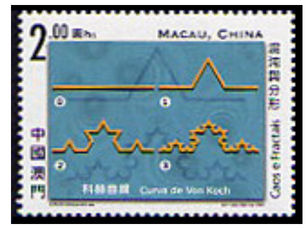
Waclaw Sierpinski (1882-1969), a Polish mathematician working in number theory and set theory, described the self-repeating, or fractal design shown on the Macau and Finnish stamps at left. Sierpinski triangles are created by connecting the the midpoints of the sides of a triangle to form four smaller, interior triangles, and then repeating this process for each of the outside three triangles, ad infinitum. A Hungarian stamp commemorating a mathematical congress shows a design of Sierpinski pyramids, with Michelangelo's hand of God from the Sistine Chapel ceiling thrown in for good measure. A full description of the Polish School of Mathematics appears here.

Some of its illustrious members included in a set with Sierpinski are **Stanislaw Zaremba** (1863-1942), **Stefan Banach** (1892-1945), and **Zygmunt Janiszewski** (1888-1920).

Stamps commemorating mathematical congresses often use eye-catching figures to draw attention. The Austrian stamp shows Escher's impossible cube. The German stamp issued for the International Congress of Mathematicians held in Berlin in 1998 shows the constant **pi** calculated to ever increasing accuracy and spiraling outward. (Detail)



The World Mathematical Year 2000 was observed in many countries with postage stamps picturing significant theorems or relationships of a mathematical nature. The Belgian stamp at left shows a circle, the bell shape of the Gaussian distribution, Stokes' theorem, Fermat's last theorem valid for n=2, and some white scratch marks at the bottom the stamp which should not be ignored. They are marks found on the Bone of Ishango, a 6,000 to 30,000 year old artifact discovered in the 30's by a geologist in Congo. The numbers of the notches display certain mathematical relationships, such as multiplication by 2, as well as addition. The bone now resides in the Belgian Museum of Natural Sciences in Brussels, and was considered significant enough in the history of mathematics to be included on the Belgian stamp.



One example of a

fractal is the "snowflake" curve constructed by taking an equilateral triangle and repeatedly erecting smaller equilateral triangles on the middle third of the progressively smaller sides. Theoretically, the result would be a figure of finite area but with a perimeter of infinite length, consisting of an infinite number of vertices. In mathematical terms, such a curve cannot be differentiated. The Swedish mathematician Helge von Koch created this curve 100 years ago. Four such iterations are shown on the right snowflake (three on the left) but cannot be distinguished with this low magnification. (Encarta) The Macau stamp is part of a set on chaos and fractals.

Chemistry I

Joseph Priestley (1733-1804) was a great experimental chemist, but in his own mind more importantly a minister, theologian, and educator. He was persecuted for his political and religious views to the point that he had to leave England and emigrate to the United States, where he spent the last ten years of his life. His important work with gases included the preparation of oxygen, the discovery of ammonia, sulfur dioxide, carbon monoxide, nitric oxide, and hydrogen sulfide.

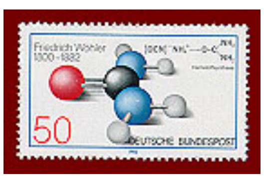
Antoine Laurent Lavoisier (1743-94)(Detail) was a French chemist whose work in combustion showed that substances gain weight when

	burned, and the air they burn in loses weight, now known as the law of conservation of mass. He stated that air was composed of two gases, one of which supported combustion (Priestley's oxygen) and the other of which was inert, nitrogen. He made a list of elements then known and started the practice to name compounds after their constituent parts. His life was cut short by the guillotine during the French Revolution.
	**Joseph Louis Gay-Lussac** (1778-1850) studied the properties of gases. Hot air ballooning was becoming a popular activity and Gay-Lussac availed himself of the new technology. He found, after balloon ascents, that the composition of the air at high altitudes is the same as at sea level, and that the earth's magnetic field remains constant with altitude. He also discovered that different gases expand by the same amount for the same rise in temperature (Gay-Lussac's Law).
	Amedeo Avogadro (1776-1856) took Gay-Lussac's Law one step further. He stated one of the basic concepts of modern chemistry

	in his Law, that equal volumes of gases at the same temperature and pressure contain equal numbers of molecules. The very small print and the crowded text on this Italian commemorative (Detail) may suggest a large (Avogadro's) number of molecules confined to some small space.
	**Jons Jakob Berzelius** (1779-1848), a Swedish chemist, devised the symbolic language of chemistry, designating each element by the first letter(s) of its Latin name. He measured atomic weights and advanced the idea of radicals, and was the influential author of a textbook and annual reviews of chemical progress.
	**Johan Gadolin** (1760-1852) was a Finnish chemist who in the late 18th century experimented with a mineral from Ytterby, Sweden, which contained new, uncommon oxides, or "earths." Over the next century other investigators were able to identify more than a dozen unknown elements contained in this rare earth, which were called lanthanides. Lecoq

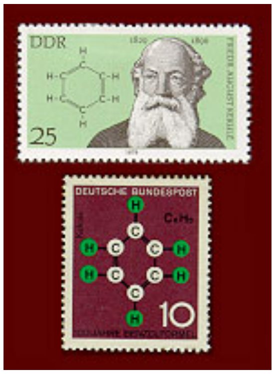
de Boisbaudran, himself the discoverer of gallium, named one of the rare earths to honor Gadolin: this was gadolinium.

Justus von Liebig (1803-1873) worked in quantitative organic analysis and was the great chemistry teacher of the 19th century. He founded a laboratory in Giessen where research methods were taught. His research into chemical fertilizers earns him a spot on the East German stamp on the right.



Friedrich Wohler (1800-1882) was a German chemist who first synthesized a natural product, urea. As shown on the stamp, ammonium cyanate decomposes when heated into urea. Wohler originated many analytical procedures, isolating boron and silicon, among others. A collaborator of Liebig's, he also edited *Annalen der Chemie.*

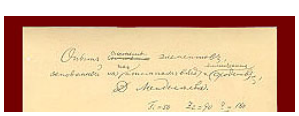
Friedrich August Kekule von Stradonitz (1829-1896) was a German chemist who investigated chemical bonds, suggested that



carbon was tetravalent, and proposed a ring structure for benzene. He introduced the convention of using the term organic chemistry generally for the chemistry of carbon compounds; this term had previously been reserved for compounds of living matter.

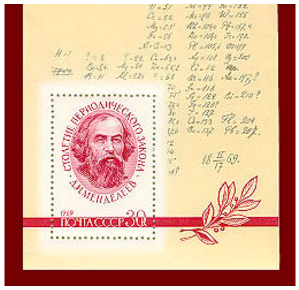
Chemistry II

Like many Russians, **Nikolai Zinin** (1812-1880) looked to western Europe for the latest scientific thought. He worked with Liebig in Giessen and later took his degree in Russia. He is known for his research on reduction of nitro compounds into amino derivatives, specifically nitrobenzene into aniline, the compound shown on the Russian stamp. This work was important for the development of the aniline dye industry.



The periodic table of elements as we know it today was the inspired work of **Dmitri Ivanovich Mendeleyev** (1834-1907). His generalization of sequences of atomic weights and properties

of elements, data already known to other scientists and arranged systematically by them, was more than a convenient scheme positioning the elements as they were then known; it represented to him a "law of nature."



(Click for detailed view)

containing gaps for elements yet undiscovered, and predicting their existence. Some of these elements were soon found, and had indeed the properties predicted by Mendeleyev: gallium and scandium.

The following profiles of chemistry Nobel laureates are not chronologically arranged but follow the order of the stamps in this very attractive booklet from Sweden. All were Swedish nationals, though some were foreign-born.

Arne Tiselius (1902-71) was proficient not only in physical chemistry, but biochemistry and some areas of medicine as well. He developed methods of analysis by adsorption particularly of colorless substances, and was awarded the 1948 Nobel prize in chemistry "for his research on electrophoresis and adsorption analysis, especially for his discoveries concerning the complex nature of the serum proteins."

Born in Hungary, **George de Hevesy** (1885-1966) worked and studied with many notable scientists, among them Haber and Rutherford. He discovered the element hafnium with Coster while at

the Institute for Theoretical Physics (Niels Bohr Institute) in Copenhagen. His most important work was "on the use of isotopes as tracers in the study of chemical processes." These processes were both in chemical reactions and also in living tissue, human and animal. Following the lead of Irene Joliot-Curie, he produced radio isotopes of phosphorus and sulfur by alpha bombardment. The Nobel prize in chemistry was awarded to him in 1943.

Svante Arrhenius (1859-1927) received the 1903 Nobel prize in chemistry "in recognition of the extraordinary services he has rendered to the advancement of chemistry by his electrolytic theory of dissociation." This theory (Berzelius' electrochemical theory revisited) dealt with the dissociation of salts in solution into positively and negatively charged ions which were able to conduct a current over a potential drop. The extent of dissociation of a substance determines its value as an electrolyte.

Theodor Svedberg (1884-1971) developed the ultracentrifuge by which colloidal dispersions could be evaluated for particle size. The progressive distribution of increasingly large particles within the extremely rapidly whirling solution could be observed and recorded photographically. For this research on dispersions he received the 1926 Nobel prize in chemistry.

Hans von Euler-Chelpin

Hans von Euler-Chelpin (1873-1964) shared the 1929 Nobel prize in chemistry with Sir Arthur Harden of Great Britain "for their investigations on the fermentation of sugar and fermentative enzymes." The fermentation process had already been investigated by Liebig and Pasteur but the contribution of enzymes in the creation of alcohol was here recognized. On the stamp, a large sugar molecule results in a smaller ethanol molecule.

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A SELECTIVE HISTORY OF SCIENCE ON STAMPS

Chemistry III

While celebrating its centenary in 1977, the Royal Institute of Chemistry of Great Britain shared honors with English Nobel prize winners in chemistry and physics on these stamps: William Henry Bragg and William Lawrence Bragg, for their analysis of crystal structure by means of X-rays and their X-ray spectrometer; **Archer Martin** (1910-) and **Richard Synge** (1914-94), for their invention of partition chromatography; **Walter Haworth** (1883-1950), for research on carbohydrates and the synthesis of vitamin C; and **Derek Barton** (1918-), for his work in conformational analysis of steroids.

Louis Pasteur (1822-1895) advanced the field of stereochemistry with his studies of optical isomers and methods of separating them. He went on to develop vaccines for rabies and anthrax, and the process now known as pasteurization, in which microorganisms which cause spoilage of products such as wine or milk are killed by the application of heat. His work helped to disprove the theory of spontaneous generation, which was still current in the 1860's: it was believed that living organisms could spontaneously arise from inanimate matter, such as maggots from meat. Pasteur excluded invisible airborne organisms from samples by means of S-shaped necks on flasks.

Leo Hendrik Baekeland (1863-1944) was a Belgian inventor who worked in the United States. From phenol and formaldehyde he developed the first plastic impervious to heat, water, and solvents which he called bakelite. This substance had important applications in electronics and the automotive industry, and was followed by the countless number of synthetic plastics in use today.

Victor Grignard (1871-1935) was a French mathematician turned organic chemist. His investigation of organomagnesium compounds led to his discovery of the so-called Grignard reagents, compounds useful in the synthesis of hydrocarbons, alcohols, ketones, aldehydes, ethers, and more. For this achievement he shared the 1912 Nobel prize in chemistry with Paul Sabatier.

Paul Sabatier (1854-1941) discovered the catalytic effect of finely ground metals on organic reactions, leading to the hydrogenation of organic compounds (for example, margarine). This work was important for many industrial processes, and resulted in the award of the shared 1912 Nobel prize in

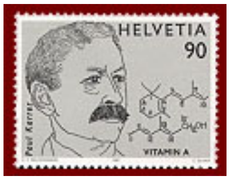
	1912 Nobel prize in chemistry for Sabatier.
	**Ernest Solvay** (1838-1922) was a Belgian industrial chemist who originated the Solvay process for the manufacture of sodium carbonate (soda ash) from salt, ammonia, carbon dioxide and limestone by an ingenious sequence of reactions involving recovery and reuse of practically all the ammonia and part of the carbon dioxide. He became very wealthy from his many patents and founded international institutes for research in chemistry, physics, and sociology.
	**Friedrich Wilhelm Ostwald** (1853-1932) received the 1909 Nobel prize in chemistry "in recognition of his work on catalysis and for his investigations into the fundamental principles governing chemical equilibria and rates of reaction."

Chemistry IV

Walther Nernst (1864-1941) won the Nobel prize in chemistry in recognition of his work in thermochemistry. His work at low temperatures resulted in his heat theorem - the Third Law of Thermodynamics. As entropy changes approach zero near absolute zero, it becomes impossible to reach this temperature, even by an infinite number of steps. Nernst also developed an electric lamp based on rare earth and magnesium filaments that did not need a vacuum to sustain its glow. This bulb is shown next to his portrait on the stamp.

Fritz

Haber (1868-1934) found a solution to the problem of dwindling nitrate deposits in Chile, which were used in the manufacture of fertilizers. He received the 1918 Nobel prize in chemistry "for the synthesis of ammonia from its elements" by subjecting hydrogen and nitrogen to high pressure in the presence of a catalyst. On the industrial scale this resulted in the Haber-Bosch process.



This Swiss stamp and a similar one honoring Alfred Nobel himself were a joint issue of Sweden and Switzerland in 1997. Swiss chemist **Paul Karrer's** (1889-1971) research was in the chemistry of natural products, particularly carotinoids and flavins. He isolated vitamin A and determined its structure, the first vitamin so identified. Likewise, he identified vitamin B2 and was able to synthesize it. He shared the 1937 Nobel prize for chemistry with W. N. Haworth of England (see above, Royal Society of Chemistry).

