History of Women in Science

MSE 302

An Overview of Women in Science

- Women have made significant contributions to science from the earliest times. Historians who have an interest in both gender and science study the scientific accomplishments of women and the barriers they have faced.
- The earliest known involvement of women occurred in the field of medicine in several early civilizations. The study of natural philosophy in ancient Greece was also open to women. Women contributed to the proto-science of alchemy in the first or second centuries AD.
- During the Middle Ages, convents were an important place of education for women, and some of these communities provided opportunities for women to contribute to scholarly research.
- The eleventh century saw the emergence of the first universities, however women for the most part were excluded from university education. [1]
- Italy was more liberal than other places, in regards to education for women specifically in medical fields. Eighteenth century Italian scientist, Laura Bassi, was the first known woman to earn a university chair in a scientific field of study.

- Although gender roles were largely defined in the eighteenth century, women experienced great advances in science. During the nineteenth century, women were excluded from most formal scientific education, but they began to be admitted into learned societies during this period. In the later nineteenth century, the rise of the women's college provided jobs for women scientists and opportunities for education.
- Marie Curie, a physicist and chemist who conducted pioneering research on radioactive decay, was the first woman to receive a Nobel Prize in Physics and became the first person to receive a second Nobel Prize in Chemistry. Forty women have been awarded the Nobel Prize between 1901 and 2010. Seventeen women have been awarded the Nobel Prize in physics, chemistry, physiology or medicine.[2]

Ancient History

- The involvement of women in the field of medicine has been recorded in several early civilizations. An ancient Egyptian, **Merit-Ptah** (c. 2700 BC), described in an inscription as "chief physician", is the earliest known female scientist named in the history of science. **Agamede** was cited by Homer as a healer in ancient Greece before the Trojan War (c. 1194–1184 BC). **Agnodike** was the first female physician to practice legally in fourth century BC Athens.

- The study of natural philosophy in ancient Greece was open to women. Recorded examples include **Aglaonike**, who predicted eclipses; and **Theano**, mathematician and physician, who was a pupil (possibly also wife) of Pythagoras, and one of a school in Crotone founded by Pythagoras, which included many other women.[6]
- During the period of the Babylonian civilization, around 1200 B.C., two perfumeresses named Tapputi-Belatekallim and -ninu (first half of her name lost) were able to obtain the essences from plants by using extraction and distillation procedures. If we are to argue chemistry as the use of chemical equipment and processes, then we can identify these two women as the first chemists.

- Even during the time of the Egyptian dynasty, women were involved in applied chemistry, such as the making of beer and the preparation of medicinal compounds.[9] A good number of women have been recorded to have made major contributions to alchemy.[9] Many of which lived in Alexandria around the 1st or 2nd centuries AD, where the gnostic tradition led to female contributions being valued.
- The most famous of the women alchemist, **Mary the Jewess**, is credited with inventing several chemical instruments, including the double boiler (bain-marie); the improvement or creation of distillation equipment of that time.[9][10] Such distillation equipment were called kerotakis (simple still) and the tribikos (a complex distillation device).[9]
- **Hypatia of Alexandria** (c. 350–415 AD), daughter of Theon of Alexandria, was a well-known teacher at the Neoplatonic School in Alexandria teaching astronomy, philosophy, and mathematics.[11][12] She is recognized to be the first known woman mathematician in history through her major contributions to mathematics.[12] Hypatia is credited with writing three major treatises on geometry, algebra and astronomy; as well as the invention of a hydrometer, an astrolabe, and an instrument for distilling water.[6][13] There is even evidence that Hypatia gave public lectures and may have held some sort of public office in Alexandria.[14] However, her fruitful life was cut short in 415 AD by Christian Zealots, known as Parabalani, who stripped her, dismembered her, and the pieces of her body burned.[14] Some scholars even say her death marked the end of women in science for many hundreds of years.[12]

The Medieval Europe

- The early parts of the European Middle Ages, also known as the Dark Ages, were marked by the decline of the Roman Empire. The Latin West was left with great difficulties that affected the continent's intellectual production dramatically. Although nature was still seen as a system that could be comprehended in the light of reason, there was little innovative scientific inquiry.[15] The Arabic world deserves credit for preserving scientific advancements. Arabic scholars produced original scholarly work and generated copies of manuscripts from Classical periods.[16] During this period, Christianity underwent a period of resurgence, and Western civilization was bolstered as a result. This phenomenon was, in part, due to monasteries and nunneries that nurtured the skills of reading and writing, and the monks and nuns who collected and copied important writings produced by scholars of the past.[16]

