Women in Astronomy

En Hedu'Anna 2354 BC (Akkad/Sumer - Mesopotamian)
Second recorded technical name; First technical recorded name: Imhotep (Great Pyramid).
Daughter of King Sargon I: empire joined Sumer and Akkad; later became Babylon. (He was Akkadian).

En (means "high priestess") Hedu'Anna was appointed by her father to be the head priestess of the Moon god's temple in Ur. Nanna - moon god; Innana - goddess. "Chief Priestess of the Ornament of Heaven." First of 500 years of high priestesses; important in government - father was cementing sovereignty; priestesses confirmed rulers. Temples were also places of learning and governance, and places used for observing the sky - studying motions etc.

Disk (heavily restored) is in the University of Pennsylvania Museum

(Astronomically speaking, Babylonian records are the first we have: they gave us the basis for our modern calendars and 360 degrees in a circle. Using Babylonian records, Hipparchus discovered the precession of the Earth's rotation axis.)

Oldest known author (identifies herself; writes in first person). 42 poems remain, mostly to her goddess. Nanna - moon god; Innana - goddess

"En Hedu'Anna is the last in a long line of women who followed the stars and the cycles of the Moon and whose names are lost to us. She is the first in a long line of women whose names we know - the women who thought, created and built for the past 4000 years."

Aglaonike (c. 200 BC)
"First woman astronomer"
Greek (Thessaly); knew how to predict eclipses - 'could make the moon disappear at will.' She was thought to be a witch! She is mentioned by Plutarch as being able to "call the moon down" from the sky... In *Orpheus and Euridice* she was the evil high priestess of the moon-goddess Hecate.

Hypatia (c. 370 - 415 AD)
This engraving is from the book "Little Journeys to the Homes of Great Teachers" by Elbert Hubbard (New York: Roycrafters), 1908 [4000 years site]

Daughter of Theon (mathematician, philosopher); he worked in the Museum of Alexandria - precursor to universities. He educated Hypatia, who got further training and then became an instructor at the Platonist School. She was considered a "charismatic orator." She was generally regarded highly and was very popular. She wrote commentaries on mathematics, and helped her father edit his commentary on Ptolemy's Almagest. She is considered the first "true astronomer."

Her popularity and connection with the Neoplatonists (pagans) got her in trouble politically with the early Christians of the time, especially Cyril, the patriarch (bishop) of Alexandria. Neoplatonists were considered rivals of Christians. Her friendship with Orestes, the Roman prefect, led to her death: she was attacked and killed by a mob as part of the rivalry between Cyril and Orestes. She was torn apart and used as a example: she was a scientist and pagan - so used "magic and mysticism" according to the early Christians!

Her death marks the beginning of the end of scholarship in Alexandria, as many scholars begin to leave.

Her works (editing?) include

Euclid's Geometry
A Commentary on the Arithmetica of Diophantus
A Commentary on the Conics of Apollonious
She edited the third book of her father's Commentary Ptolemy's Almagest

Sophia Brahe (1556 - 1643); Tycho's sister
10 years younger than Tycho, she was educated by tutors and by Tycho himself. As a teenager, she assisted him in his observations and calculations at his observatory, Uraniborg, on the island of Hven. She left upon her marriage, but returned 10 years later, after her husband's death. With Tycho, she helped compile a very accurate star catalog and database of planetary positions and motions (but receives little historical credit). She was also a horticulturist, a healer, and a historian. She

was disowned by her parents upon Tycho's death in 1601, and remarried. She later supported herself by horoscopes and healing. Died age 87.

Marie Cunitz (1610 - 1664)
"...simplified, and 'corrected'" Johannes Kepler's work. Kepler was hired by Tycho Brahe, and used 'his' (their!) data to determine how the planets moved (Kepler's three laws of Planetary Motion). She was born in Silesia (Poland); which was torn by strife. She was educated by her father, and encouraged in her intellectual pursuits by her husband. She spoke 7 languages, and was versed in astronomy and mathematics. In her book "Urania Propitia", she added original work to Kepler's Rudolphine Tables: new tables and methods, and included a more simple and direct solution to "Kepler's Problem." Her work made Kepler's contributions available to a much wider range of people. She published her "translations" of Kepler's works in 1648 - they were delayed for a few (two?) years due to the 30 years War. These translations were the only ones available to scholars of her time for years to come. She became so well known that she was called *Urania Propitia* : closest to the muse of Astronomy, Urania. She has a crater, Cunitz, named after her on Venus.