Willard Frank Libby (1908-1980) won the 1960 Nobel prize in chemistry for discovering a technique for dating objects of biological origin and used in archaeology and other sciences by measuring the decay of radioactive carbon 14 which they contain. This isotope is continually being created by gamma radiation of nitrogen in the upper atmosphere, and it decays with a half-life of 5700 years. A tiny fraction of the carbon in the atmosphere, it quickly forms carbon dioxide and is equally assimilated by living organisms such as organisms such as trees. However, when an organism dies, its exchange of carbon dioxide with the atmosphere ceases, and the fraction of carbon 14 in its molecular structure starts to decrease. The time period from its death can then be calculated from the carbon decay in comparison to that of a living specimen. Unlike many other Nobel prize winning discoveries, this one is simple to grasp and yet is a powerful tool in verifying age of natural remains. The stamp shows the exponential decay curve of carbon 14, an archaeological dig, and the head of a mummy.

Guilio Natta (1903-1979) and **Karl Ziegler** (1898-1973) shared the 1963 Nobel prize in chemistry and now this Swedish stamp for their work in polymer and organometallic chemistry. Ziegler was able to polymerize ethylene under ambient conditions with trialkyl aluminum and titanium chloride as catalysts, which had important applications for the plastics industry. Natta went one step further from Ziegler's research to achieve the stereo-regular polymerization of propylene, butene-1, and styrene. Stereo-regular polymers had been found in nature, but as yet not produced in the laboratory. Such a chain, regular in the stereochemical configurations of its repeat units, is shown on the stamp beneath the spider's web, whose silk is itself a polyalanine, with a certain amount of randomness and not simple repeats in its structure.

Ilya Prigogine (1917-), a Russian-born Belgian chemist, received the 1977 Nobel prize in chemistry for theoretical work on "dissipative structures" by applying thermodynamics and statistical mechanics to non-equilibrium, irreversible processes and systems. Prigogine showed that this new form of ordered structures can exist under conditions far from thermodynamic equilibrium, but only in symbiosis with their environment. For these, entropy and disorder increase in the real world, but they remain themselves internally highly ordered as systems. This Swedish stamp is a fascinating allegory of this theory; the horses in their environment are such "dissipative structures."

The design on the British stamp at left looks suspiciously like a soccer ball, known to inspire passion and riots among fans of the sport. As such it predates by many years its alternate incarnations both as the geodesic dome designed for the 1967 Montreal Exhibition by architect Buckminster

Fuller, and as a newly discovered molecular structure for the element Carbon. While Carbon in the form of graphite and diamond has been around forever, it was not known that it could also form completely closed ball-shaped stable structures of 60 or more atoms in just such a pattern as the soccer ball. The discoverers, Robert F. Curl, Jr. and Richard E. Smalley, both of the USA, and Harold W. Kroto of the UK won the 1996 Nobel prize in Chemistry for creating and describing these molecules they called Buckminsterfullerenes, in honor of the architect, fullerenes for short, or informally, buckyballs. The British stamp was issued in celebration of the 100th anniversary of the Nobel prizes, in 2001.

On this stamp from Upper Volta (Burkina Faso) **Linus Pauling** (1901-1994) is commemorated for his Nobel prize in chemistry in 1954, "for the study of the nature of the chemical bond and the determination of the structure of molecules and crystals." But in the background, behind the (inaccurately drawn) resonance structures of the benzene molecule, a vast fireball is rising, introducing a jarring element into the stamp design. Why this strange admixture? Pauling was deeply involved in the peace movement and campaigned ceaselessly, "not only against nuclear weapons tests, not only against the spread of these armaments, not only against their very use, but against all warfare as a means of solving international conflicts." So, in effect, this stamp not only celebrates Pauling's 1954 Nobel prize in chemistry, but his 1962 Nobel prize for Peace as well. The US caught up with a Pauling stamp in 2008, noting his work with hemoglobin in the study of sickle cell disease.

Ozone was discovered and named by German chemist **Christian Schönbein** (1799-1868), although others before him had no doubt smelled this acrid gas created by electric discharges, such as lightning, from the dissociation of oxygen into atoms and their subsequent recombination into the ozone O3 molecule. Most ozone resides in a thin layer in the lower stratosphere, 10-50 km above the earth. Here solar ultraviolet radiation creates the free oxygen necessary to form the gas. The ozone layer protects the earth from harmful UV radiation; its destruction would have dire consequences for life on earth. However, the use of chlorofluorocarbons (CFC), such as freon, in industry has brought about just such a scenario. The ozone layer is being depleted through a catalytic reaction involving CFCs, where a single halide atom can combine repeatedly with ozone thousands of times. Mexican chemist Mario Molina and American Sherwood Rowland first described this reaction, shown on the Mexican stamp, and won the Nobel chemistry prize in 1995, along with Paul Crutzen of the Netherlands. The ozone depletion is most severe over the polar regions, where growing holes are found.

Dorothy Hodgkin (1910-1994) was a British chemist specializing in crystallography who discovered the structure of penicillin, insulin, and vitamin B12, winning the Nobel prize for chemistry in 1972. Her crystallographic studies of DNA were instrumental in the discovery of its structure by Crick, Watson, and Wilkins.

Evolution and the Fossil Record

A convincing argument for evolution can be made from the fossilized, extinct life forms found in rock formations, whose age can be determined. Darwin likened these remains to the dropped, decayed branches of the great tree of life, which fill the crust of the earth; these are whole families and genera of which there are now no living representatives. Meanwhile, the living branches and twigs, or species, continue to branch out and cover the earth with ever greater ramifications. Although there were competing theories of evolution in the 19th century, the most successful of these was launched with the 1859 publication of Charles Darwin's *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (the title says it all). **Darwin** (1809-1882) developed many of his ideas for *Origin of Species* from observations on a five-year voyage of scientific exploration on the H.M.S. Beagle. The British stamps above hint at quirks of evolution of the exotic fauna he encountered in the Galapagos Islands, where isolation from the mainland and other continents brought forth specialized beaks in finches, among other developments.

Alfred Russel Wallace (1823-1913) was a British naturalist who developed a theory of evolution by natural selection independently from Darwin, based on his travel observations as a collector and purveyor of animal specimens. His communications with Darwin, which included a paper on evolution, stimulated the latter to hasten his publication of the Origin of Species. Wallace was an authority on the geographic distribution of species around the world and the effects of features such as landbridges. He noted the abrupt separation of Asian species from those of Australia by an imaginary line running through a deep ocean channel between the islands of Borneo and Sulawesi and through the Lombok Strait, now known as the Wallace Line.

Eohippus, a primitive four-toed horse of Europe and North America, is the oldest fossil record of the evolution of the horse family. This dog-sized animal dates back to the lower Eocene period, or 50 million years ago. The German stamp shows a German fossil; the U.S. stamp, an artist's conception of the animal that roamed this country. The companion stamp to the little horse shows a fossil bat.

Archaeopteryx (above, bottom row, center), the most ancient type of fossil bird yet discovered, dates from the upper Jurassic period, or 160 million years ago. The fossil has a reptilian skull and tail, somewhat like those of the pterodactyl shown at right in the row above. The ubiquitous trilobite appears on many stamps; it is a common, small, and easily recognized fossil.

Prehistoric life in Canada is depicted on this block:

trilobite (Cambrian)
sea scorpion (Silurian)
fossil algae (Precambrian)
soft invertebrate (Cambrian)

Dinosaurs have been extinct for the last 60-odd million years, but they are now all the rage in movies, books, toys, and also on stamps, as more and more fossils are uncovered. Many countries have issued stamps featuring skeletons, or startling "true-to-life" artists' renditions to satisfy the popular interest. These Lesotho stamps retain some of the mystery surrounding these large beasts and their sudden demise, perhaps from a earth-meteor collision that caused catastrophic climatic changes and plunged our world into temporary darkness. Plateosaurus was a genus of moderate-sized chiefly bipedal Triassic (150 million years ago) saurischian dinosaurs whose fossilized footprints can be found in Lesotho, Africa.

While most of the fossils we encounter are of now extinct species, there is one which surprisingly turned up alive in the past century. Coelacanth fossils from about 360 million years predate the age of the dinosaurs, and this strange, primitive lobe-finned fish (fins that bring to mind the limbs of terrestrial animals) was thought to have become extinct with the giant reptiles about 80 million years ago. However, a specimen was caught in 1938 off the coast of South Africa and identified as a member of this genus, but it could not be completely preserved for further detailed study. Native fishermen in the area between the coast of East Africa and Madagascar, notably in the Comoro Islands, were alerted and delivered further catches of this rare fish which is virtually unchanged over millions of years. In 1998 a different species of coelacanths was discovered in Indonesia. These "living fossils" are thought to be the ancestors of terrestrial reptiles, or to share a common ancestor, such as the only other (now extinct) lobe-finned fishes, the Rhipidistia. When swimming, the fins of "old four-legs" do not move in unison as do the fins of a modern fish, but alternately, approximating the gait of quadrupeds (left front with right hind, right front with left hind leg). The South African stamp at left shows the rear view of this fish, being studied by a scientist in a small submarine.

Biology

Andreas Vesalius (1514-1564) of Belgium who flourished in Italy, chiefly in Padua, was the founder of modern anatomical science. He revived the dissection of human bodies as practiced in ancient Rome and Alexandria and described his findings precisely in classic Latin in his groundbreaking work, *De Humanis Corporis Fabrica*. This book was illustrated with woodcuts of the anatomist at work over a human corpse, surrounded by a mass of spectators, and by pictures of the musculature and skeleton, the venous and arterial systems. It set a standard for clarity and accuracy not previously achieved and was plagiarized extensively over the centuries.

William Harvey (1578-1657) was an English physician who had studied in Padua. He discovered the mechanisms of circulation of blood and the action of the heart and its various chambers. Considering the sheer volume of blood in the body, Harvey did not expect it could constantly be generated by the liver, as previously supposed. He explored the functioning of veins and arteries and laid to rest many other erroneous beliefs held since the time of Galen. His studies of embryos and chicks in the egg produced insights into the development of organs and limbs in the fetus.

Carolus Linnaeus (Carl von Linne, 1707-1778) had a medical education, receiving his doctorate in the Netherlands. Here he associated with **Hermann Boerhaave** (1668-1738) who was the pre-eminent teacher and professor of medicine at the University of Leyden. But Linne's interest lay more in identifying and classifying the flora and fauna of his native Sweden and the increasingly great numbers of foreign specimens brought to his attention. One of the great 18th century naturalists, he devised a binomial system of taxonomy that has endured to this day. Earlier naturalists had felt free to name specimens as they thought best described them. But besides assigning a species (for the specific organism) and a genus (for a group of similar organisms) Linne assigned each organism to a hierarchy of higher orders, classes, and kingdoms, based on ever more general shared physiological properties. Throughout his life he made lengthy collecting trips and walking tours in Sweden and Lapland, collecting plants and animals. He wrote accounts of these travels, which are the basis for the remarkable stamp booklet at the left. Descriptive phrases from his

the basis for the remarkable stamp booklet at the left. Descriptive phrases from his writings are inside the booklet cover. The sweep of the highlands, the diverse shorebird population, the high sandstone cliffs mentioned in his journals here come to life for the philatelist. Bedecked in furs, the young Linne posed in native Lapp costume for an artist after his first journey to Lapland. The twin flower, linnaea borealis, was Linne's favorite flower (red stamp).

Jean Henri Fabre (1823-1915) was a French entomologist and writer who studied insect behavior and wrote *Marvels of the Insect World, Life of the Spider* and many other descriptions of insects.

August Krogh (1874-1949), Danish physiologist, showed that diffusion is the process by which oxygen passes through capillary walls into tissue. As muscles respond to a stimulus and

more oxygen is needed, more capillaries open up to provide extra blood flow and with it oxygen to the muscle. For this discovery of the capillary motor mechanism he was awarded the 1920 Nobel prize in Physiology.

Until the 19th century it was generally believed that disease could be transmitted through bad air (miasma), and that organisms could be spontaneously generated in it, causing disease. This idea was replaced by the germ theory of disease. Pasteur showed in experiments that microorganisms were present in air and not created, and that their action could be defeated by the application of heat or chemicals. Hungarian obstetrician **Ignaz Semmelweis** (1818-1885) showed that hand washing by attendant doctors prevented the spread of childbirth fever. Mindful of these observations, British surgeon **Joseph Lister** (1827-1912) fought the infection of postoperative wounds by applying carbolic acid (phenol) to tissue, surgical instruments, and bandages, reducing dramatically the occurrence of gangrene. He can be considered the father of antiseptic surgery. The British stamp above shows his carbolic spray apparatus. Listerine, the mouthwash, though named for Lister, does not contain phenol but alcohol and has other germ-fighting uses beyond an oral rinse.

Alexander Fleming (1881-1955) was a Scottish bacteriologist and physician. His accidental discovery of the mould penicillin in a culture of streptococcus revealed to him the antibacterial action of this organism which moreover was not harmful to living tissue. The Gabonese stamp displays the molecular structure of penicillin while commemorating the 50th anniversary of Fleming's discovery of antibiotics in 1928. Fleming shared the 1945 Nobel prize for medicine for this discovery.

Robert Koch (1843-1910) was a German bacteriologist who revolutionized the methods of culturing and staining bacterial organisms, and discovered the tubercle bacillus, the cause of tuberculosis. His study of the anthrax bacillus determined that its spores can survive in the ground for years, and he identified the cholera bacillus in victims of the disease in Africa and India, where he traveled to study other tropical diseases.

