

Glossary

Hearing Aid (Page 9)- As of 1898 a major scientific breakthrough in telephonic transmissions allowed for the invention of the Akouphone by Miller Reese Hutchinson (pictured right below). Before his wearable, electrical solution, HOH folks would have to carry around ear trumpets (pictured right above) to amplify ambient sounds. As of 1900, the device sold for around \$60 (\$1800 in today's money), so it was an investment for the family and would still be relatively new to Henrietta, which makes sense for how often she would remove it. She started losing her hearing at age 17, probably due to meningitis, and it got progressively worse with age.



“The Akouphone, powered by a battery, was revolutionary in its use of **electrical amplification**. A crucial component, the **carbon transmitter**, converted sound vibrations into electrical signals. These signals were then amplified through a small electric current, resulting in a significant increase in sound volume. This technological leap made the Akouphone portable hearing aids.”



1. [Learn more here.](#)
2. [Learn more here.](#)

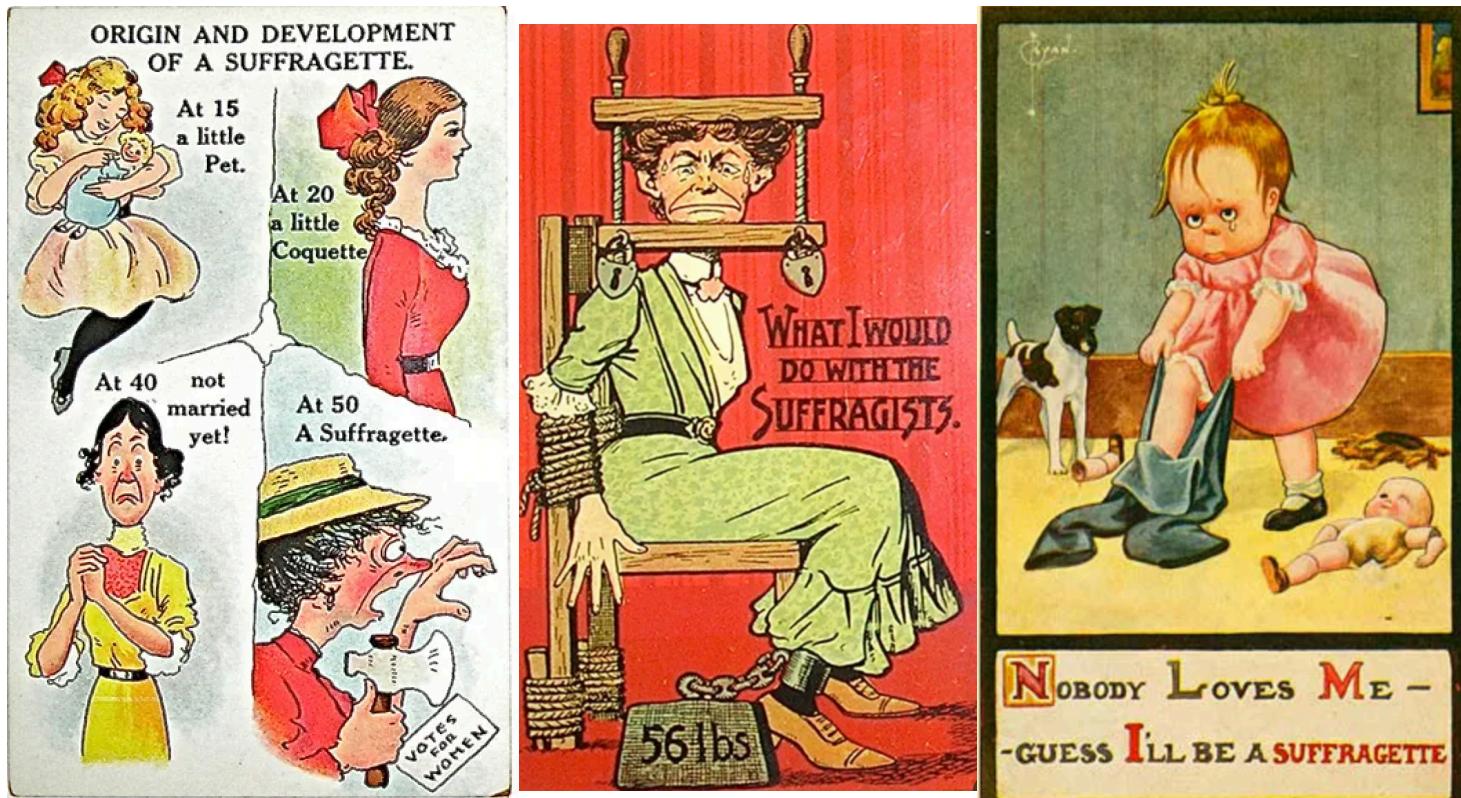
Radcliffe (Page 11)- Originally known as the Harvard Annex, it was founded as the female wing of Harvard University, founded in 1879 for women to be taught by Harvard faculty after being barred from admission or receiving degrees from Harvard's then president. In 1882, it was incorporated as the Society for the Collegiate Instruction of Women but still wasn't allowed to confer degrees, only certificates of study. It wasn't until 1894 that Radcliffe College was officially established and granted the ability to confer undergraduate and graduate degrees to women, despite the teaching and faculty to be identical to Harvard courses. Henrietta received a certificate of study from the Society in 1892, after completing her undergraduate coursework at Oberlin in Ohio. [Current Radcliffe Institute](#)