- Convents were an important place of education for women during this period, for the monasteries and nunneries encourage the skills of reading and writing, and some of these communities provided opportunities for women to contribute to scholarly research.[16] An example is the German abbess **Hildegard of Bingen** (1098–1179 A.D), a famous philosopher and botanists, known for her prolific writings include treatments of various scientific subjects, including medicine, botany and natural history (c.1151–58).[17] Another famous German abbess was **Hroswitha of Gandersheim** (935–1000 A.D.)[16] that also helped encourage women to be intellectual. However, with the growth in number and power of nunneries, the all-male clerical hierarchy was not welcomed toward it, and thus it stirred up conflict by having backlash against women's advancement. That impacted many religious orders closed on women and disbanded their nunneries, and overall excluding women from the ability to learn to read and write. With that, the world of science became closed off to women, limiting women's influence in science.[16]

Hildegard of Bingen

- Entering the 11th century, the first universities emerged. Women were, for the most part, excluded from university education.[1] However, there were some exceptions. The Italian University of Bologna, for example, allowed women to attend lectures from its inception, in 1088.[18]

- The attitude to educating women in medical fields in Italy appears to have been more liberal than in other places. The physician, **Trotula di Ruggiero**, is supposed to have held a chair at the Medical School of Salerno in the 11th century, where she taught many noble Italian women, a group sometimes referred to as the "ladies of Salerno".[10] Several influential texts on women's medicine, dealing with obstetrics and gynecology, among other topics, are also often attributed to Trotula.
- **Dorotea Bucca** was another distinguished Italian physician. She held a chair of philosophy and medicine at the University of Bologna for over forty years from 1390.[18][19][20][21] Despite the success of some women, cultural biases affecting their education and participation in science were prominent in the Middle Ages. For example, St. Thomas Aquinas, a Christian scholar, wrote, referring to women, "She is mentally incapable of holding a position of authority."[1]

Scientific Revolution (sixteenth and seventeenth centuries)

- **Margaret Cavendish**, a seventeenth-century aristocrat, took part in some of the most important scientific debates of that time. She was however, not inducted into the English Royal Society, although she was once allowed to attend a meeting. She wrote a number of works on scientific matters, including Observations upon Experimental Philosophy (1666) and Grounds of Natural Philosophy. In these works she was especially critical of the growing belief that humans, through science, were the masters of nature. The 1666 work attempted to heighten female interest in science. The observations provided a critique of the experimental science of Bacon and criticized microscopes as imperfect machines.[23]

Margaret Cavendish

- In Germany, the tradition of female participation in craft production enabled some women to become involved in observational science, especially astronomy. Between 1650 and 1710, women were 14% of German astronomers.[24] The most famous female astronomer in Germany was **Maria Winkelmann**. She was educated by her father and uncle and received training in astronomy from a nearby self-taught astronomer. Her chance to be a practicing astronomer came when she married Gottfried Kirch, Prussia's foremost astronomer. She became his assistant at the astronomical observatory operated in Berlin by the Academy of Science. She made original contributions, including the discovery of a comet. When her husband died, Winkelmann applied for a position as assistant astronomer at the Berlin Academy – for which she had experience. As a woman – with no university degree – she was denied the post. Members of the Berlin Academy feared that they would establish a bad example by hiring a woman. "Mouths would gape", they said.[25]
- Winkelmann's problems with the Berlin Academy reflect the obstacles women faced in being accepted in scientific work, which was considered to be chiefly for men. No woman was invited to either the Royal Society of London nor the French Academy of Sciences until the twentieth century. Most people in the seventeenth century viewed a life devoted to any kind of scholarship as being at odds with the domestic duties women were expected to perform.

- A founder of modern botany and zoology, the German **Maria Sibylla Merian** (1647–1717), spent her life investigating nature. When she was thirteen, Sibylla began growing caterpillars and studying their metamorphosis into butterflies. She kept a "Study Book" which recorded her investigations into natural philosophy. In her first publication, The New Book of Flowers, she used imagery to catalog the lives of plants and insects. After her husband died, and her brief stint of living in Siewert, she and her daughter journeyed to Paramaribo for two years to observe insects, birds, reptiles, and amphibians.[26] She returned to Amsterdam and published The Metamorphosis of the Insects of Suriname, which "revealed to Europeans for the first time the astonishing diversity of the rain forest."[27][28] She was a botanist and entomologist who was known for her artistic illustrations of plants and insects. Uncommon for that era, she traveled to South America and Surinam, where, assisted by her daughters, she illustrated the plant and animal life of those regions.[29]
- Overall, the Scientific Revolution did little to change people's ideas about the nature of women - more specifically - their capacity to contribute to science just as men do. According to Jackson Spielvogel, 'Male scientists used the new science to spread the view that women were by nature inferior and subordinate to men and suited to play a domestic role as nurturing mothers. The widespread distribution of books ensured the continuation of these ideas'.[30]