The biochemist **Otto Warburg** (1883-1970) worked on the problem of respiration of tissue, the role of enzymes in this process, and the metabolism of cancer. He received the 1931 Nobel Prize in medicine and physiology.

Karl Landsteiner (1868-1943), Austrian born biologist and physician, discovered the existence of different blood groups in the human body, and the fact that they were not always compatible, the transfusion of the wrong type of blood causing the destruction of the original cells by agglutination, or clumping. With Alexander Wiener he discovered the Rh factor in blood, and with Erwin Popper, the polio virus.

Frank Macfarlane Burnet (1899-1985), an

Australian, studied the mechanism of immunity and the formation of antibodies. He speculated that the ability to form antibodies in response to a foreign organism or protein in the body, which then combine with it and render it harmless, is not inborn but takes place soon after birth. Exposure to antigens of an embryo produced immunological tolerance. For this he shared the Nobel prize in medicine and physiology in 1960. His clonal selection theory of acquired immunity is of great importance for organ transplants. This Australian stamp is one of a set of four equally illegible issues crowded with text.

The scales of some fishes, such as these herring, have annular rings that can be counted to determine their age.

Heredity and the Genetic Code

Gregor Johann Mendel (1822-1884), an Austrian Augustinian monk and botanist, discovered the laws of heredity, and the basis of genetics, from his experiments with garden peas. His work, which was unknown to Darwin, supplied a mechanism for the inheritance of random variations. It was ignored during his lifetime and was not rediscovered until 1900.

The Swedish stamps above offer insights into the Nobel prize winning work done by the scientists listed below:

Thomas Hunt Morgan (1866-1945) was aware of Mendel's work, which had just been rediscovered, and performed his own genetic experiments, not with peas, but with fruit flies, which could reproduce rapidly and in great numbers and had only four pairs of chromosomes. He found that Mendel's Law of the independent assortment of characters was true, but that in some cases a linkage existed between characters. The extent of linkage between characters was a measure of their position, or nearness to each other, on the same chromosome. Mapping the genes and their positions in the chromosomes explained the range of Mendelian results. Morgan won the 1933 Nobel prize in physiology or medicine.

Francis Crick, James D. Watson, and Maurice Wilkins determined the molecular structure of DNA as a double helix or two intertwined spirals of phosphate and sugar molecules linked by pairs of organic bases. The sequences of the paired organic bases form the genetic code of an organism.
Doug Sutton raises the possibility that the x-ray picture in the background of this stamp may be "photo 51", and as such the only philatelic reference to the work of Rosalind Franklin, whose x-ray studies yielded the images that suggested the DNA structure to the prize recipients.
The double helix is an eye-catching symbol appearing on many stamps, including the Czech Mendel stamp above, and examples from Liechtenstein and Israel below.

Werner Arber (1929-), **Daniel Nathans** (1928-), and **Hamilton Smith** (1931-) received the 1978 Nobel prize in physiology or medicine for the "discovery of restriction enzymes and their application to problems of molecular genetics." They may be used to cut DNA into fragments. From these segments the sequence of genes in chromosomes may be studied, their structure may be analyzed, or the genes may be recombined in different order.

The **World Medical Association General Assembly** in Tokyo in 2004 features DNA as part of man's makeup on the stamp to the right.

Barbara McClintock's lifelong research interest was in the genetics of maize. She studied individual chromosomes and related them to the physical characteristics of the kernels on the cob, finding that changes in the color pattern of the kernels corresponded to the transposition of structural elements of the chromosomes, or "jumping genes." She made this discovery before the structure of DNA was known.

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Physics

Democritus (460-370 BC) was a Greek philosopher who advanced the theory that all matter consisted of tiny, indivisible and also invisible particles called atoms. These atoms are in constant motion and have properties that explain the physical characteristics of substances. They are eternal and cannot be created or destroyed. While this theory was discredited in Aristotelian thought, modern physics proved it accurate, though with many modifications: although atoms as building blocks of matter determine the characteristics of substances, they themselves are made up of even smaller subatomic particles.

Archimedes (3rd century BC) was the greatest mathematician of

the ancient world, and also an engineer. He discovered the principle of buoyancy as well as the principle of the lever. The equation governing the latter is shown on this Nicaraguan stamp. (Detail). Another invention attributed to him is the Screw of Archimedes, shown on the right. A cylinder containing a screw is placed in water, which is then transported to a higher level when the screw is turned. For more stamps, check out Stamps of Archimedes and also Mathematics and Computation I.

Otto von Guericke (1602-1686) was a German natural philosopher and writer who also became the mayor of Magdeburg. Inspired by the work of Torricelli and Galileo, he tried to create a vacuum and invented the air pump. He devised the astonishing spectacle of the Magdeburg Hemispheres, which brought him fame in his own time. Here two large metal hemispheres were joined together with a gasket and evacuated; two teams of horses pulling in opposite directions were unable to separate them. Once air was readmitted, they fell apart.

Evangelista Torricelli (1608-1647), the Italian

physicist and mathematician, is famous for his discovery of the principle of the barometer. He was Galileo's assistant until the latter's death. The unit Torr (1/760 of a standard atmosphere) bears his name. (Detail).

Robert Boyle (1627-91), British physicist and chemist, formulated Boyle's Law for an ideal gas: at constant temperature, pressure and volume are inversely proportional. With Robert Hooke, he developed an improved air

pump (shown on the stamp) based on von Guericke's designs. Boyle was foremost an experimentalist who recorded data so that experiments could be reproduced, in what is now called the scientific method.

Christiaan Huygens (1629-1695) was a key figure of 17th century physics, astronomy and mathematics. A member of the French Academy of Sciences and the Royal Society, he made many important discoveries. His telescopes had improved lenses of his own devising and surpassed those of his contemporaries. He was the first to see a moon of Saturn (Titan), and determine that Saturn had a ring. He constructed and patented the first pendulum clock to aid mariners in navigation, but the effects of a ship's motion defeated his purpose of dealing with the longitude problem. He was interested in games of chance and wrote the first book dealing with the theory of probability. He also advanced the wave theory of light.

Blaise Pascal (1623-62), the French philosopher

remembered by many college students of that language for his *Pensees*, was also a mathematician and physicist of note. He defended Toricelli's assertion that a vacuum existed in the enclosed end of a barometer, and that air had weight. He took a barometer up a mountain, demonstrating that air became thinner with altitude and therefore exerted less pressure to counterbalance a column of mercury. Pascal worked out the hydraulic principle, that pressure is transferred through a fluid in an enclosed container, and he also developed a calculating machine that was capable of adding and subtracting. Like for many other inventors of calculating devices, technical difficulties encountered here outweighed sound principles. (Detail).

In the late 18th century the Montgolfiere brothers, Joseph and Etienne, invented a working hot air balloon, making the first manned flight in 1783. But the hot air had to be continually fed and replenished by a fire on board, causing scorching and burning hazards. Simultaneously, hydrogen balloons were developed by the Robert brothers and Jacques Charles, also in France, and became the favored technology of ballooning. No fuel needed to be carried here, but the explosive nature of hydrogen   was a danger, too, devastatingly proved by the burning of the Hindenburg dirigible in Lakehurst, NJ in 1937. Tethered balloons were used in warfare to reconnoiter enemy positions, as in the Civil War by Union forces with the balloon Intrepid. In 1935 the helium-filled balloon Explorer II manned by the US Army Air Corps rose to an altitude of 74,000 feet, carrying instruments for atmospheric exploration. Helium did not have the lift of hydrogen, but was a safer medium, being an inert gas. **Auguste Antoine Piccard** (1884-1962) was a Swiss physicist and inventor. He built a pressurized gondola to make it possible to fly his hydrogen balloon above the atmosphere, eventually ascending to an altitude of above 16 km, where he collected data on cosmic rays.

James Watt (1736-1819) was a Scottish engineer who did not actually invent the steam engine, but devised such improvements to the existing Newcomen steam engine as to make it commercially useful. His invention converted reciprocal engine motion to rotary motion. In 1782 he Invented the double-acting engine. To rate his engines, he devised the term horsepower, a unit describing the work done by a horse (the usual source of energy at that time) in pound-foot/minute. The SI system unit of power is called the watt in his honor. He also invented, in 1767, an attachment that adapted telescopes for distance measurement. The Mali stamp shows the double-acting engine.

Austrian physicist **Christian Doppler** (1805-1853) derived the mathematical reliationship describing the change in the frequency of sound observed when source and receptor are moving relative to each other. We are familiar with the increasing pitch of a train whistle as the train approaches, and the decreasing pitch when it has passed and is moving away. The sound waves are crowded together and then strung apart. The same principle applies to electromagnetic waves, for example in astronomical observations of distant galaxies or other objects which show spectral shifts in their emission of light. Red shifts of galactic spectra indicate that the galaxy is moving away, a sign that the universe is expanding. The motion of weather systems can likewise be detected by constantly reflecting radio waves. The weather report references to Doppler radar are now commonplace.

The Austrian physicist and philosopher **Ernst Mach** (1838-1916) investigated the flight of projectiles both theoretically and photographically and noted the dynamic processes that occurred once the speed of sound was exceeded. His name lives on with the Mach number, the ratio of an object's speed to the speed of sound in the medium in which it travels. The first aircraft to achieve supersonic speed was the American X-1 rocket plane, piloted by Chuck Yager in

1947, built in Buffalo, NY, and shown on the stamp at right. Modern aircraft have traveled many times that speed, as have spacecraft.

The sonic boom, which can sometimes be heard, is due to the compressed sound waves ahead of the plane, intersecting with the ground below.

Leon Foucault (1819-68), the French physicist, is remembered for his pendulum experiment which proved the rotation of the earth. A very long pendulum is suspended and left to swing in the vertical plane containing the pendulum bob and the point of suspension. As the earth rotates beneath the bob, the plane of oscillation appears to rotate uniformly 2pi cos theta radians a day, where theta is the colatitude of that point on earth. Visitors to the United Nations in New York may observe just such a pendulum in the lobby. Foucault also successfully measured the speed of light by means of a system of rotating mirrors, and observed a bright yellow spectral line in an electric arc light at the exact position of the yellow lines observed by Fraunhofer.(Detail).

Heike

Kamerlingh Onnes (1853-1926) discovered superconductivity when studying the properties of substances at very low temperatures. He succeeded in liquifying helium by first cooling it with liquid air. In 1913 he received the Nobel prize in physics for his investigations. This work was continued by, among others, the Russian Piotr Kapitsa (1894-1984), who discovered a way to produce liquid helium by cooling it by periodic expansion. At 2.3 K, this

liquid changes into a new form, He II, with unusual properties: a superfluid with vanishing viscosity, a quantum fluid with zero quantum fluid with zero entropy. Kapitsa shared the 1978 Nobel prize in physics for his remarkable experimental and technical achievements in the study of superconductivity. See Penzias and Wilson.

K. E. Tsiolkovsky (1857-1935) was a self-trained Russian scientist who was a pioneer of space flight and rocketry. His writings, about liquid fuel and multi-stage rockets and space travel, predated the work of the American rocket engineer Robert Goddard and laid the foundation for the Russian space program launched with Sputnik in 1957. His "rocket formula" of 1903 on the stamp describes the increase in a rocket's velocity: (u-u0)/v=ln(M0/M), where u,u0 and M,M0 are initial and final velocity and mass of the rocket, respectively, and v is the velocity of the exhaust gases. On the stamp, inside the outline of a space capsule suspended from two parachutes, we see a blazing multi-stage rocket over the curved earth and a much enlarged outline of central America featuring Nicaragua. (Detail).

Modern Physics I

In the words of physicist Philip Morrison, "twentieth-century physics began about five years ahead of the century itself." The discovery of X-rays by Wilhelm Conrad Roentgen and Henri Becquerel's investigations of phosphorescent salts that fogged photographic plates whether or not they had been exposed to light ushered in the era of modern physics. Becquerel did not immediately realize that a previously unknown type of energy caused his so-called uranium rays - what Marie and Pierre Curie would call "radioactivity." Roentgen and the Curies appear on stamps from many countries around the world, whereas Bequerel did not capture the popular imagination, nor the attention of other than French postal authorities who decide whom to commemorate.

Wilhelm Conrad Roentgen (1845-1923) worked with cathode ray tubes and chemoluminescence. He discovered an invisible yet highly penetrating radiation which he called X-rays, and received the first Nobel prize in physics as a result. "Modern physics" had its beginning here. The year 1995, the centenary of his discovery, brought forth a spate of stamps from diverse countries, many of which show the striking skeletal image of Roentgen's wife's hand, with ring. Forever associated with radiology, and the medical applications of X-rays, Roentgen and his cathode ray tube have appeared on earlier issues as well.

Antoine Henri Becquerel (1852-1919) (Detail) was a French physicist whose research led him to the study of fluorescence in minerals. He discovered radioactivity when studying uranium compounds, which, unlike other fluorescent substances, fogged photographic plates even without having been exposed to strong light. He shared a Nobel prize for his discovery with Pierre and Marie Curie in 1903.

Marie Sklodowska Curie (1867-1934) was a double Nobel Prize winner, jointly with her husband Pierre (1859-1906) and Becquerel for the discovery of radiactivity in 1903, and by herself in

1911 for the discovery and isolation of radium. One of many stamps issued by her native Poland just emerging from the ravages of World War II dispenses with perforations. The Monaco stamp shows the cumbersome apparatus used to separate the raw ores from which radium was finally obtained. She is

also shown with a glowing bowl containing her discovery, and again holding a laboratory sample. Together, the Curies appear on a stamp of Central Africa with what appears to be a very active molecular cluster. The word "radioactive" was first used by Marie Curie to describe her observations, as published in *Comptes Rendus*.