Caroline Herschel (1750 - 1848)
Sister of William Herschel. Born in Germany into a musical family (dad); mom only believed in educating the boys (4 boys, 2 girls) though. She had typhus at age 10, which stunted her growth (she was 4' 3"!) and, in her parents' opinion, ruined her chances for marriage. At 22, when her older brother William offered to pay their mother for a maid to replace her, she left Germany to work with William in England. He started as a professional musician, but gave it up for full-time astronomy after his discovery of the planet Uranus. Caroline, who became well known as a singer, had been assisting him with his observations; eventually she became his apprentice. She ground and polished mirrors, took data, and did the calculations. She detected and recorded her observations of nebulae (only detectable because of William's fine telescopes). William gave her her own telescope, and with it she discovered her first comet in 1786. King George gave her a pension (œ50) (as he had for William - œ200) in recognition of her discovery - she became the first "professional" woman astronomer - she got paid for her work! She eventually discovered 8 comets and made a catalog of over 2500 nebulae. She

also mentored and worked with her nephew John, William's son, who became a well known astronomer in his own right. She was awarded a gold medal by the Royal Astronomical Society in 1828 (at the age of 78; she died at 98!).

http://wwwgroups.dcs.stand.ac.uk/~history/Mathematicians/Herschel_Caroline.html

1786 - 1797: discovered 8 comets
1798 - published (RAS) an index + corrections to Flamsteed's star catalog
1822 - returned to Hanover upon William's death; continued to assist John by compiling a catalog of 2500 nebulae
1828 - Gold medal from RAS
1835 - Honorary membership to RAS (with Mary Somerville; first 2 women)
1838 - membership in Irish Royal Academy
1846 - Gold medal from King of Prussia

Mary Somerville (1780 - 1872)
Born in Scotland; died in Italy. One of 4 (surviving) children (2 boys, 2 girls) in a well-to-do family that didn't believe in educating their two daughters - just taught Mary to read (not write!). But after about age 10, she determined to educate herself and began reading everything she could find, although she was criticized for it by her family, except for her uncle. He encouraged her and helped her learn Latin when she visited him.

After age 13, she became interested in mathematics - her painting teacher, the artist Nasymth was explaining how Euclid's *Elements* "formed the basis for understanding perspective" to another pupil, and that it was also the basis for understanding sciences, including astronomy. Mary got her younger brother's tutor to help her study Euclid, as well as algebra, which she had read about in a women's magazine!

At 24 she married Samuel Grieg; but he disapproved of her studies. After his death 3 years later (and two children), she returned to her studies, and in 1811 won a silver medal for her solution to one of the mathematical problems in the

Mathematical Repository; this solution arose from her correspondences with a mathematics professor, William Wallace, at the Royal Military College. Wallace encouraged her; and she read Newton's *Principia* and Laplace's *Mecanique Celeste* (among other texts).

She married William Somerville in 1812; he was the son of the Uncle that helped educate her. Not surprisingly then, William encouraged her intellectual pursuits and was interested in science himself. They moved in scientific and intellectual circles; and William became a member of the Royal Society in 1816. They met with many famous scientists and thinkers of the time in London and Paris over the next several years, including the Hershels, Babbage, Laplace, Poisson...

In 1826, Mary published her first paper: *The magnetic properties of the violet rays of the solar spectrum*; and in 1827 she was asked to translate Laplace's *Mecanique Celeste* for the Royal Society. Her "translation" (1831) was much more than that - she explained Laplace's mathematics in great detail, and it was through her translation that his work became known in England.

In the sixth edition of her next book, *The Connection of the Physical Sciences,* she proposed a hypothetical 8th planet perturbing Uranus, which led John Couch Adams to investigate the possibility - and discover Neptune.

1835: elected to Royal Astronomical Society
1834: Societe de Physique et d'Historie Naturelle de Geneve; Irish Royal Academy; awarded civil pension œ200, later œ300 (1837).
Moved to Italy when her husband's health began to fail; continued working. Her work influenced Maxwell.

She supported Sufferage; hers was the first name (by request) on John Stuart Mill's petition to allow women the vote.