Eighteenth century

- Although women excelled in many scientific areas during the eighteenth century, they were discouraged from learning about plant reproduction. Carl Linnaeus' system of plant classification based on sexual characteristics drew attention to botanical licentiousness, and people feared that women would learn immoral lessons from nature's example. Women were often depicted as both innately emotional and incapable of objective reasoning, or as natural mothers reproducing a natural, moral society.[31]

- The eighteenth century was characterized by three divergent views towards woman: that women were mentally and socially inferior to men, that they were equal but different, and that women were potentially equal in both mental ability and contribution to society.[32] While individuals such as Jean-Jacques Rousseau believed women's roles were confined to motherhood and service to their male partners, the Enlightenment was a period in which women experienced expanded roles in the sciences.[33] The rise of salon culture in Europe brought philosophers and their conversation to an intimate setting where men and women met to discuss contemporary political, social, and scientific topics.[34] While Jean-Jacques Rousseau attacked women-dominated salons as producing ‘effeminate men’ that stifled serious discourse, salons were characterized in this era by the mixing of the sexes.[35]

Laura Bassi

- **Lady Mary Wortley Montagu** defied convention by introducing smallpox inoculation through variolation to Western medicine after witnessing it during her travels in the Ottoman Empire.[36][37] In 1718 Wortley Montague had her son inoculated[37] and when in 1721 a smallpox epidemic struck England, she had her daughter inoculated.[38] This was the first such operation done in Britain.[37] She persuaded Caroline of Ansbach to test the treatment on prisoners.[38] Princess Caroline subsequently inoculated her two daughters in 1722.[37] Under a pseudonym, Wortley Montague published an article describing and advocating in favor of inoculation in September 1722.[39]
- After publicly defending forty nine theses[40] in the Palazzo Pubblico, **Laura Bassi** was awarded a doctorate of Philosophy in 1732 at the University of Bologna.[41] Thus, Bassi became the second woman in the world to earn a philosophy doctorate after Elena Cornaro Piscopia in 1678, 54 years prior. She subsequently defended twelve additional theses at the Archiginnasio, the main building of the University of Bologna which allowed her to petition for a teaching position at the university.[41] In 1732 the university granted Bassi's professorship in philosophy, making her a member of the Aca the Sciences and the first woman to earn a professorship in physics at a university in Europe[41] But the university value that women were to lead a private life and from 1746 to 1777 she gave only one formal dissertation per yea in topic from the problem of gravity to electricity.[40] Because she could not lecture publicly at the university regu began conducting private lessons and experiments from home in the year of 1749.[40] However, due to her increa responsibilities and public appearances on behalf of the university, Bassi was able to petition for regular pay incre which in turn was used to pay for her advanced equipment. Bassi earned the highest salary paid by the University Bologna of 1,200 lire.[42] In 1776, at the age of 65, she was appointed to the chair in experimental physics by the Institute of Sciences with her husband as a teaching assistant.[40]

Laura Bassi

- According to Britannica, **Maria Gaetana Agnesi** is "considered to be the first woman in the Western world to have achieved a reputation in mathematics."[43] She is credited as the first woman to write a mathematics handbook, the Instituzioni analitiche ad uso della gioventù italiana, (Analytical Institutions for the Use of Italian Youth). Published in 1748 it "was regarded as the best introduction extant to the works of Euler."[44][45] The goal of this work was, according to Agnesi herself, to give a systematic illustration of the different results and theorems of infinitesimal calculus.[46] In 1750 she became the second woman to be granted a professorship at a European university. Also appointed to the University of Bologna she never taught there.[44][47]
- The German **Dorothea Erxleben** was instructed in medicine by her father from an early age[48] and Bassi's university professorship inspired Erxleben to fight for her right to practise medicine. In 1742 she published a tract arguing that women should be allowed to attend university.[49] After being admitted to study by a dispensation of Frederick the Great,[48] Erxleben received her M.D. from the University of Halle in 1754.[49] She went on to analyze the obstacles preventing women from studying, among them housekeeping and children.[48] She became the first female medical doctor in Germany.[50]