Pierre Curie, (Detail) besides his work in radioactivity, was the discoverer of piezoelectricity. He also observed that permanent magnets lose their magnetic properties when heated above a critical temperature, which is called the Curie temperature.

Irene (1897-1956) and **Frederic Joliot-Curie** (1900-1958), daughter and son-in-law of the Curies, continued the study of radioactivity, producing artificial radioisotopes by alpha bombardment of aluminum and other light nuclei, and also shared a Nobel Prize in chemistry for this work. Frederic continued research on uranium fission and the accompanying production of neutrons. He became the leader of the French atomic energy program. After World War II, he had a deep concern for world peace, becoming the first president of the World Council for Peace.

Hendrik Antoon Lorentz (1853-1928)and his student Pieter Zeeman (1865-1943) shared the 1902 Nobel prize in physics for the investigation and explanation of what is now called the Zeeman effect: when a spectral source is placed in a magnetic field, the emission lines are found to be first broadened and then split into components as the magnetic field strength increases; moreover, the emitted light is polarized. Lorentz' theoretical work on the electromagnetic theory of light assumed that charged particles called electrons carry currents or transport electric charge, and their vibrations are the cause of electromagnetic waves. This

preceded the identification of the electron, for which J. J. Thomson received the 1906 Nobel prize. The effect of a magnetic field on the light emitted and spectroscopically analyzed conformed to Lorentz' theory, confirming the electromagnetic wave nature of light. Further mathematical achievements by Lorentz include the Lorentz transformations, which describe the motion of bodies at close to relativistic speeds, and appear in Einstein's special theory of relativity.

Johannes Stark (1874-1957) was able to demonstrate the splitting of atomic spectral lines due to an electric field, just as Zeeman had done with a magnetic field. However, the patterns are not symmetrical about the original line, as in the Zeeman effect, nor are the relationships between field strength and change in wave length quite as simple, making the Stark effect not a useful tool for spectral analysis. Stark won the Nobel prize in physics in 1919 for this discovery, as well as for the observation of the Doppler effect in radiation emitted by accelerated hydrogen atoms in

	a discharge tube.

Physics Index

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SCI-PHILATELY

A SELECTIVE HISTORY OF SCIENCE ON STAMPS

Modern Physics II

	Physicist **Josef Stefan** (1835-1893) was a native of Slovenia, then a part of the Austro-Hungarian Empire. He studied the relationship between black body radiation and temperature and found that the radiation was proportional to the fourth power of the object's temperature. This was later derived empirically by his student Boltzmann and is known as the Stefan-Boltzmann Law.
 	The Austrian physicist **Ludwig Boltzmann** (1844-1906)(Detail) developed and advanced the theories of thermodynamics, the kinetic theory of gases, and electromagnetism at a time when new discoveries about the structure of matter were being made. Boltzmann supposed that the behavior of gases depended on the movement of their atoms or molecules. From a consideration of the second law of thermodynamics he arrived at a mathematical formulation of the fact that equilibrium is the most probable state for a gas to achieve. As expressed by his famous equation,

entropy is proportional to the log of probability: the Boltzmann constant, k, is named after him. The Nicaraguan stamp (Detail) features an internal combustion engine as an application of kinetic theory. Boltzmann is also commemorated on the Austrian stamp bearing his likeness.

Max Planck (1858-1947) solved the dilemma of describing accurately the frequency distribution of radiation from a black body, a problem that had been approached from both the high (Wien) and low (Rayleigh) frequency ends, but with no apparent smooth overlap. Planck postulated that electromagnetic energy was not infinitely divisible, but existed in particles, or quanta, proportional to the frequency of the radiation. The Planck constant, h, in the exponent of the black body spectral distribution equation tamed the ultraviolet catastrophy to produce distribution curves such as shown in the Fraunhofer stamp of radiation from the sun. Planck received the 1918 Nobel prize in physics, and Einstein and Bohr applied quantum theory to the photoelectric effect and atomic structure, explaining away some baffling paradoxes of classical physics. The German stamp shows a black body emitting a quantized amount of energy, while the spectrum of this

	radiation appears continuous to the eye. Planck's constant also commemorates the anniversary of his death in 1947.
	Cathode rays were observed in vacuum tubes by many researchers in the late 19th century. When a voltage was applied to the two electrodes of such a tube, the glass near the positive terminal was observed to glow. These rays traveled in straight lines and cast a shadow of any object placed in their path. Their nature was not understood; were they particles or radiation? British physicist **J.J. Thomson** (1856-1940) by a series of ingenious experiments was able to show their corpuscular nature as minute negatively charged particles by deflecting their path by magnetic and electric fields. From measurements of their charge-to-mass ratio they were found to be more than a thousand times smaller than a hydrogen ion. Thomson received the 1906 Nobel prize in physics for this discovery of the electron. He proposed a model of the atom as a positive mass in which these electrons were embedded as raisins in a pudding; he appears on the left on this stamp. His model was modified by Rutherford, who showed that the positive mass of the atom was centered in a nucleus, and that the rest of the atom was mostly empty space

occupied by electrons.

Japanese physicist **Hantaro Nagakoa** (1865-1950) also proposed a model of the atom in 1904, with a massive nucleus circled by electrons distributed in rings, analogous to the rings around the planet Saturn. Although a nuclear model was later confirmed by Rutherford, the electron rings of Nagakoa's atom would have been unstable and he soon abandoned his theory. The world had to wait for Bohr's theory of the hydrogen atom to understand the stability of electrons inside the atom.

Ernest Rutherford (1871-1937)(Detail) worked with radioactivity, which he found to be of different kinds, distinguishing between positive, or alpha rays, and negative, or beta rays. In this work he was assisted by the German physicist Hans Geiger ( ), with whom he devised an instrument to detect

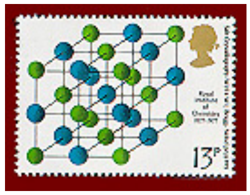
and count these particles. The instrument consisted of a tube containing gas with a wire at high voltage along the axis. Each particle entering the tube ionized some gas, causing an electron avalance and a measurable pulse, or click. He discovered that the alpha particles were helium nuclei. By 1909, Geiger and E Marsden used alpha particles to bombard very thin metal foils. Sometimes the alpha particles were scattered backward as if repelled by other positive charges; this led Rutherford to propose the theory of a nuclear atom, containing a very small positive nucleus, surrounded by negatively charged electrons and a great deal of empty space. In 1928 Geiger and W. Muller designed an improved counter to measure radioactivity, the Geiger- Muller counter.

Danish physicist **Niels Bohr** (1885-1962) (Detail) won the Nobel prize in physics for his model of the hydrogen atom, in which the electron occupied discrete energy levels, or orbits, around the nucleus, and radiated or absorbed energy only when moving between energy levels,

whereas classical theory predicted that an orbiting electron (a moving charge) should radiate energy continuously. This model of circular orbits was able to account for the major series of the hydrogen spectrum, but it was left to Sommerfeld to explain its fine structure by adding elliptic orbits to the model, resulting in the Bohr- Sommerfeld atom. Bohr is commemorated with circular electron orbits on the Swedish stamp but with an elliptic orbit on the Danish stamp, which also indicates the quantized nature of the energy transition between orbits. The stamp showing Bohr and his wife on a garden bench enjoys some minor fame because the bench only has three legs.

Max von Laue (1879-1960) (Detail) postulated that diffraction of X-rays in a crystal might occur if lattice spacing and X-ray wavelength were of the same order of magnitude. Patterns such as those on the stamps were obtained experimentally, proof of the periodic structure of crystals and the wave nature of X-rays, and sufficient to win him the 1914 Nobel physics prize only two years after successful experiments.

Sir William Henry Bragg (1862-1942)



and Sir William Lawrence Bragg (1890-1971), father and son, were intensely interested in the X-ray diffraction work done by von Laue. They used his discovery to study crystal structure and developed the X-ray spectrometer. Their Nobel prize in physics followed von Laue's by a year, in 1915. The Royal Institute of Chemistry stamp shows the crystal structure of salt, as determined by WLB, and used by WHB to determine X-ray wavelengths.

Modern Physics III

Albert Einstein's (1879-1955) name is associated with the general and special theories of relativity, but his explanation of the photoelectric effect, a phenomenon which could not be accounted for by electromagnetic wave theory, won him the Nobel prize in physics. He proposed a corpuscular model of radiation as the photoelectric mechanism. Light travels in quanta (or photons) and must be of a certain threshhold energy (or color) to cause the emission of electrons from a given surface, while its intensity determines only the number of electrons so released. This German stamp shows electrons escaping at random angles while light strikes the surface.

Einstein's law E=mc2 is shown on Nicaragua Scott 879 and features a stylized mushroom cloud generally associated with a nuclear bomb explosion. Inside the mushroom cap appears a beryllium atom with four electrons orbiting a nucleus of four protons and five neutrons. "Beryllium is a highly efficient generator of neutrons when bombarded with alpha particles. It may serve as a source of neutrons to initiate the nuclear fission within the fuel nucleus of a reactor." (*Gmelin Handbook* Be Suppl.vol. A1 p.124). At the base of the mushroom are roiling, churning clouds of debris as seen on actual photos of nuclear events. However, front and center in the picture is a prone white-draped figure being irradiated from upper left, watched by a technician behind a window to the right. This peaceful application of nuclear energy somewhat mitigates the stark symbolism of the mushroom cloud. The image of Einstein transcends

national boundaries; here are but a few impressions of his somber countenance.

The 14th International Conference on General Relativity and Gravitation was held in Florence in 1995 and was commemorated with this stamp. It shows the dome of Florence, Galileo, a pensive Einstein, and the general relativity field equation in its condensed form against a sky filled with constellations, among them Omega. G is the curvature of four-dimensional space-time, and T, a measure of the distribution and flow of energy and momentum, which is linked to the mass distribution. Gravity is no force but an aspect of the geometry of space-time. Space is not an absolute invariant entity, but is influenced by the distribution of mass and energy in the Universe. The basic field equation of general relativity therefore relates the curvature of space to the mass/energy density: G = k T. Galileo, who flourished in Florence, was aware of the principle of equivalence, central to Einstein's theory.

The word laser is an acronym for the

phrase "light amplification by stimulated emission of radiation". This is a process already predicted by Einstein in 1917, in which an atom in an excited energy state, when struck by a photon of the correct size (corresponding to the energy difference between the excited state and a lower or ground state) will emit just such a photon, which will travel in tandem with the original impinging photon. Now there are two photons where there was one before, and in effect,

the light has been amplified. Before the first laser was built by the physicist Theodore Maimam in 1960, the process was already used in the construction of the maser by Harold Lyons in 1949, amplifiying the natural vibrational frequency of the ammonia molecule, which lies in the microwave region of the spectrum, hence "m"aser. Since then, lasers have been built in many regions of the spectrum, of solid and gaseous materials, emitting continuous or pulsed radiation, which is monochromatic (since only one frequency is being excited) and can be collimated. High precision and intensity can be achieved by such beams, for example in surgery of the eye, as is pictured on the French stamp at left. Naturally occurring lasers have been observed in distant galaxies in the infrared, ultraviolet, and microwave regions.

While the invention of holography preceded the development of the laser, the technique never really came into its own until lasers were used to produce the coherent, monochromatic light necessary to create these novel representations of three-dimensional reality. While the light used in an ordinary photographic exposure is incoherent and registered only in its intensity on film, the reflection of coherent waves from different areas of an object preserves their phase and causes interference patterns that vary in intensity depending on the angle of observation. The Hungarian physicist Dennis Gabor developed the idea to let the light reflected from an object fall on a plate together with a light beam that had not been disturbed; the interference of these waves would recall the topography of the object. For this theory he received the 1971 Nobel prize in physics. The potential of holography in the examination of three-dimensional objects, including plasmas, is great, and holograms are can now be commonly seen on credit cards, and even postage stamps. This very beautiful British stamp shows a hologram of an atomic model of unknown species. Another stamp with a hologram is the German stamp

showing the impact of comet fragments on Jupiter.

This German stamp commemorates two Nobel laureates, friends for life, and expatriates. (Detail) Max Born's work in quantum mechanics, at a time when both Heisenberg and Schroedinger developed their formalisms, linked wave mechanics with probability by interpreting the square of the wave function as a probability density. His contributions were recognized with the Nobel prize in physics in 1954. James Franck received his prize in 1926, for the famous Franck-Hertz experiment, which is a photoelectric effect in reverse. Together with Gustav Hertz, nephew of Heinrich Hertz, Franck bombarded mercury vapor with electrons and found that the electron energy dropped sharply at a certain level. The atoms absorbed the kinetic energy of the electrons, emitting it then in the form of light as resonance radiation. This confirmed the existence of discrete energy levels in atoms according to Bohr's theory of the atom and validated Planck's quantum theory. Gustav Hertz' later work was in isotope separation by diffusion cascade diffusion cascade, used to produce enriched uranium, U235, among others.

Louis Victor de Broglie (1892-1987) demonstrated mathematically that elemenary particles should exhibit wave-like characteristics, just as under certain circumstances light waves assume the properties of particles. The relationship between mass, velocity, and wavelength of such a particle is shown on the French and Nicaraguan stamps. A diffraction pattern and electron microscope complete the picture on the latter. The wave-like behavior of electrons was subsequently demonstrated by Germer and Davisson in 1927, and de Broglie received the 1929 Nobel prize in physics. The Swedish stamp honoring de Broglie's achievement suggests the wave-particle duality by actual electron diffraction patterns in the shaded areas of the amplitude where the particle associated with the wave is more likely to be.