1848: published *Physical Geography*, which was used as THE text in universities for the next 50 years.
1857: American Geographical and Statistical Society
1870: Italian Geographical Society; Victoria Gold Medal of Royal Geog. Society
1879: Somerville College in Oxford named after her

Maria Mitchell (1818-1889)
Born on Nantucket (one of 10!) - ALL educated. Fishing community; women tended to need to be independent. Father was amatuer astronomer, rating chronometers/setting sextants, surveying (long. and lat. determinations). Maria assisted him. She was sent to a (non-traditional) female academy, where she learned higher math and became an instructor. At 18, she became the first librarian of the Nantucket Atheneum, and finished her education on her own. She observed most nights, and in 1847, she discovered a comet telescopically - one not visible to the naked eye. For this, she won a Gold Medal from the King of Denmark, who had established the prize 16 years earlier. In 1848, she became the first woman member (later, fellow) of the American Academy of Arts and Sciences - the only woman for the next 100 years. In 1849, she received a position with the American Ephemeris and Almanac (next 15 years) - becoming America's first female professional astronomer.

When her friend, Matthew Vassar, founded a college in 1865 (to educate his niece!), he asked her to head up the Astronomy Department, which she did until 1888, a year before her death. While there, she educated scores of young women, often taking them on trips to observe solar eclipses and meet influential women of the day (Louisa May Alcott, Elizabeth Cady Stanton, Julia Ward Howe). She hired her father as her assistant!

There is now an observatory on Nantucket named after her, and a Maria Mitchell Association dedicated to understanding the universe through research and education.

1847 discovered the comet of 1847 Comet Mitchell 1847VI
1848 appointed the first woman to the Academy of Arts and Sciences
1853 awarded the first advanced degree given to a woman from Indiana Hanover College.
1859 awarded the Medal of Merit from Switzerland and the Republic of San Moreno
1865 appointed to the American Philosophical Society
1865 appointed the first woman to the faculty of Vassar - $800/yr; men got $2500

1875 elected president of the American Association for the Advancement of Women

Naval Observatory Computers

1903 picture of computers, and 1932 staff picture.
http://maia.usno.navy.mil/women_history/history.html

Miss Lansom
Ms. Krampe
Ms. Elsie Willis Ms. Savage
Lewis Hedrick

Although men and women hired as computers started at the same salary, the men usually quickly advanced to better-paying jobs. The highest ranking jobs required a military commission, which was unavailable to women. Also, computers/ assistants could only publish under a supervisor's name; this also made it hard for women to advance. Much of the work being done used the Observatory's telescopes, but women were not allowed to observe with them (immoral) until after WWI when the labor shortage became acute.

Women of the Harvard College Observatory

Computers: calculate orbits, measure positions and brightnesses of stars, classify spectra. Edward Pickering, director of the HCO from 1877 - 1919, hired women (eventually, a total of 45) to examine the photographic plates being taken by the Observatory. They were cheaper; he said he could hire 3 or 4 women in the place of one man! Efficiency-minded...
Many of these plates were part of the Henry Draper Memorial project to classify stellar spectra.

Williamina Fleming (1857 - 1911) large picture

A group of women staff members directed by Mrs. Williamina Fleming, circa 1890. Standing: Fleming and Edward C. Pickering, sitting on right facing Pickering is Evelyn Leland, examining a plate; at rear left is Antonia Maury. (Courtesy Curator of Astronomical Photographs at Harvard College Observatory)

One of first women hired by Pickering - she was his maid!

Born in Scotland, emigrated to US 1877 (20 yrs old) with husband. "Marriage failed"; got a job as domestic. 1881 started work at Observatory (bet). Set up classification system for spectra, 17 classes: A - Q. Classified over 10,000 spectra published in the first Henry Draper catalog. Discovered 10/24 then-known novae, over 300 variable stars, over 59 nebulae. In 1885, published two papers under her own name in ApJ; published others with Pickering (who gave her credit, and nominated her 3 times for an award given by the ASP - unsuccessfully). In 1899, she received the first professional position for a woman at HCO, as Curator of Astronomical Photographs.

First American woman admitted to the Royal Astronomical Society (honorary).

[http://www.geocities.com/Wellesley/1582/muses.html#Scientists]

Antonia Maury (1866 - 1952) Seated; rear left
Henry Draper's niece; graduated Vassar in 1887 (Maria Mitchell still at Vassar). Hired by Pickering 1887. Worked on spectroscopic binaries, determining periods - Pickering discovered first (Mizar), she calculated its period. She discovered second (B Aurigae). Developed luminosity classes based on width of spectral lines. Herzsprung used it to verify his "discovery" of dwarf vs. giant stars. This led to the HR diagram - realizing that stars with the same T (spectral class), could have different L - which meant different R:
$L = 4\pi\sigma R^2 T^4$.