- In 1741-42 Charlotta Frölich became the first woman to be published by the Royal Swedish Academy of Sciences with three books in agricultural science. In 1748 Eva Ekeblad became the first woman inducted into that academy.[51] In 1746 Ekeblad had written to the academy about her discoveries of how to make flour and alcohol out of potatoes.[52][53] Potatoes had been introduced into Sweden in 1658, but had been cultivated only in the greenhouses of the aristocracy. Ekeblad's work turned potatoes into a staple food in Sweden, and increased the supply of wheat, rye and barley available for making bread, since potatoes could be used instead to make alcohol. This greatly improved the country's eating habits and reduced the frequency of famines.[53] Ekeblad also discovered a method of bleaching cotton textile and yarn with soap in 1751,[52] and of replacing the dangerous ingredients in cosmetics of the time by using potato flour in 1752.[53]
- **Émilie du Châtelet**, a close friend of Voltaire, was the first scientist to appreciate the significance of kinetic energy, as opposed to momentum. She repeated and described the importance of an experiment originally devised by Willem 's Gravesande showing the impact of falling objects is proportional not to their velocity, but to the velocity squared. This understanding is considered to have made a profound contribution to Newtonian mechanics.[54] In 1749 she completed the French translation of Newton's Philosophiae Naturalis Principia Mathematica (the Principia), including her derivation of the notion of conservation of energy from its principles of mechanics. Published ten years after her death, her translation and commentary of the Principia contributed to the completion of the scientific revolution in France and to its acceptance in Europe.[55]

Émilie du Châtelet

- Marie-Anne Pierrette Paulze and her husband Antoine Lavoisier rebuilt the field of chemistry, which had its roots in alchemy and at the time was a convoluted science dominated by George Stahl’s theory of phlogiston. Paulze accompanied Lavoisier in his lab, making entries into lab notebooks and sketching diagrams of his experimental designs. The training she had received allowed her to accurately and precisely draw experimental apparatuses, which ultimately helped many of Lavoisier's contemporaries to understand his methods and results. Paulze translated various works about phlogiston into French. One of her most important translation was that of Richard Kirwan's Essay on Phlogiston and the Constitution of Acids, which she both translated and critiqued, adding footnotes as she went along and pointing out errors in the chemistry made throughout the paper.[56] Paulze was instrumental in the 1789 publication of Lavoisier's Elementary Treatise on Chemistry, which presented a unified view of chemistry as a field. This work proved pivotal in the progression of chemistry, as it presented the idea of conservation of mass as well as a list of elements and a new system for chemical nomenclature. She also kept strict records of the procedures followed, lending validity to the findings Lavoisier published.

- The astronomer **Caroline Herschel** was born in Hanover but moved to England where she acted as an assistant to her brother, William Herschel. Throughout her writings, she repeatedly made it clear that she desired to earn an independent wage and be able to support herself. When the crown began paying her for her assistance to her brother in 1787, she became the first woman to do so at a time when even men rarely received wages for scientific enterprises—to receive a salary for services to science.[57] During 1786–97 she discovered eight comets, the first on 1 August 1786. She had unquestioned priority as discoverer of five of the comets[57][58] and rediscovered Comet Encke in 1795.[59] Five of her comets were published in Philosophical Transactions, a packet of paper bearing the superscription, "This is what I call the Bills and Receipts of my Comets" contains some data connected with the discovery of each of these objects. William was summoned to Windsor Castle to demonstrate Caroline's comet to the royal family.[60] Caroline Herschel is often credited as the first woman to discover a comet; however, Maria Kirch discovered a comet in the early 1700s, but is often overlooked because at the time, the discovery was attributed to her husband, Gottfried Kirch.[61]

Early nineteenth century

- Science remained a largely amateur profession during the early part of the nineteenth century. Women's contributions were limited by their exclusion from most formal scientific education, but began to be recognized by admittance into learned societies during this period.
- Scottish scientist **Mary Fairfax Somerville** carried out experiments in magnetism, presenting a paper entitled 'The Magnetic Properties of the Violet Rays of the Solar Spectrum' to the Royal Society in 1826, the second woman to do so. She also wrote several mathematical, astronomical, physical and geographical texts, and was a strong advocate for women's education. In 1835, she and **Caroline Herschel** were the first two women elected as Honorary Members of the Royal Astronomical Society.[62]
- English mathematician **Ada, Lady Lovelace**, a pupil of Somerville, corresponded with Charles Babbage about applications for his analytical engine. In her notes (1842–3) appended to her translation of Luigi Menabrea's article on the engine, she foresaw wide applications for it as a general-purpose computer, including composing music. She has been credited as writing the first computer program, though this has been disputed.[63]
- In Germany, institutes for "higher" education of women (Höhere Mädchenschule, in some regions called Lyzeum) were founded at the beginning of the century.[64] The Deaconess Institute at Kaiserswerth was established in 1836 to instruct women in nursing. Elizabeth Fry visited the institute in 1840 and was inspired to found the London Institute of Nursing, and Florence Nightingale studied there in 1851.[65]

Late 19th century in western Europe

- The latter part of the 19th century saw a rise in educational opportunities for women. Schools aiming to provide education for girls similar to that afforded to boys were founded in the UK, including the North London Collegiate School (1850), Cheltenham Ladies' College (1853) and the Girls' Public Day School Trust schools (from 1872). The first UK women's university college, Girton, was founded in 1869, and others soon followed: Newnham (1871) and Somerville (1879).
- The Crimean War (1854–6) contributed to establishing nursing as a profession, making **Florence Nightingale** a household name. A public subscription allowed Nightingale to establish a school of nursing in London in 1860, and schools following her principles were established throughout the UK.[65] Nightingale was also a pioneer in public health as well as a statistician.
- **James Barry** became the first British woman to gain a medical qualification in 1812, passing as a man. Elizabeth Garrett Anderson was the first openly female Briton to qualify medically, in 1865. With Sophia Jex-Blake, American Elizabeth Blackwell and others, Garret Anderson founded the first UK medical school to train women, the London School of Medicine for Women, in 1874.