The

Austrian physicist **Erwin Schroedinger**

Erwin Schroedinger (1887-1961) (Detail) incorporated the wave nature of the electron suggested by de Broglie into the theory of the hydrogen atom, substituting standing waves to describe the likely whereabouts of the electron in favor of the Bohr-Sommerfeld orbits. These solutions to the Schrodinger wave equation are discrete in that they depend on an integral number of wavelengths to occur in a possible orbit so as not to cancel each other out. Two such electronic states, in which the hydrogen atom is in a stable position, are shown on the Swedish stamp.

Modern Physics IV

P.A.M. Dirac (1902-1984), the British mathematical physicist, shared the 1933 Nobel prize with Schroedinger. His theory of quantum mechanics was broad enough to encompass both wave and matrix mechanics. From purely mathematical considerations, he concluded that the electron could exist in two energy states, positive or negative, and hence that there should exist its antiparticle with a positive charge. Such a particle, the positron, was discovered in 1932 from cloud chamber photographs, where in a magnetic field the tracks of particles of opposite charges curve in opposite directions, as on this Swedish stamp. Since then other particles of antimatter have been observed, each having its corresponding mirror particle. By combining quantum mechanics with the special theory of relativity, Dirac was also able to explain the spin of the electron.

	**S. N. Bose** (1894-1974) the Indian Physicist was able to derive Planck's equation from quantum mechanics as applied to photons. His collaboration with Einstein produced Bose-Einstein statistics which have found wide application in describing the behavior of particles with zero or integral spin that are now known as bosons, as opposed to fermions (electrons, protons, etc.) Multiple bosons may occupy the same energy state; the Pauli exclusion principle does not apply.
	Physicist **Wolfgang Pauli** (1900-1958) (Detail) empirically made the connection between closed electron shells in an atom with the complex spectra observed in a strong magnetic field (the Zeeman effect of splitting of spectral lines). Already, three quantum numbers had been assigned to the electron in the Bohr-Sommerfeld model of the atom, and to these Pauli added a fourth. Moreover, he generalized that there can never be two or more equivalent electrons

with the same four quantum numbers in an atom, and this is known as the Pauli exclusion principle. While we now associate the fourth quantum number with the spin of the electron, this was not known in 1925 when Pauli published his conclusions. Since there are only so many permutations the sets of quantum numbers for a given Bohr orbit may have and still remain unique, the buildup of the periodic table of elements naturally follows. Pauli won the 1945 Nobel prize in physics for his work.

Physicist **Werner Heisenberg** (1901-1976) derived the uncertainty principle named after him, which states that the product of the changes in momentum and position of a particle must be greater than Planck's constant/2 pi, meaning that both its position and momentum cannot be known simultaneously with complete accuracy. He invented a matrix mechanics that was a non-commutative algebra of probability amplitudes. For this work he received the Nobel prize in physics in 1932.

Robert Millikan (1868-1953) (Detail) is one of the few American physicists honored by the U.S. Postal Service. His work on the measurement of the charge of the electron remained the most accurate one by far for many years. By means of his ingenious oil drop experiment, in which he balanced charged droplets between counteracting electric and gravitational fields, he was able to confirm the particle nature of the electron and its indivisible charge. He received the Nobel prize in physics in 1923.

Otto Hahn (1879-1968) (Detail) was successful in splitting the uranium atom, and anticipated the possible destructive use to which his discovery could be put, and would be; it eventually resulted in the construction of the atomic bomb. Hahn's assistant Fritz Strassmann is also mentioned on the middle stamp, which shows a schematic of a reactor core surrounded by the characteristic blue glow of Cerenkov radiation, but he did not share his 1944 Nobel prize in chemistry.

Lise Meitner (1878-1968) was Otto Hahn's collaborator for over thirty years until she had to leave Nazi Germany just before World War II and was replaced by Strassmann. A share of Hahn's Nobel prize eluded her, as well. She was, however, the first to publish a report of nuclear

	fission from her refuge in Denmark, alerting the scientific community to this momentous development. (Detail)
 	**Hideki Yukawa's** (1907-1981) 1934 theoretical calculations on the forces binding the atomic nucleus predicted the existence of new subatomic particles, now called mesons. These particles were expected to be 200 to 300 times as heavy as the electron and because of their mass act at very short intranuclear distances. Many different types of these highly unstable particles which may be charged or neutral were later observed experimentally, including resulting from cosmic rays, and their study has proved to be of fundamental importance for the understanding of the forces acting in the atomic nucleus. Yukawa won the 1949 Nobel prize in physics.
	The Cerenkov effect manifests itself by the emission of light when a charged particle, the result of radioactive decay, traverses an inert medium, such as water. It is possible that such particles may travel through the material with a speed faster than light, whose speed is limited by the

refractive index of the substance. The interaction of the particle's electric field with the molecules of the material causes the emission of light, most commonly a bluish glow, as in the case of water. Any college student who has toured Brookhaven will not forget the mysterious blue glow of the reactor pool. (See the center stamp under Otto Hahn above). This effect was studied in various fluids by the Russian physicist P. A. Cerenkov, who showed that it was not the result of fluorescence, and was later explained by the theoretists I. Y. Tamm and I. M. Frank. It is analogous to the phenomenon of the sonic boom, where an aircraft travels at a speed faster than the speed of sound in air. The 1958 Nobel prize in physics was awarded jointly to these three scientists.

Enrico Fermi (1901-1954) (Detail) produced thermal neutrons by slowing them down in water, and then used them to start the first self-sustainig chain

reaction in uranium, at the University of Chicago under the football stadium in 1942; it was the beginning of the nuclear age. Very few stamps show the powerful image of a nuclear explosion. The accompanying mushroom cloud is generally stylized in deference to the real events in Hiroshima and Nagasaki in 1945. The Mexican stamp at left commemorates the tenth anniversary of the nuclear nonproliferation treaty in the Americas. The green living tree's shape is mirrored by what might result if nuclear weapons are unchecked -- a doomed earth in the lurid glow of destruction.

Richard Feynman (1918-1988) was an American physicist and Nobel prize winner who worked in QED, quantum electrodynamics. Feynman diagrams were his way of representing qed events and processes to make them more easily understood. However, the American public will remember him as the physicist who, before a Congressional

investigative committee, cut through red tape and obfuscation to pinpoint the cause of the Challenger disaster - the blowup of the shuttle right after lift-off - with a simple demonstration involving an O-ring and a glass of ice water. The defective stamp at left showing the doomed space vehicle, or one just like it, may serve as a reminder that great theoretical minds can also have keen commonsensical insights.

Electromagnetic Theory and Light

Electric charge is a fundamental property of all matter, which consists of atoms, and it has existed since the beginning of the universe. One of its most spectacular visible manifestations is lightning, a discharge of electricity between clouds or between a rain cloud and the earth. The discharge heats the air molecules which are pushed apart with explosive force, creating a booming sound, or thunder. We see a lightning flash almost instantly, but the sound of thunder may trail the flash by seconds, since the speed of sound is much slower reaching us than the speed of light. Royal Mail effectively used such an image on a Franklin stamp below.

Thales of Miletus (625?-546?BC) was a natural philosopher who investigated the nature of matter and the universe in all its states.

His hypothesis was that all things came from water and ultimately returned to it. He was the founder of the Milesian school of philosophy and considered one of the Wise Men of Ancient Greece. While no

writings by Thales exist, he is said to have predicted a solar eclipse in 585 BC, which so frightened the Medes and Lydian armies engaged in battle that the warring factions ceased fighting and made peace. He also recommended navigating by Ursa Minor, the constellation which contains Polaris. On the Greek stamp at left Thales is commemorated as the discoverer of static electricity generated when a piece of amber is rubbed with fur: it is then able to attract light objects such as straw or feathers. This effect was called "electricity" by William Gilbert in 1600, after elektron, the Greek word for amber.

Abu Ali al'Hasan ibn al'Haitam is known in the West as Alhazen, born 965 in Persia and dying in 1039 in Egypt. He is called the Father of Optics for his writings on and experiments with lenses, mirrors, refraction and reflection. He correctly stated that vision results from light that is reflected into the eye by an object, not emitted by the eye itself and then reflected back, as Aristotle believed. He solved the problem of finding the locus of points on a spherical mirror from which light will be reflected to an observer. From his studies of refraction he determined that the atmosphere has a definite height, and that twilight is caused by refraction of solar radiation from beneath the horizon. The optical diagram on this Pakistani commemorative in blue

	commemorative in blue, green and black is hard to decipher because of the lack of contrast.
 	**Benjamin Franklin** (1706-1790), sometimes called the American Newton, was an inventor, publisher of pamphlets, maps, and broadsides, and experimenter besides being one of the country's founding fathers and first Postmaster General. We owe to Franklin the idea of positive and negative charge, and the law of conservation of charge. Famous for his daring kite experiment, in which he drew electricity from thunder clouds to a key suspended from the kite string, and thence to a Leyden jar, he also investigated the direction and velocity of the Gulf Stream.
	**Prokop Divis** (1698-1765) was a Czech scholar who studied and experimented with atmospheric electricity. He attempted to draw electricity from clouds and built a working lightning conductor, the first to offer actual protection, in 1753.
	French physicist **Charles-Augustin de Coulomb** (1736-1806) studied the interaction between charged particles by means of a torsion balance and arrived at the conclusion that the force between them is proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance separating them. This is

separating them. This is known as Coulomb's law, and the SI unit of charge is the coulomb.

Luigi Galvani (1737-1798) was an Italian anatomist and physician who, like many contemporary investigators, performed electrical experiments . He found that severed frogs' legs twitched when near a spark generator, and also when they came in contact with two different metals. Galvani concluded that the muscles were a heretofore unknown source of electricity, animal electricity. He was sadly disappointed when somewhat later Volta showed, in constructing his pile, that that the frog legs were not necessary to create a spark, rather, that two different metal s sufficed when separated by moist cardboard. Still, Galvani is credited with the original observation of this phenomenon.

Alessandro Volta (1745-1827) was an

Italian physicist whose important invention was the voltaic pile, an antecedent of the storage battery. He found that an electric current can be produced when chemicals come in contact with metals. This is the basis of electrolysis. Volta constructed his pile from alternating layers of copper and zinc discs in a salt water solution. Galvani had already discovered a current passing between two metals touching a muscle. Volta dispensed with the muscle and found that a current could still be produced. The electric unit volt is named in his honor. The stamp at left shows the voltaic pile on the right.

The 

connection between electricity and magnetism was first demonstrated by **Hans Christian Oersted** (1777-1851). He brought a magnetic needle near a wire which was carrying an electric current. The needle was deflected at right angles to the wire, as is shown on the Danish stamp to the left.

The 1994 German stamp at left shows a resistor, a common element in electronic circuits, and commemorates the discovery of Ohm's law, named after the German mathematician **Georg Simon Ohm** (1787-1854) who formulated it. Ohm aspired to be a university professor, and after many teaching positions as a mathematician began to experiment in physics. His law describes the relationship between current, voltage, and resistance in a circuit,

namely, that a voltage drop across a resistor is equal to the resistance times the current running through it, or V =R x I. The unit of resistance is also called an ohm; one ohm causes a one volt drop for a current of one ampere. Resistors are color-coded to show their value, or amount of resistance: the band at far right refers to the tolerance, or accuracy, and may be gold or silver, (5% or 10% accuracy). The two bands at the left indicate two numbers, which together form a value, such as 27 in this case; (red = 2, violet = 7). The third band is the code for a multiplier in powers of 10, in this case yellow, which stands for 10,000. The value for this resistor is therefore 270,000 ohms, but the tolerance value is somewhat in doubt, being neither distinctly gold, nor silver, though the yellow-greenish tinge makes gold more likely.

Andre Marie Ampere (1775-1836) was inspired by the work of Oersted to study the interactions between current-carrying wires, and derived a mathematical formula describing this force. He devised the right-hand rule to describe current-flow. The unit of current, Ampere, is named after him.

Dark spectral lines on the solar emission continuum are caused by absorption of radiation in the outer, cooler layers of the solar atmosphere. Although observed before, they were first mapped by **Joseph von Fraunhofer** (1787-1826), German physicist and inventor of the transmission grating. This illustrative stamp shows the Fraunhofer lines in the solar spectrum, which approximates that of a black body with 5800 degree K effective temperature peaking in the yellow, as we see each sunny day.

Michael Faraday's (1791-1867) interests in electricity and magnetism were wide and varied. Observing the alignment of iron filings around a bar magnet, he decided that they followed lines of force of a magnetic field. He induced a current in one of two wire coils wrapped around a metal ring by passing a current through the other coil, creating a transformer. His ideas about force fields were later expressed mathematically by Maxwell as Maxwell's equations. As a chemist Faraday liquified carbon dioxide and chlorine and discovered benzene.

Hermann von Helmholtz (1821-1894) was a protege of Humboldt's distinguished for his research in optics and the physiology of vision and acoustics, the law

of conservation of energy, and electrodynamics. He made important discoveries about the structure and mechanism of the human eye and invented the opthalmoscope. He suggested the investigation of light beyond the visible range to his student Heinrich Hertz.

Gustav Robert Kirchhoff (1824-1887) was a German physicist who worked with Bunsen on the development of the spectroscope and the measurement of spectra of the elements. He discovered that sodium emits the bright yellow lines appearing in absorption in the solar spectrum as observed by Fraunhofer; this suggested the possibility of investigating the composition of stars by spectrographic methods. His work in electricity is noted on this stamp: the sum of potential drops around a closed circuit loop is zero.