Bloomers (Page 11)- Named after suffragist Amelia Bloomer, these gathered, legged undergarments for women became synonymous with the fight for women's rights since the 1850s. The word “describes any loose, full, trouser-like garment which is gathered at some point between the knee and ankle and worn under long skirts.” Their popularity also mirrored the rising popularity of bicycling, since the popular dress of the time was impractical for the activity. They were championed by the “Rational Dress Movement” which advocated for women's wear that was more practical, comfortable, and allowed for increased mobility than the structured corsets and cages of the era. [Sources](#)

Dowry (Page 11)- A dowry is the financial promise from a bride's family to the new husband as "payment" for taking over the responsibility of caring for the bride. This can come in the form of cash, real estate, stakes in companies, and other non-liquid assets. Henrietta came from a decently well-off family, so hers would have been substantial enough to live off of, but would also be considered a deeply unusual and unorthodox request in her religious community. However, as is mentioned in the text, the lack of pay from the Harvard Observatory, despite the prestigious opportunity, would have necessitated the acquisition of her dowry in order to survive in Cambridge unmarried.

Spinster (Page 11)- the literal definition of "spinster" is an unmarried woman, usually past the prime marrying age" but it has negative and offensive connotations in its usage, typically. The term itself, which originally referred to the women who made fabrics and textiles, implies a working woman— someone who has chosen work over family and being a wife. Much of the female workforce in the late 19th and early 20th century were unmarried women, and therefore the concept was deeply tied to "gender transgressors" who attempted to live independently without being tethered to men for financial freedom. [Sources](#)

Suffragettes (Page 11)- The term refers to the women, specifically, that supported and worked toward earning women the right to vote from the mid 19th century through the 19th amendment's ratification. The movement, however, had a history of division post Civil War between white women and women of color because of the deep racism from leaders such as Elizabeth Cady Stanton and Susan B. Anthony who vocally resented the ability for Black people to vote before white women. Due to the highly visible and dramatic tactics taken by many suffragettes in the late 19th century, they were villainized in the media for being unfeminine and dangerous to American society. This is the kind of rhetoric Margie is warning Henrietta of. [More info](#)



Cowboy (Page 11)- the vision of the early American cowboy was highly glamorized in media of the late 19th century because of the push for young men to move and expand westward, especially after the Gold Rush. The way that Margie is describing the suffragettes reflects more of the gunslinging, saloon-frequenting cowboys of lore than the women fighting for rights, which is Henrietta's joke.

For The Beauty of the Earth (Page 13)- Written in 1864 utilizing scripture from Psalms 95:1-6 and 33: 1-6 and put to an older tune that many would know already from 1838.

For the beauty of the earth,
For the beauty of the skies,
For the love which from our birth
Over and around us lies,
Lord of all, to thee we raise
This our hymn of grateful praise.

For the beauty of each hour
Of the day and of the night,
Hill and vale, and tree and flow'r,
Sun and moon, and stars of light,
Lord of all, to thee we raise
This our hymn of grateful praise.

For the joy of human love,
Brother, sister, parent, child,
Friends on earth, and friends above,
For all gentle thoughts and mild,
Lord of all, to thee we raise
This our hymn of grateful praise.

[Listen here.](#)

Summa Cum Laude (Page 14)- literally translates to “with great honors,” it is a distinction awarded to graduating students within the top 1-5% of their class, typically with GPAs between 3.9-4.0

The Great Refractor (Page 14)- Installed in 1847, the Great Refractor Telescope was once the largest telescope in the United States. The 15 inch diameter lens for the telescope was 3x the size of its contemporaries, and the wooden tube attached to it was 20 feet long from lens to eyepiece. In its first 30 years of use, many important visual discoveries were made and first early photographs of stars were crafted. Once Pickering took over in 1877, the telescope was used almost entirely for **photometry**, which is defined as the science of measuring light, specifically focusing on its intensity and brightness as perceived by the human eye, using units like lumens and candelas, and accounting for eye sensitivity. [More info](#) and a virtual tour.

Harem (Page 15)- defined as the quarters reserved for the wives, concubines, and female servants of a polygamous man, this “clever nickname” was obviously offensive to the women

and their work in the observatory by reducing them to both their gender and their service to their male counterparts.

Concubine (Page 15)- a woman who lives with a polygamous man with a lower status than a wife, e.g a mistress

Gilbert and Sullivan (Page 16)- this famous opera-writing duo would have recently exploded onto the scene, in the midst of writing 14 major hits with some of their most famous works such as The Mikado (1885), The HMS Pinafore (1878), and The Pirates of Penzance (1879). The duo are credited with launching proto-musical theatre with their operettas, which was on the rise in earnest in the United States in the early 20th century.