- **Annie Scott Dill Maunder** was a pioneer in astronomical photography, especially of sunspots. A mathematics graduate of Girton College, Cambridge, she was first hired (in 1890) to be an assistant to Edward Walter Maunder, discoverer of the Maunder Minimum, the head of the solar department at Greenwich Observatory. They worked together to observe sunspots and to refine the techniques of solar photography. They married in 1895. Annie's mathematical skills made it possible to analyze the years of sunspot data that Maunder had been collecting at Greenwich. She also designed a small, portable wide-angle camera with a 1.5-inch-diameter (38 mm) lens. In 1898, the Maunders traveled to India, where Annie took the first photographs of the sun's corona during a solar eclipse. By analyzing the Cambridge records for both sunspots and geomagnetic storm, they were able to show that specific regions of the sun's surface were the source of geomagnetic storms and that the sun does not radiate its energy uniformly into space, as William Thomson, 1st Baron Kelvin had declared.

Annie Scott Dill Maunder

Late nineteenth century Russians

- In the second half of the 19th century a large proportion of the most successful women in the STEM fields were Russians. Although many women received advanced training in medicine in the 1870s,[69] in other fields women were barred and had to go to western Europe—mainly Switzerland—in order to pursue scientific studies. In her book about these "women of the [eighteen] sixties" (шестидесятницы), as they were called, Ann Hibner Koblitz writes:[70]
- To a large extent, women's higher education in continental Europe was pioneered by this first generation of Russian women. They were the first students in Zürich, Heidelberg, Leipzig, and elsewhere. Theirs were the first doctorates in medicine, chemistry, mathematics, and biology.
- Among the successful scientists were Nadezhda Suslova (1843–1918), the first woman in the world to obtain a medical doctorate fully equivalent to men's degrees; Maria Bokova-Sechenova (1839–1929), a pioneer of women's medical education who received two doctoral degrees, one in medicine in Zürich and one in physiology in Vienna; Iulia Lermontova (1846–1919), the first woman in the world to receive a doctoral degree in chemistry; the marine biologist Sofia Pereiaslavtseva (1849–1903), director of the Sevastopol Biological Station and winner of the Kessler Prize of the Russian Society of Natural Scientists; and the mathematician Sofia Kovalevskaia (1850–1891), the first woman in 19th century Europe to receive a doctorate in mathematics and the first to become a university professor in any field.[70]

Late nineteenth century in the United States

- In the later nineteenth century the rise of the women's college provided jobs for women scientists, and opportunities for education.
- Women's colleges produced a disproportionate number of women who went on for PhDs in science. Many coeducational colleges and universities also opened or started to admit women during this period; such institutions included just over 3000 women in 1875, by 1900 numbered almost 20,000.[68]
- An example is **Elizabeth Blackwell**, who became the first certified female doctor in the US when she graduated from Geneva Medical College in 1849.[71] With her sister, Emily Blackwell, and Marie Zakrzewska, Blackwell founded the New York Infirmary for Women and Children in 1857 and the first women's medical college in 1868, providing both training and clinical experience for women doctors. She also published several books on medical education for women.
- In 1876, Elizabeth Bragg became the first woman to graduate with a civil engineering degree in the United States, from the University of California, Berkeley.[72]

Early twentieth century

Europe before World War II

- **Marie Skłodowska-Curie**, the first woman to win a Nobel prize in 1903 (physics), went on to become a double Nobel prize winner in 1911, both for her work on radiation. She was the first person to win two Nobel prizes, a feat accomplished by only three others since then. She also was the first woman to teach at Sorbonne University in Paris, France.[73]
- **Lise Meitner** played a major role in the discovery of nuclear fission. As head of the physics section at the Kaiser Wilhelm Institute in Berlin she collaborated closely with the head of chemistry Otto Hahn on atomic physics until forced to flee Berlin in 1938. In 1939, in collaboration with her nephew Otto Frisch, Meitner derived the theoretical explanation for an experiment performed by Hahn and Fritz Strassman in Berlin, thereby demonstrating the occurrence of nuclear fission. The possibility that Fermi's bombardment of uranium with neutrons in 1934 had instead produced fission by breaking up the nucleus into lighter elements, had actually first been raised in print in 1934, by chemist Ida Noddack (co-discover of the element rhenium), but this suggestion had been ignored at the time, as no group made a concerted effort to find any of these light radioactive fission products.