James Clerk Maxwell (1831-79) derived mathematically the four equations that describe the interaction and relationship between electricity and magnetism as already observed by Faraday, and which are the foundation of electromagnetic theory. Maxwell's equations are the basis of all modern communication: they apply to all electromagnetic radiation, be they TV, radio, radar, light, or x-rays. The Nicaraguan stamp shows a transmission tower superimposed on a dish antenna and spherically emanating waves. Maxwell shares honors with Hertz on the Mexican stamp which commemorates global telecommunications.

Heinrich Hertz (1857-1894) devised an oscillating electrical circuit ending in two metal spheres. The oscillations caused sparks across the air gap between the spheres, and Hertz was able to detect and map the electromagnetic fields generated, as predicted by Maxwell's equations. German and Czech stamps note the centenary of his research, showing the spark gap and the field lines.

Albert Michelson (1852-1931) was the first American to win a Nobel prize (physics, 1907) but has not been recognized for this achievement by the U.S. Postal Service. A Swedish stamp gives us his small profile. His studies of the velocity of light with ever greater accuracy were based on a modification of

Foucault's rotating mirrors. Light, as a wave motion, was then supposed to require the presence of a medium for its propagation, and this invisible substance was called the luminiferous ether, through which the earth also moved. It was supposed that light would have different velocities when moving perpendicular and parallel to the hypothetical ether, being "dragged" in the former case. By an ingenious experiment of splitting light beams and bringing them back together in his interferometer, Michelson and his associate Edward Morley, a chemist dedicated to producing high precision instruments, were unable to detect any difference in time traveled for the split beams, both parallel to and with the ether. This failed experiment obviated the need for the ether's existence, and proved that the velocity of light is constant, an assumption later made by Einstein in his general theory of relativity.

Nikola Tesla (1856-1943) was an

electrical engineer born in Yugoslavia. He developed the first alternating current induction motor after becoming a U.S. citizen. The Niagara Falls Power Company was the first to adopt his invention in the exploitation of hydro power, proving the universal adaptability of alternating current.

Guglielmo Marconi (1874-1937) was an Italian engineer and physicist who recorded the first transatlantic transmission of radio signals. Hertz before him had already transmitted and received radio signals in the microwave range over short distances. Marconi received the 1909 Nobel prize in physics for his achievement.

Chandrasekhara Venkata Raman (1888-1970) was an Indian physicist and Nobel Prize winner who discovered that light scattered by molecules in solution had some components changed in wavelength and that these changes were characteristic of the target molecules. These Raman spectra can be used to investigate and identify molecular structure. Such a spectrum appears next to Raman's portrait on this Indian stamp

The Scottish physicist **Robert Alexander Watson-Watt** (1892-1973) is credited with the development of the first workable radar system in the 1930's, although there was

	concurrent research in other countries. Based on the reflection of shortwave radio waves, radar pinpoints a moving object's location by measuring the time elapsed between emitted and reflected pulses as well as their direction.
	German-born Canadian physicist and molecular spectroscopist **Gerhard Herzberg** (1904-1999) received the Nobel prize in Chemistry in 1971 for his contributions to molecular spectroscopy and investigation of free radicals, short-lived intermediate products in chemical reactions. Herzberg's techniques were fundamental in discovering the electronic structure and changing geometry of free radicals, which only exist for a fraction of a second while a reaction is taking place and offer insights in how it proceeds.
	Spectroscopy plays an integral part in modern forensic science in the identification of substances. Spectra are featured on this Canadian stamp commemorating the 100th anniversary of the Royal Canadian Mounted Police.

Magnet Earth

Ancient mariners on the open seas had guided their ships by steering by the sun, the stars **[1]**, or staying in sight of land. They accomplished this without the use of a compass, which did not reach Europe until the 13th century, having arrived with Arab traders from China, where it was invented and used as such around 1000 AD **[5]**. However, the compass **[6]** also introduced some problems. It did not point to true north, as defined by the axis of the earth's spin and shown on maps, but to the magnetic north pole, the existence of which was unknown at the time. Moreover, this magnetic declination or variance changed with location and also over time. English physicist and physician to Queen Elizabeth I, William Gilbert (1544-1603) in his 1600 book De Magnete was the first to describe the earth as a gigantic magnet that attracted the compass needle **[2]**. Some years earlier, in 1576, London instrument maker Robert Norman discovered magnetic inclination, where a compass needle freely suspended in the vertical plane dips below the horizon **[3]**. A modern dip circle is shown below **[4]**.

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Today Edmond Halley **[7]** is remembered chiefly for predicting the return of a comet, now named for him, using the principles of Newton's law of gravitation. Not as well remembered are his investigations of terrestrial magnetism. The first expedition dispatched expressly with the purpose of making magnetic observations was an English one under the command of Halley between 1698 and 1700. Initially planned for the entire globe, it covered only the North and South Atlantic. Halley had hoped to arrive at a direct correlation between magnetic variation and longitude, the elusive measurement so necessary to safe navigation. Upon his return, Halley ingeniously plotted his data on a global map and arrived at curves of equal magnetic declination, an isogonic chart, the first known graph of experimental data. Halley was able to extend this chart from the observations of other seafarers to include the Indian Ocean and the China Sea. This chart went through many editions and was very useful to sailors, but did not provide a measure of longitude. Unfortunately, it also was not permanent due to the migration of the earth's magnetic poles, which caused changes in the variance, considerable even in a man's lifetime. When accurate chronometers **[8]** were invented, such as the one by John Harrison (1693-1776), the calculation of longitude precisely with reference to the Greenwich meridian **[9]** became possible and Halley's chart fell into disuse. To account for the changing declination, Halley promoted the hypothesis of two magnetic poles in each hemisphere, at Spitzbergen and the Bering Strait in the north, and in the Antarctic Ocean in the south. According to Halley, these poles lay on different concentric shells of the earth, and the relative motion of these spheres accounted for changes in the variance at different locations.

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Halley also studied auroras **[10]** and found that their arcs corresponded to magnetic field lines in the polar region similar to the array of iron filings around a magnetized sphere (terrella). The invention of a magnetometer by the English instrument maker George Graham made it possible for him to observe diurnal variations of magnetic declination (1722), and Anders Celsius **[11]** (1701-1744) in Uppsala noted that some of these coincided with auroral displays. A magnetic storm on the sun was thus observed simultaneously in London and Uppsala in 1741, though nobody had yet PHILATELIA CHIMICA ET PHYSICA, VOL. 84 34, NO. 2 — SPRING 2012 associated auroras with solar activity. We now know that there is a stream of highly energetic charged particles (protons and electrons) emitted by the sun's corona **[12]**, called the solar wind **[13]**, which distorts the earth's magnetic field, or magnetosphere. Erupting flares **[14]** on the sun are sometimes associated with coronal mass ejections, or solar storms, which move faster than the solar wind and induce ejections of protons and electrons into the atmosphere, causing the auroras. They also deplete the electrons trapped in the van Allen Belts **[15]**, sending them hurtling into space.

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Halley's isogonic charts inspired the Norwegian physicist and astronomer Christian Hansteen (1784-1873) more than a century later **[16]**. He collected available data and also mounted an expedition to Siberia, where he took many measurements for an atlas of magnetic strength and declination. He produced maps of declination **[17]** for the period 1600-1800 from the data, and the changes of the values not only by location but also over time underscored the need for further study. Although he did not discover the cause of the earth's magnetic behavior, he inspired interest in further study by Humboldt **[18]** and Gauss **[23]**.

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While maritime nations primarily focused on magnetic observations at sea, there was widespread interest in magnetic phenomena on land as well. Alexander von Humboldt (1769-1859) had been fascinated by magnetism since early hiking expeditions. In 1798 he collaborated in Paris with Jean-Charles de Borda (1733-1799), a seasoned experimenter, who in 1790 had provided instruments for measuring the length of a meridian between Dunkirk and Barcelona to establish the length of the meter PHILATELIA CHIMICA ET PHYSICA, VOL. 34, NO. 2 — SPRING 2012 85 **[20]**. Humboldt continued his magnetic observations on his 1799–1804 travels in South America **[19]**. In particular, at Borda's suggestion, he searched for the magnetic equator, where the compass needle lies parallel to the meridian and does not dip. He deduced that the angle of the dip and the intensity of the magnetic field increase with proximity to the pole.

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Upon his return he further worked in Berlin on various problems with Joseph Louis Gay-Lussac (1778-1850), the French physicist and chemist **[21]** who in an 1804 balloon flight up to 20,000 feet found that the earth's atmospheric composition and magnetic intensity remained constant to that altitude. They jointly discovered that two volumes of hydrogen combine with one volume of oxygen to form water and in 1805 they traveled across the Alps and made measurements of the inclination of the compass needle.

Back in Paris in 1807, Humboldt consulted with François Arago (1786-1853) **[22]** who was by then head of the Bureau des Longitudes, where regular geomagnetic measurements were performed. While Humboldt studied the diurnal variations of the magnetic declination and sought to explain them, he concluded that a coordinated campaign of measurements was needed and ordered several identical instruments to be used at different locations: first Paris, Berlin, and Freiberg. The last of these was installed deep in a mine shaft. Data from the underground Freiberg station showed that the diurnal variations were independent of temperature. On a trip to Russia he established further magnetic observatories in St. Petersburg, Kazan and the Crimea.

In 1828 Humboldt suggested to Carl Friedrich Gauss (1777-1855) that he apply his mathematical talents to magnetism, and Gauss invented a device to measure the strength of the magnetic field and applied a serial approximation from celestial mechanics to describe it. Humboldt tried to interest Gauss in joining his enterprise of magnetic observatories, but Gauss formed his own Magnetischer Verein in Göttingen, taking the study of magnetic phenomena from the field into the laboratory. Design and instrumentation of laboratories were standardized to avoid errors due to different conditions on land or at sea, and with improved instruments at far-flung observatories Gauss gathered a mass of data that were published annually.

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In times of peace, the British navy was deployed on voyages of both scientific and commercial exploration. The first expedition to reach the North Magnetic Pole was led by Sir John Ross in search of the elusive Northwest Passage to Asia. His nephew James Clark Ross **[24]** recorded a 90° needle dip at Cape Adelaide on the Boothia Peninsula in Arctic Canada on June 1, 1831. Roald Amundsen **[26]** found the pole in a slightly different location in 1903. A subsequent observation by Canadian government scientists at Allen Lake on Prince of Wales Island in 1947, showed the pole shifting at ever increasing speeds in a northwesterly direction towards Russia. The discovery of the North Magnetic Pole gave new impetus to British magnetic researches, and James Clark Ross spent the years 1835 to 1838 working on a magnetic survey of Britain.

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Captain James Cook **[28,29]** had already circumnavigated Antarctica in 1772. A later Royal Society-sponsored scientific expedition to the Antarctic regions to record magnetic and geographic features of this unknown land was captained by James Clark Ross from 1839 to 1843. The ships HMS Erebus and HMS Terror **[25]** were specially outfitted to withstand ice damage and carried an onboard magnetic observatory free from iron nails that might distort magnetic readings. The expedition established magnetic observatories in St. Helena, the Cape of Africa, and Tasmania before proceeding south. Ross did not reach his goal, being blocked by a vast abrupt ice barrier (now known as the Ross Ice Barrier), but sailing along it he was finally able to push through the packed ice to find a bay of open water and an active volcano, which he named Mt. Erebus. However, the quest for the South Magnetic Pole was continued intermittently in later years until, in the early 20th century, two nearly simultaneous expeditions converged on the continent in 1908 and 1910. One was sponsored by the British Admiralty and led by Captain Robert Falcon Scott (1868-1912) on his second Antarctic expedition **[30,31]**; the other was privately financed and headed by Ernest Shackleton **[31]** (1874-1922). In January 1909 a group from Shackleton's party succeeded **[27]**, fixing the pole's position at that time as 72° 15′ S, 155° 16′ E, at an elevation of 7,260 feet, a considerable distance from the geographic pole which had been an additional destination. The goal was achieved by Scott in January 1912, but he had been beaten by Norwegian Roald Amundsen (1872-1928) in 1911, five weeks earlier. Scott's party perished on its return journey while Amundsen came back safely. This essentially concluded the heroic age of Antarctic exploration as war threatened Europe; but measurements of geomagnetic phenomena continue to this day, sometimes by satellites and rockets.

In closing, it is also worth noting that the early pioneers of magnetic studies are commemorated by in the CGS system: the gauss (G or Gs) is the unit of magnetic dipole moment per unit volume and the gilbert (Gi) is the unit of magnetomotive force.

Bibliography

- Edward J. Larsson. *An Empire of Ice*. New Haven: Yale University Press, 2011.
- Diane Greco. *From the Field to the Laboratory: Terrestrial Magnetism at Göttingen*, 1833-1839. Working Paper no. 24, Program in Science, Technology and Society, Massachusetts Institute of Technology, Cambridge, MA, 1995. http://web.mit.edu/sts/pubs/pdfs/MIT_STS_WorkingPaper_24_Greco.pdf [accessed May 24, 2012]
- David P. Stern. "A Millennium of Geomagnetism 3. Halley, Coulomb, Oersted and Ampere." *Reviews of Geophysics* 2002, 40(3), pp 1-1 to 1-30. http://www.phy6.org/earthmag/mill_3.htm [accessed May 24, 2012]
- Jörg Zaun. *Alexander von Humboldts magnetischer Verein und die Freiberger Beiträge zur internationalen Erforschung des Erdmagnetfeldes*; Freiberg, 2009. [accessed May 24, 2012]
- Jeffrey Love. "Magnetic monitoring of Earth and space." *Physics Today*. February 2008, pp 31-37. http://geomag.usgs.gov/downloads/publications/pt_love0208.pdf [accessed May 24, 2012]
- N. Kollerstrom. "The Hollow World of Edmond Halley." *Journal for the History of Astronomy* 1992, 23,185-192. http://dioi.org/kn/halleyhollow.htm [accessed May 24, 2012]

The Atomic Bomb

Author's note: this article appeared in the May-June 2002 issue of ***Topical Time,*** the ***Journal of Thematic Philately of the American Topical Association.*** Several of the stamp images shown have already appeared in the **Modern Physics** and **Chemistry** sections of **SCI-PHILATELY,** but I wanted to bring them all together to underscore the negative feelings they express and the universal disapproval they arouse.