Pickering didn't like her system though; it required confirming spectra, and was time-consuming (not efficient!). This led to her leaving HCO for a teaching position; she also worked with Shapley on binaries. Received Annie Jump Cannon award from the AAS in 1943.

Annie Jump Cannon (1863 - 1941)
Born in Delaware; mostly deaf due to childhood illness. Graduated from Wellesley (Sarah Whiting) in 1884; back home in Delaware for 10 years. Got a job at Wellesley in 1894 after her mother died, teaching physics; also studied astronomy at Radcliffe. Hired in 1896 as a computer at HCO. She took over, reorganized, simplified, and refined Fleming's and Maury's classification schemes for stellar spectra, which resulted in the system used today. It was adopted by all

American observatories in 1910, and by the IAU in 1922. During her work with the Henry Draper Catalog, she classified and published 350,000 spectra. These catalogs are still used today. She also discovered over 300 variable stars.

She won numerous awards and honorary doctorates, but she didn't receive a formal permanent position with HCO until 1938 at the age of 74. She retired two years later!

1921 - doctorate in Astronomy from Groningen University (first woman)
1923 - voted one of 12 greatest living American women
1925 - honorary degree from Oxford (first woman)
1931 - honorary member of Royal Astronomical Society
Draper Gold Medal from the National Academy of Sciences
1932 - last woman to win Ellen Richards Research prize; donated money to AAS to establish award - Annie Jump Cannon Award, for women astronomers in the early stages of their career. Very presitigious.

First woman officer of AAS.

Henrietta Swan Leavitt (1868 - 1921)
Graduated Radcliffe; joined HCO 1895 (originally as volunteer-assistant). Became deaf from illness. Returned to HCO in 1902: permanent position; director of photographic photometry department. Discovered 1,777 new variables in SMC: 1912: discovered Period-Luminosity relationship for Cepheid variables: inherently brighter (more L) stars had slower periods. This enabled Hertzsprung to calculate distances (HR diagram); enabled Shapley to estimate size and shape of our galaxy, and Hubble to calculate distance to Andromeda. Eventually discovered over 2,400 variables, about half the total then-known. Created Harvard Standard for measuring photographic magnitudes; adopted internationally. Considered "brightest mind at the Observatory." A member of the Swedish Academy thought she deserved a Nobel prize, but she died before she could be nominated.

Cecilia Payne-Gaposchkin (1900 - 1979)
Born in England; graduated from Cambridge in 1923; came to US - better prospects. New director of HCO (Shapley), offered her the Pickering Fellowship

(for women students) - attended Radcliffe, where she worked on her doctorate (at HCO). [Continued Leavitt's photometric classification work] In 1925, she became the first PERSON to receive a doctorate in Astronomy from Harvard or Radcliffe (or HCO). In her doctorate, she established that the spectral sequence was a temperature sequence. All those spectral lines were an effect of temperature, not composition (per se) - and all stars were made primarily of H. In 1960, Otto Stuve called it "the most brilliant Ph.D. thesis ever written in astronomy."

But - trouble with Henry Norris Russell: "impossible" - so she published it saying it was "almost certainly not real." Hah! [He had a competing theory: that the sun (and stars) had the same composition as the Earth; if you heated the Earth, its spectrum would look like the Sun's.]

Although she obtained a position for her future husband at Harvard in 1932, she didn't receive a formal position ("astronomer") there until 1938. In 1956, she became the first woman full professor at Harvard, and chair of the Astronomy Department - the first woman to hold a "regular" chair (not created specifically for a woman).

She received numerous awards, including the first Annie Jump Cannon award in 1943; and the Henry Norris Russell (!) Prize from the AAS in 1976 (lifetime achievements).

"The reward of the young scientist is the emotional thrill of being the first person in the history of the world to see something or to understand something. Nothing can compare with that experience; it engenders what Thomas Huxley called the Divine Dipsomania. The reward of the old scientist is the sense of having seen a vague sketch grow into a masterly landscape. Not a finished picture, of course; a picture that is still growing in scope and detail with the application of new techniques and new skills. The old scientist cannot claim that the masterpiece is his own work. He may have roughed out part of the design, laid on a few strokes, but he has learned to accept the discoveries of others with the same delight that he experienced his own when he was young."