- **Emmy Noether** revolutionized abstract algebra, filled in gaps in relativity, and was responsible for a critical theorem about conserved quantities in physics. One notes that the Erlangen program attempted to identify invariants under a group of transformations. On 16 July 1918, before a scientific organization in Göttingen, Felix Klein read a paper written by Emmy Noether, because she was not allowed to present the paper herself. In particular, in what is referred to in physics as Noether's theorem, this paper identified the conditions under which the Poincaré group of transformations (now called a gauge group) for general relativity defines conservation laws.[76] Noether's papers made the requirements for the conservation laws precise. Among mathematicians, Noether is best known for her fundamental contributions to abstract algebra, where the adjective noetherian is nowadays commonly used on many sorts of objects.
- Mary Cartwright was a British mathematician who was the first to analyze a dynamical system with chaos. Inge Lehmann, a Danish seismologist, first suggested in 1936 that inside the Earth's molten core there may be a solid inner core.[77] Women such as Margaret Fountaine continued to contribute detailed observations and illustrations in botany, entomology, and related observational fields. Joan Beauchamp Procter, an outstanding herpetologist, was the first woman Curator of Reptiles for the Zoological Society of London at London Zoo.
- Florence Sabin was an American medical scientist. Sabin was the first woman faculty member at Johns Hopkins in 1902, and the first woman full-time professor there in 1917.[78] Her scientific and research experience is notable. Sabin published over 100 scientific papers and multiple books.[78]

United States before World War II

- Women moved into science in significant numbers by 1900, helped by the women's colleges and by opportunities at some of the new universities. Margaret Rossiter's books Women Scientists in America: Struggles and Strategies to 1940 and Women Scientists in America: Before Affirmative Action 1940–1972 provide an overview of this period, stressing the opportunities women found in separate women's work in science.[79][80]
- In 1892, **Ellen Swallow Richards** called for the "christening of a new science" – "oekology" (ecology) in a Boston lecture. This new science included the study of "consumer nutrition" and environmental education. This interdisciplinary branch of science was later specialized into what is currently known as ecology, while the consumer nutrition focus split off and was eventually relabeled as home economics.,[81][82] which provided another avenue for women to study science. Richards helped to form the American Home Economics Association, which published a journal, the Journal of Home Economics, and hosted conferences. Home economics departments were formed at many colleges, especially at land grant institutions. In her work at MIT, Ellen Richards also introduced the first biology course in its history as well as the focus area of sanitary engineering.
- Women also found opportunities in botany and embryology. In psychology, women earned doctorates but were encouraged to specialize in educational and child psychology and to take jobs in clinical settings, such as hospitals and social welfare agencies.

- In 1901, Annie Jump Cannon first noticed that it was a star's temperature that was the principal distinguishing feature among different spectra.[dubious – discuss] This led to re-ordering of the ABC types by temperature instead of hydrogen absorption-line strength. Due to Cannon's work, most of the then-existing classes of stars were thrown out as redundant. Afterward, astronomy was left with the seven primary classes recognized today, in order: O, B, A, F, G, K, M;[83] that has since been extended.
- Henrietta Swan Leavitt made fundamental contributions to astronomy.[84] Henrietta Swan Leavitt first published her study of variable stars in 1908. This discovery became known as the "period-luminosity relationship" of Cepheid variables.[85] Our picture of the universe was changed forever, largely because of Leavitt's discovery.
- The accomplishments of Edwin Hubble, renowned American astronomer, were made possible by Leavitt's groundbreaking research and Leavitt's Law. "If Henrietta Leavitt had provided the key to determine the size of the cosmos, then it was Edwin Powell Hubble who inserted it in the lock and provided the observations that allowed it to be turned", wrote David H. and Matthew D.H. Clark in their book Measuring the Cosmos.[86] Hubble often said that Leavitt deserved the Nobel for her work.[87] Gösta Mittag-Leffler of the Swedish Academy of Sciences had begun paperwork on her nomination in 1924, only to learn that she had died of cancer three years earlier[88] (the Nobel prize cannot be awarded posthumously).
- In 1925, Harvard graduate student Cecilia Payne-Gaposchkin demonstrated for the first time from existing evidence on the spectra of stars that stars were made up almost exclusively of hydrogen and helium, one of the most fundamental theories in stellar astrophysics.[83][85]