One of the most powerful symbols to come out of the 20th century and World War II is the mushroom shaped cloud accompanying an atomic bomb explosion. It is instantly recognizable as a sign of war, death, and destruction. The grim reaper and the horsemen of the apocalypse of earlier times have been superseded by the monstrous cloud that sucks up what the fireball of the explosion has destroyed and carries it to ever greater heights, only to shower down as a toxic, lethal rain of radioactive fallout in areas far beyond its origin. The destructive power of such a bomb is vastly greater than that of any explosive known to earlier generations of belligerents. For lack of a better measure it is expressed as equivalent to tons of TNT, the material of heretofore conventional weapons. But mere tons do not adequately describe it; this power is measured in kilotons, and even megatons, of TNT. It is small wonder, then, that there are few stamps that bear this frightening image. The few nations which possess nuclear weapons have been reluctant to issue postal reminders of the destructive powers they control, while non-members of the nuclear club can only hint at their apprehension of a world engulfed in nuclear war. In this article we will examine the few examples of mushroom clouds on stamps that have been issued. Even stamps that commemorate treaties designed to limit or ban the use and spread of nuclear weapons rarely incorporate such a design.

The atomic bomb was the culmination of an intensive, secret WWII scientific venture called the Manhattan Project. Discoveries in physics described in the **Modern Physics** sections were the basis of this project. The United States was in a race with Germany to be the first to have such a weapon which could determine the outcome of the war. The theoretical and experimental aspects of nuclear fission had been explored in earlier years, leading to the splitting of the uranium atom under slow neutron bombardment by Otto Hahn and Fritz Strassmann in 1938. If a chain reaction of the fission process could be sustained, an explosion would likely result. The US in a concerted effort was first able to produce such a weapon, test it, and use it against Japan on Hiroshima and Nagasaki in 1945. So massive were the effects of these bombs that Japan surrendered to end the war. This was the only time nuclear weapons were used against another nation.

However, the successful application of nuclear fission was now known and before too many years had passed, by fair means or foul, the Soviet Union, Great Britain, and France had acquired the secrets of nuclear bomb production. They were followed by Peoples' Republic of China and later by India and Pakistan. There ensued a period of building and testing of nuclear weapons, particularly by the superpowers, stockpiling them and achieving ever more powerful weapons and the capability to annihilate all mankind many times over. The testing did not take place in the homeland because of the recognized danger from fallout. Rather, the US moved its testing operations to the South Pacific, namely the Marshall Islands, specifically Bikini. Here, far from scrutiny, the first test detonations after Hiroshima and Nagasaki took place, totally polluting and poisoning the atoll. The Marshall Islands in 1996 issued a set of semi-postals intended to assist the Bikini refugees on the 50th anniversary of their displacement.

Two of these stamps (shown above) are based on actual photos of the first two US nuclear tests in 1946. This test series was called Operation Crossroads and the tests were named Able (left), an airdrop, and Baker (right), an underwater shot. The awesome size of the Baker test can be appreciated by noting the naval vessels in the foreground, dwarfed by the ascending fireball. The Marshall Islands also issued a souvenir sheet of 15, named Events of the 20th Century 1940-1949, which makes a reference to nuclear destruction with a stamp showing a grinning skull against a mushroom cloud. This stamp is described as "Mankind faces Atomic Age" and is shown at the top of this page. The evacuated population of Bikini has yet to return to its homeland.

From 1945 to 1988 the U.S. conducted a total of 930 known nuclear tests with a combined yield estimated to be 174 megatons. Approximately 137 megatons of that total was detonated in the atmosphere. Similarly, the British government conducted tests on islands off Australia; the USSR, in the Ustyurt desert and on islands off Siberia; France, in the Algerian desert. All these tests were atmospheric or under water. There was wide-spread, loud condemnation of testing both home and abroad, and the world was gripped by the fear that an accidental release of a nuclear weapon could result in instant retaliation, followed by the global destruction of all life and environment. The drive for nuclear superiority was finally suspended by the 1963 "hot line" agreement between the US and the USSR, which kept a telecommunications line open between Washington and Moscow to avoid any accidental start to a war. This was followed by the limited Test Ban Treaty of August 1963 between the US, UK, and USSR, prohibiting tests of nuclear devices in the atmosphere, in outer space, and underwater, while allowing nuclear testing to continue underground.

This ratified treaty provided the occasion for the United Nations to issue the first stamp displaying a mushroom cloud, with a padlock inscribed "cessation of nuclear testing." But only a year later China, not a signatory, detonated its first bomb. In 1967 the three earlier signatories agreed to the Outer Space Treaty, banning nuclear weapons from space or any celestial body, such as the moon. In the same year, alarmed by the Cuban Missile Crisis, when Soviet missiles were brought to the Western hemisphere, Latin American countries banded together for the Treaty for the Prohibition of Nuclear Weapons in Latin America (also known as the Treaty of Tlatelolco). This treaty obligates Latin American parties not to acquire or possess nuclear weapons, nor to permit the storage or deployment of nuclear weapons on their territories by other countries.

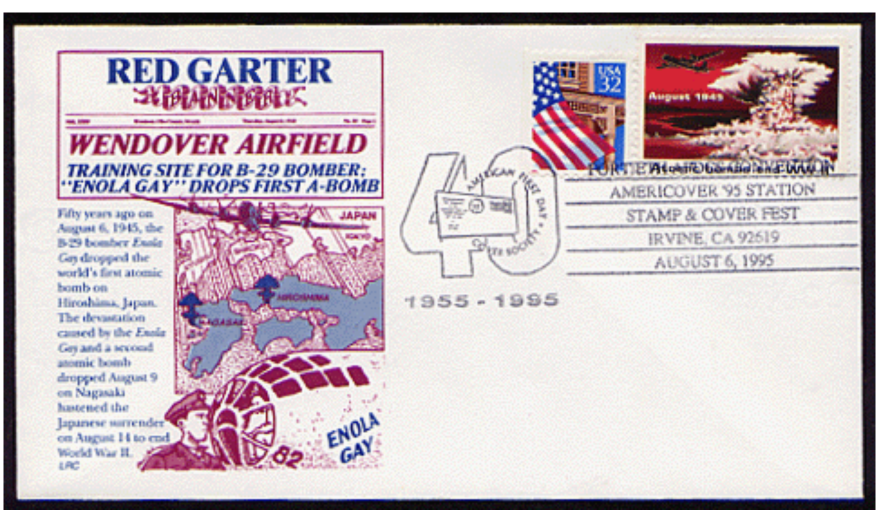
Mexico marked both the 10th and 30th anniversaries of the Tlatelolco treaty with stamps showing mushroom clouds. The 10th anniversary stamp on the left shows an adaptation of Leonardo da Vinci's drawing of Vitruvian Man, a male figure inscribed both into a circle and a square. Da Vinci based this figure on ideal human proportions from the writings of the first century AD Roman architect Vitruvius who enjoyed a revival in the Renaissance. On the stamp the human form has been replaced by a skeleton topped by a grinning skull against the lurid background of a nuclear explosion, a portent for humanity in the nuclear age. The 1997 stamp mirrors a healthy green tree over the shape of a mushroom cloud in a red sky, signaling an alternative of fiery destruction.

1968 brought the Nuclear Non-Proliferation Treaty, a multilateral agreement signed and ratified by the US, USSR, UK, and 133 non-nuclear-weapon states to prevent the spread of nuclear weapons and to assure that the peaceful nuclear programs of non-nuclear-weapon states were not diverted to weapons production. The United Nations notes this event with a stamp in 1972 (above), showing an atomic cloud crossed out with an X. Belgium also observes the 25th anniversary of this treaty (but not till 1995) with another impressive example of a mushroom cloud inscribed with the words "plus jamais" - never again.

The mushroom symbol is also used in an off-beat issue from Nicaragua. (above) Einstein's law E=mc2 is shown in a set of stamps showing the ten mathematical formulas that changed the face of the earth, and it features a stylized mushroom cloud. Inside the mushroom cap appears a beryllium atom with four electrons orbiting a nucleus of four protons and five neutrons. Beryllium is a highly efficient generator of slow neutrons when bombarded with alpha particles, and may serve as a source of neutrons to initiate nuclear fission. At the base of the mushroom are roiling churning clouds of debris as seen on many actual photos of nuclear events. However, front and center in the picture is a prone white-draped figure being irradiated from upper left, watched by a technician behind a window to the right. This peaceful application of nuclear energy somewhat mitigates the stark symbolism of the mushroom cloud.

Another unusual example showing a nuclear explosion is from Upper Volta (Burkina Faso) in 1977. Stamps showing Nobel laureates are popular with collectors and many are issued by third world nations who have no Nobel laureates of their own but want to share in the philatelic market. Here Linus Pauling is commemorated for his Nobel prize in chemistry in 1954, "for the study of the nature of the chemical bond and the determination of the structure of molecules and crystals." But in the background, behind some molecular structures, a vast fireball is rising, introducing a jarring element into the stamp design. Why this strange juxtaposition? Pauling was deeply involved in the peace movement and campaigned ceaselessly, "not only against nuclear weapons tests, not only against the spread of these armaments, not only against their very use, but against all warfare as a means of solving international conflicts." He eloquently described "the consequences, should there be a major war involving hydrogen bombs: a thousand million men and women dead, and the earth's atmosphere permeated with toxic radioactive substances, from which no human being, animal, or plant would be safe." He initiated a declaration, signed by 52 Nobel prize winners, warning "all nations must come to the decision to renounce force as a final resort. If they are not prepared to do this, they will cease to exist." So, in effect, this stamp not only celebrates Pauling's 1954 Nobel prize in chemistry, but his 1962 Nobel prize for Peace as well.

Fifty years after the end of WWII, the USPS planned to include a picture of the Hiroshima bomb as a historic event in a souvenir sheet commemorating the end of the war (11). However, due to objections from Japan, followed by pressure from the White House, the design was replaced with a picture of President Truman announcing the end of war. According to Linn's Stamp News, five different private labels have been printed showing the A-bomb stamp design, or similar ones, in response to, or as a protest against the USPS action. The one shown below is the originally proposed USPS design which was subsequently duplicated on a label with replaced captions above and below: "Japan surrenders 1945" and "US surrenders 1994". Another label, shown on cover below with a legitimate US stamp, states "Atomic Bombs End WW II"



Geology and Mapping

Terrestrial globes as the one above left are used to present the physical features of the earth in proportion. It was made by Johannes Praetorius, in 1568, and shows Europe, Asia, and Africa, as well as the recently discovered Americas. Celestial globes, as the one on the right, show the relative positions of astronomical features of the heavens, such as stars and constellations as seen from earth. Globes have been produced since the time of the Pythagoreans. They became more important when on voyages of discovery more distant lands beyond the familiar Mediterranian were found. and accurate maps were urgently needed. The earliest extant globe was made by Martin Behaim of Nürnberg in 1492, the year Columbus discovered America, which of course is not yet shown on it. Germany and Flanders were centers of globe manufacture, and particularly distinguished was Gerhardus Mercator (1512-1594), a Flemish geographer who broke away from the Ptolemaean stranglehold on cartography in the late Middle Ages. Venerated maps with centuries-old misinformation were found to be increasingly inconsistent with the recent observations of mariners. His solution to the problem of distortion of physical features on the sphere of the earth when projected onto a flat map was the cylindrical, or Mercator, projection still in use today. The Belgian stamp on left shows Mercator holding his famous globe.

Old maps show the coast of North America and Iceland, country of issue.

This U.S.

Bicentennial stamp

Bicentennial stamp shows **Benjamin Franklin** (1706-90) with an early map of North America, though not one of his own. Franklin published maps of the newly founded United States and he also mapped the currents of the gulf stream during his frequent crossings to Europe. Great Britian honored Franklin on the occasion of the American Bicenteninial in 1976.

Christopher Hansteen (1784-1873), a native of Norway, was a physicist and astronomer who devoted his time to the study of geomagnetism. In 1701 Halley had already published a map of magnetic declinations, and the subject was studied by Humboldt, de

Borda, and Gay-Lussac, among others. Hansteen collected available data and also mounted an expedition to Siberia, where he took many measurements for an atlas of magnetic strength and declination.