- Canadian born Maud Menten worked in the US and Germany. Her most famous work was on enzyme kinetics together with Leonor Michaelis, based on earlier findings of Victor Henri. This resulted in the Michaelis–Menten equations. Menten also invented the azo-dye coupling reaction for alkaline phosphatase, which is still used in histochemistry. She characterised bacterial toxins from B. paratyphosus, Streptococcus scarlatina and Salmonella ssp., and conducted the first electrophoretic separation of proteins in 1944. She worked on the properties of hemoglobin, regulation of blood sugar level, and kidney function.
- World War II brought some new opportunities. The Office of Scientific Research and Development, under Vannevar Bush, began in 1941 to keep a registry of men and women trained in the sciences. Because there was a shortage of workers, some women were able to work in jobs they might not otherwise have accessed. Many women worked on the Manhattan Project or on scientific projects for the United States military services. Women who worked on the Manhattan Project included Leona Woods Marshall, Katharine Way, and Chien-Shiung Wu.

- Women in other disciplines looked for ways to apply their expertise to the war effort. Three nutritionists, Lydia J. Roberts, Hazel K. Stiebeling, and Helen S. Mitchell, developed the Recommended Dietary Allowance in 1941 to help military and civilian groups make plans for group feeding situations. The RDAs proved necessary, especially, once foods began to be rationed. Rachel Carson worked for the United States Bureau of Fisheries, writing brochures to encourage Americans to consume a wider variety of fish and seafood. She also contributed to research to assist the Navy in developing techniques and equipment for submarine detection.
- Women in psychology formed the National Council of Women Psychologists, which organized projects related to the war effort. The NCWP elected Florence Laura Goodenough president. In the social sciences, several women contributed to the Japanese Evacuation and Resettlement Study, based at the University of California. This study was led by sociologist Dorothy Swaine Thomas, who directed the project and synthesized information from her informants, mostly graduate students in anthropology. These included Tamie Tsuchiyama, the only Japanese-American woman to contribute to the study, and Rosalie Hankey Wax.

- In the United States Navy, female scientists conducted a wide range of research. Mary Sears, a planktonologist, researched military oceanographic techniques as head of the Hydgrographic Office's Oceanographic Unit. Florence van Straten, a chemist, worked as an aerological engineer. She studied the effects of weather on military combat. Grace Hopper, a mathematician, became one of the first computer programmers for the Mark I computer. Mina Spiegel Rees, also a mathematician, was the chief technical aide for the Applied Mathematics Panel of the National Defense Research Committee.
- Gerty Cori was a biochemist who discovered the mechanism by which glycogen, a derivative of glucose, is transformed in the muscles to form lactic acid, and is later reformed as a way to store energy. For this discovery she and her colleagues were awarded the Nobel prize in 1947, making her the third woman and the first American woman to win a Nobel Prize in science. She was the first woman ever to be awarded the Nobel Prize in Physiology or Medicine. Cori is among several scientists whose works are commemorated by a U.S. postage stamp.[89]

United States after World War II

- Kay McNulty, Betty Jennings, Betty Snyder, Marlyn Wescoff, Fran Bilas and Ruth Lichterman **were six of the original programmers for the ENIAC, the first general purpose electronic computer.[93]**
- Linda B. Buck is a neurobiologist who was awarded the 2004 Nobel Prize in Physiology or Medicine along with Richard Axel for their work on olfactory receptors.
- Biologist and activist Rachel Carson published Silent Spring, a work on the dangers of pesticides, in 1962.
- Eugenie Clark, popularly known as The Shark Lady, was an American ichthyologist known for her research on poisonous fish of the tropical seas and on the behavior of sharks.
- Ann Druyan is an American writer, lecturer and producer specializing in cosmology and popular science. Druyan has credited her knowledge of science to the 20 years she spent studying with her late husband, Carl Sagan, rather than formal academic training.[citation needed] She was responsible for the selection of music on the Voyager Golden Record for the Voyager 1 and Voyager 2 exploratory missions. Druyan also sponsored the Cosmos 1 spacecraft.
- Gertrude B. Elion was an American biochemist and pharmacologist, awarded the Nobel Prize in Physiology or Medicine in 1988 for her work on the differences in biochemistry between normal human cells and pathogens.
- Sandra Moore Faber, with Robert Jackson, discovered the Faber–Jackson relation between luminosity and stellar dispersion velocity in elliptical galaxies. She also headed the team which discovered the Great Attractor, a large concentration of mass which is pulling a number of nearby galaxies in its direction.
- Zoologist Dian Fossey worked with gorillas in Africa from 1967 until her murder in 1985.
- Astronomer Andrea Ghez received a MacArthur "genius grant" in 2008 for her work in surmounting the limitations of earthbound telescopes.[94]
- Maria Goeppert-Mayer was the second female Nobel Prize winner in Physics, for proposing the nuclear shell model of the atomic nucleus. Earlier in her career, she had worked in unofficial or volunteer positions at the university where her husband was a professor. Goeppert-Mayer is one of several scientists whose works are commemorated by a U.S. postage stamp.[95]
- Sulamith Low Goldhaber and her husband Gerson Goldhaber formed a research team on the K meson and other high-energy particles in the 1950s.
- Carol Greider and the Australian born Elizabeth Blackburn, along with Jack W. Szostak, received the 2009 Nobel Prize in Physiology or Medicine for the discovery of how chromosomes are protected by telomeres and the enzyme telomerase.
- Rear Admiral Grace Murray Hopper developed the first computer compiler while working for the Eckert Mauchly Computer Corporation, released in 1952.