Friedrich Wilhelm Heinrich Alexander von Humboldt (1769-1859)

explored many parts of the earth, including the Americas; the cold current off the west coast of South America bears his name. He was a geologist, naturalist and collector of specimens who wrote an encyclopedic work in geology and geography, *Kosmos.*

This interesting stamp was issued by the DDR in 1980 as part of a set of four dealing with geophysics and the methods used to explore various properties of the earth. A seismograph is used to measure vibrations in the earth, or earthquakes. Here is a diagram of the concentric layers of the earth, the main ones being the core, the mantle, and the crust. The relatively thin crust is composed of rocks like granite and basalt, while the mantle contains much denser mineral rocks. The lithosphere comprises the crust and the upper part of the mantle and is divided into the tectonic plates which move around on the astenosphere. It includes much of the upper mantle, and while not liquid, deforms by plastic flow. Between the crust and the mantle there exists a boundary known as the Mohorovicic discontinuity, or Moho. Here P (compressional) waves are propagated at a much higher rate than in the crust above. The Moho lies from 5 km under the oceanic ridges to 75 km under the continents. The inner core is 1220 km thick and composed of solid iron; the outer core is nearly twice as thick (2220 km) and is liquid iron

Alfred Wegener (1880-1930), a German geologist and arctic explorer, advanced a theory of continental drift where the lighter continents are floating on denser underlying material in the earth's crust. What was a single landmass, the supercontinent Pangaea, supposedly broke up into our present continents, which then drifted apart, as shown on the Berlin stamp on the right. Wegener noticed how the the shapes of Brazil and Africa fit together. The existence of a landbridge in the past would account for the paleontological similarities discovered between the two continents. Wegener disappeared on his fiftieth birthday while on an meteorological expedition in Greenland.

Since Wegener's time, much research has led to a detailed picture of the movements of continents and their plates in the 4.6 billion years of the earth's history. In time, the global crust formed supercontinents which thousands of millions of years later broke up again into smaller sections that moved apart. The latest supercontinent Pangaea, was composed of a northern part Laurasia (made up of present-day North America, Europe, and Asia) and a southern part Gondwana, which was incidentally formed 500-700 MYA (million years ago) after the breakup of an earlier supercontinent, Rodinia. Laurasia broke away from Pangaea about 150 MYA, leaving Gondwana (incorporating Africa, Antarctica, Australia, India, and South America), which also began to disintegrate. The set of stamps from British Antarctic Territory issued in 1982 deals with the continental drift of Gondwana and its resulting parts, as seen from the vantage point of Antarctica and the South Pole. It also documents the climatic changes that have taken place in Antarctica as revealed by fossils of trees, shrubs, and animals. Shown is lystrosaurus. What was a tightly packed assembly 280 MYA (#1) had moved north en masse by 175 MYA (#3), when violent volcanic activity also occurred. The continents were seen widely dispersed 50 MYA (#5), Africa and South America opening a wide rift 100 million years ago and moving north while Australia was still closely bound to Antarctica. In the upper right quadrant India, a triangle, can be seen heading for Asia to form the Himalayas. The last stamp (#6) shows the present alignment of the continents around Antarctica, and penguins as its current population.

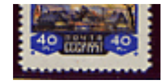
A fault results from fracturing and differential movements of layers along fractures in the earth's crust. This Canadian stamp shows a normal dip-slip fault.

When molten rock flows into a fissure of existing rock strata and later solidifies, it is called a dike. This stamp from the Aland Islands shows a diabase (dark-colored intrusive igneous rock, a coarse basalt) dike in Sottunga. Dikes can be short or many miles long. Another interesting stamp from this set shows a formation of pillow lava, which is considered to be the result of underwater extrusion.

This Russian stamp of geological exploration has it all - underground explosion, airplane, truck, derrick, reflections of waves from different layers. This is what makes science stamps, and indeed many other stamps, so much fun: they tell a story of a process, an event, they are instructive.

In 1908 a major interaction between earth and an asteroid or meteor occurred over Siberia, then, as now, sparsely populated. Thousands of acres of pine forest were devastated and went up in flames, dust in the upper atmosphere colored sunsets, but outside of Siberia the cause of these signs remained unknown and was supposed to be an earthquake. In 1927 the Russian scientist Leonid Kulik mounted an expedition to the remote Tunguska area and found the blast site. The explosion is estimated to have had the force of 40 megatons of TNT, and the effects on the landscape are still visible today. Since there is no impact crater, the explosion likely took place some seven kilometers above ground.

Another meteor fall over eastern Siberia in the Sikhote-Aline mountains in 1947 was witnessed by people on the ground at distances of 300-400 km. The meteor was seen as a fireball that exploded. The impact could be felt for 100 miles and the many fragments created 24 major and 98 minor craters. The weight of the material (iron) is estimated at 70 to 100 tons. The Russian painter P.L. Medvedev observed this spectacular event and painted it from memory, as shown on the stamp at right.



Like many solitary groups of islands, the Tristan da Cunha islands are of volcanic origin, periodically fated to revisit their creation. Located south of the equator in the South Atlantic Ocean, the roughly circular main island houses the only settlement in the shadow of the volcano. One source of income of the islanders is the sale of postage stamps, and this colorful set provides vivid images of the volcanic activity that most recently in 1961 forced the evacuation of the entire population of 300 to England, half a world away. The first stamp shows the formation of a volcanic island rising up from the sea and the hot magma erupting in a lava flow. Cinder cones are formed by volcanic debris accumulating around vents.

A more recent example of the birth of an island is the creation of the island Surtsey. From 1963 to 1967, this volcanic island erupted from the sea floor south of Iceland, and as it rose to the surface, violent interactions between hot magma and cold water occurred, a process that is now called surtseying. The contemporary Icelandic stamps below show the island in the making, obviously a spectacular series of events. Volcanoes around Iceland are nothing new; accounts of St Brendan's sixth century voyage from Ireland to North America include descriptions of volcanic activity which threatened the seafaring monks, as shown on the Faroe Islands stamp below.

The question of how coral atolls are formed in the midst of deep oceans occupied scientists of the 19th century. **Charles Darwin**, trained as a geologist, observed such islands during his five year voyage on the Beagle, studied their structure, and published a simple theory upon his return to England. (***The Structure and Distribution of Coral Reefs (1842)***. Corals start growing at the shore of a volcanic island, anchored on rock. As over time the land subsides, the coral continues to grow just below sea level. If the land completely subsides, an atoll is formed. If land (like Australia) remains above sea level, the coral forms a barrier reef in front of a channel. In later years this theory was challenged by Luis and Alexander Agassiz, father and son, of Harvard University, and the controversy raged on long past Darwin's death. Darwin had suggested drilling down through the coral to find a rock base, but current equipment was not up to such deep drilling as was necessary. Starting in 1896, the Royal Society sent out three expeditions to Funafuti (now Tuvalu) to examine the deep structure of an atoll, but the findings were inconclusive: the coral was thicker than expected. Finally, in 1952, the USGS was allowed to drill on Eniwetok Atoll in the Marshall Islands before it was destroyed during US nuclear tests. Nearly a mile down the drill struck rock, proving Darwin right more than a century after his initial hypothesis.

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SCI-PHILATELY

A SELECTIVE HISTORY OF SCIENCE ON STAMPS

The Nobel Prizes

The annual Nobel prizes have come to represent the highest achievement in physics, chemistry, physiology or medicine, literature, or peace. With the weight of a century behind them, there are no more prestigious awards than these, and they are based entirely on merit. In his will Alfred Nobel stipulated that the income from his invested estate should "annually distributed in the form of prizes to those who, during the preceding year, shall have conferred the greatest benefit on mankind. The prizes were to be international in that no consideration be given to the nationality of the candidates, but that the most worthy shall receive the prize, whether he be Scandinavian or not." The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel is sometimes called the Nobel prize in economics, although no provision was made for it in his will. The annual selections are made by different institutions as follows and are eagerly awaited:

Physics - *Royal Swedish Academy of Sciences*
Chemistry - *Royal Swedish Academy of Sciences*
Physiology or Medicine - *Nobel Assembly at the Karolinska Institute*
Literature - *Swedish Academy*
Peace - *Norwegian Nobel Committee*

Alfred Nobel (1833-96) was a Swedish industrialist and inventor who harnessed the unstable nature of nitroglycerine, a powerful explosive, by mixing it with silica to form a more stable solid which he named dynamite. He patented this product and marketed it successfully, building factories in many countries and retiring a very rich man. His interests were wide-ranging in literature and social issues as well as in the sciences, and are reflected in the subject areas of the prizes.

This Swiss stamp at right is one of a pair issued jointly with Sweden. The other stamp depicts the Swiss chemist Karrer, a Nobel laureate in 1937. Nobel's taming of nitroglycerine facilitated

the building of the great Alpine tunnels at St. Gotthard and Simplon; the stamp shows a tunnel cross section - which one?

Philately would be the poorer without the Nobel prizes which provide an instant recognition factor. The Swedish postal service excels in chronicling the achievements of the laureates, and many other countries follow suit in honoring their own nationals. The United States Postal Service is slow off the mark in drawing attention to the many Americans whose achievements have dominated their fields. One must be dead ten years to appear on a U.S. stamp, and even with this restriction many of our finest science laureates are still not recognized, except for Einstein and Millikan.

The stamp booklet issued on the 100th anniversary of the date of Nobel's last will and testament shows a fragment of that document, the Paris mansion that was Nobel's home, a laboratory at Bjorkborn, and the occasion of of the award of the first Nobel prize in physics to Roentgen in 1901. The more recent booklet at left above features a portrait of Nobel that was a joint issue with the USA and the medals for the different prizes by the Swedish awarding institutions.

To view all stamps of Nobel laureates published by Swedish Post Stamps in their annual series, many of which appear on these pages, click here.

References

- Abbott, David, ed. *The Biographical Dictionary of Scientists. Physicists.* London: Blond Educational, 1984.
- Asimov, Isaac. *Asimov's Biographical Encyclopedia of Science and Technology.* 2nd rev. ed. New York: Doubleday, 1982.
- Balfour, Walter J. "The quantum story on postage stamps." *Journal of Chemical Education.* 65 (3), 1988, pp. 255-9
- Caswell, Lyman R. "American chemists and physicists on postage stamps." *Journal of Chemical Education.* 67 (10), 1990, pp. 842-7.
- *The Concise Dictionary of National Biography: From Earliest Times to 1985.* 3 vols. Oxford: Oxford UP, 1992.
- *DISCovering Science* [Online]. Detroit: GaleNet (Producer). Available: SUNY at Buffalo Libraries, Buffalo, NY . File: People
- "Enter Evolution: Theory and History." (20 Nov. 1997)
- Garrigos, L.; Ferrando, F.; Miralles, R. "A simple postage stamp periodic table." *Journal of Chemical Education.* 64 (8), 1987, pp. 682-5.
- Gillispie, Charles Coulston, ed.*Dictionary of Scientific Biography*. 18 vols. New York: Charles Scribner's Sons, 1981.
- Goldstein, Herbert. *Classical Mechanics.* Reading, MA: Addison-Wesley, 1959.
- Hawley, Gessner Goodrich. *Hawley's Condensed Chemical Dictionary.* rev. by Richard J. Lewis, Sr. 12th ed. New York: Van Nostrand Reinhold, 1993.
- Heller, Sylvia; Heller, Detlef "A philatelic history of the discovery and isolation of elements." *Journal of Chemical Education.* 65 (1), 1988, pp. 12-15
- Hillger, Donald W.; Sokol, Louis F. "The modern metric system on postage stamps." *Journal of Chemical Education.* 65 (5), 1988, pp. 384-7.
- Hillger, Don. (1996) "U.S. Metric Association (USMA)." 22 March 2001. USMA . .
- History of Astronomy . 22 March 2001.
- "Index of/biographies." Index of Biographies . 22 March 2001
- LITERATURE ONLINE [Online]. Alexandria: Chadwick-Healey, Inc. (Producer). Available: SUNY at Buffalo Libraries, Buffalo, NY File: Cambridge Biographical Encyclopedia
- Kauffman, George B.; Miller, Foil A. "Mikhail Vasil'evich Lomonosov (1711-1765): founder of Russian Science: a philatelic portrait." *Journal of Chemical Education.* 65 (11), 1988, pp. 953-8
- Kauffman, George B. "Nobel laureates in chemistry - a philatelic survey. Part III. 1935-1988." *Journal of Chemical Education.* 67 (9), 1990, pp. 774-81
- Kauffman, George B. "Nobel laureates in chemistry-a philatelic survey. Part II. 1911-1934." *Journal of Chemical*

Education. 67 (7), 1990, pp. 569-74

- Kauffman, George B. "Nobel laureates in chemistry - a philatelic survey. Part I. 1901-1910." *Journal of Chemical Education.* 67 (6), 1990, pp. 451-6
- Max-Planck-Gesellschaft Presseinformation. Universum auf Briefmarken (29 Feb. 2000)
- Miller, Foil A.; Kauffman, George B. "Alfred Nobel and philately: the man, his work, and his prizes" *Journal of Chemical Education.* 65 (10), 1988, pp. 843-6.
- Miller, Foil A. "Some stamps related to the kinetic molecular theory of gases." *Journal of Chemical Education.* 63 (8), 1986, pp. 685-6.
- Borda circle Museon...het populair-wetenschappelijk museum in Den Haag 22 March 2001.
- "The Nobel Foundation." The Nobel Foundation 22 March 2001.
- O'Connor, John and Edmund Robertson. "Welcome to the MacTutor History of Mathematics archive." Oct. 1997.MacTutor History of Mathematics archive 22 March 2001. (18 Nov. 1997).
- Sherrat, Tim. "WWW Virtual Library for the History of Science, Technology & Medicine." HSTM 22 March 2001.
- Schreck, James O. "Organic chemistry on postage stamps." *Journal of Chemical Education.* 66 (8), 1989, pp. 624-30.
- *Standard Postage Stamp Catalogue* Sidney, Ohio: Scott Publishing, 1997--.
- Weinstein, Eric W. Eric's Treasure Troves of Science. Eric's Treasure Trove of Scientific Biography .22 March 2001.
- Williams, Trevor, ed. *Biographical Dictionary of Scientists.* Glasgow: HarperCollins, 1994.
- Wilson, Robin. "Stamp Corner." *Mathematical Intelligencer.*

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