Deborah S. Jin's team at JILA, in Boulder, Colorado in 2003 produced the first fermionic condensate, a new state of matter.

Stephanie Kwolek, a researcher at DuPont, invented poly-paraphenylene terephthalamide – better known as Kevlar.

Lynn Margulis is a biologist best known for her work on endosymbiotic theory, which is now generally accepted for how certain organelles were formed.

Barbara McClintock's studies of maize genetics demonstrated genetic transposition in the 1940s and 1950s. She dedicated her life to her research, and she was awarded the Nobel Prize in Physiology or Medicine in 1983. McClintock is one of several scientists whose works are commemorated by a U.S. postage stamp.[96]

Nita Ahuja is a renowned surgeon-scientist known for her work on CIMP in cancer, she is currently the Chief of surgical oncology at Johns Hopkins Hospital. First woman ever to be the Chief of this prestigious department.

Carolyn Porco is a planetary scientist best known for her work on the Voyager program and the Cassini–Huygens mission to Saturn. She is also known for her popularization of science, in particular space exploration.

Physicist Helen Quinn, with Roberto Peccei, postulated Peccei-Quinn symmetry. One consequence is a particle known as the axion, a candidate for the dark matter that pervades the universe. Quinn was the first woman to receive the Dirac Medal and the first to receive the Oskar Klein Medal.

Lisa Randall is a theoretical physicist and cosmologist, best known for her work on the Randall–Sundrum model. She was the first tenured female physics professor at Princeton University.

Sally Ride was an astrophysicist and the first American woman, and then-youngest American, to travel to outer space. Ride wrote or co-wrote several books on space aimed at children, with the goal of encouraging them to study science.[97][98] Ride participated in the Gravity Probe B (GP-B) project, which provided more evidence that the predictions of Einstein's general theory of relativity are correct.[99]

Through her observations of galaxy rotation curves, astronomer Vera Rubin discovered the Galaxy rotation problem, now taken to be one of the key pieces of evidence for the existence of dark matter. She was the first female allowed to observe at the Palomar Observatory.

Sara Seager is a Canadian-American astronomer who is currently a professor at the Massachusetts Institute of Technology and known for her work on extrasolar planets.

Astronomer Jill Tarter is best known for her work on the search for extraterrestrial intelligence. Tarter was named one of the 100 most influential people in the world by Time Magazine in 2004.[100] She is the former director of SETI.[101]

Rosalyn Yalow was the co-winner of the 1977 Nobel Prize in Physiology or Medicine (together with Roger Guillemin and Andrew Schally) for development of the radioimmunoassay (RIA) technique.

Nobel laureates

The Nobel Prize and Prize in Economic Sciences have been awarded to women 49 times between 1901 and 2017. One woman, Marie Sklodowska-Curie, has been honored twice, with the 1903 Nobel Prize in Physics and the 1911 Nobel Prize in Chemistry. This means that 48 women in total have been awarded the Nobel Prize between 1901 and 2010. 18 women have been awarded the Nobel Prize in physics, chemistry, physiology or medicine.[2]

- **Chemistry[edit]**
- 2018 – Frances Arnold
- 2009 – Ada E. Yonath
- 1964 – Dorothy Crowfoot Hodgkin
- 1935 – Irène Joliot-Curie
- 1911 – Marie Sklodowska-Curie
- **Physics[edit]**
- 2018 – Donna Strickland
- 1963 – Maria Goeppert-Mayer
- 1903 – Marie Sklodowska-Curie

- **Physiology or Medicine[edit]**
- 2015 – Youyou Tu
- 2014 – May-Britt Moser
- 2009 – Elizabeth H. Blackburn
- 2009 – Carol W. Greider
- 2008 – Françoise Barré-Sinoussi
- 2004 – Linda B. Buck
- 1995 – Christiane Nüsslein-Volhard
- 1988 – Gertrude B. Elion
- 1986 – Rita Levi-Montalcini
- 1983 – Barbara McClintock
- 1977 – Rosalyn Yalow
- 1947 – Gerty Cori

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