Dickensian (Page 16)- referring to the work of Charles Dickens, who often used hyperbolic or overtly literal names to humorously comment on people and places within the social strata of Victorian England. In this context, Peter is poking fun of Annie being booming, dangerous to be near, etc. as being related to her last name of “Cannon.”

Twenty five cents an hour (Page 16)- “Women provided cheap labor. It was common practice for employers to pay women less than men based on the widespread belief that men needed to support families with their wages. In 1900, curator Williamina Fleming expressed frustration over compensation at the Observatory in her [private journal](#). Noting that men doing equivalent work earned \$2500 annually to her \$1500, she lamented “does [Observatory director Edward Pickering] ever think that I have a home to keep and a family to take care of as well as the men?” – [Source](#)

Photometer (Page 18)- both a person and an instrument used to measure light for photometry (see **The Great Refractor**)

Star Classifications (OBSFGKM) (Page 18) also referred to as **Spectral Class** (Page 21)- One of the major accomplishments of Annie Cannon and Williamina Fleming was the creation of the Star Classification system based on the light color of stars. In the 1890s, Cannon refined Fleming's more basic system by reordering the spectral classes in order of decreasing temperature (blue to red). Each class is also broken into 10 subdivisions 0-9, also classified from hottest to coolest within each class category. This comprehensive system allowed her to categorize stars with unfathomable speed, with sources saying she could class up to 3 stars a minute with her system. It wasn't until 1988 that her system was further refined to include three more classes of stars even cooler than the ones she could find using early photometry. [More complete info](#)

Curator in Astronomy (Page 18)- According to contemporary job descriptions, an Astronomy Curator manages astronomical collections (artifacts, data, exhibits) for museums or institutions, overseeing acquisition, care, research, and interpretation through public programs, exhibitions, and digital platforms, often requiring advanced degrees and involving significant public engagement, fundraising, and team leadership. They bridge scientific research and public

understanding, developing engaging content for planetariums, exhibits, and data repositories, ensuring proper stewardship of valuable astronomical assets.

Draper Catalogue (Page 18)- In 1886, the widow of Henry Draper (an amateur astronomer credited with taking the first photograph of a star's light spectrum) invested a fortune into Pickering's research at the Harvard Observatory in honor of her late husband. In 1890, the first publishing of Williamina Flemming's classifications of over 10,000 stars and their spectra in the northern hemisphere. In 1901, using Annie Cannon's newest classification template and a new observatory in Peru, Pickering and Cannon were able to publish more classifications for the southern sky. The Draper Catalogue is an ever-expanding register of all known stars in the universe, with the number of catalogued stars hitting over 359,000 in 2017, utilizing extensions to catalogue allowed for by ever-improving equipment and measurement techniques. [Source](#)

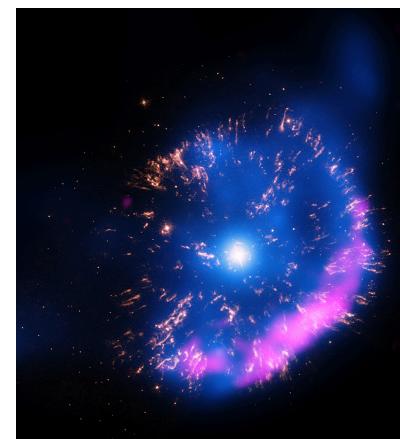
[The catalogue](#)

Nebulae (Page 18)- a giant cloud of dust and gas in space. Some nebulae (more than one nebula) come from the gas and dust thrown out by the explosion of a dying star, such as a supernova. Other nebulae are regions where new stars are beginning to form. Nebulae exist in interstellar space, meaning the space between stars. Nebulae are made of dust and gases—mostly hydrogen and helium. The dust and gases in a nebula are very spread out, but gravity can slowly begin to pull together clumps of dust and gas.

As these clumps get bigger and bigger, their gravity gets stronger and stronger. Eventually, the clump of dust and gas gets so big that it collapses from its own gravity. The collapse causes the material at the center of the cloud to heat up—and this hot core is the beginning of a star. At the time Henrietta was working, other galaxies that were not seen particularly clearly in telescopes of the time were referred to as “nebulae” (See [Hubble](#)) [Source](#)



Novae (Page 18)- A nova is the temporary flaring and dissipation of two stars, a white dwarf and a companion “regular” star, when the white dwarf gets too close to the companion and some of the companion's matter gets pulled into the white dwarf's massive gravity, causing a brief but brilliant explosion 100,000x brighter than our Sun's luminosity. Novae can be recurrent because their force doesn't eliminate or damage either star in the equation. [Novae vs. Supernovae](#)



Star Spanking (Page 19)-A physical tool: A glass plate with tiny, precisely placed dots of known brightness (magnitudes). Used to calibrate and standardize the measurement of stellar brightness (magnitudes) from photographic plates, ensuring consistency. “The fly spanker was a piece of photographic

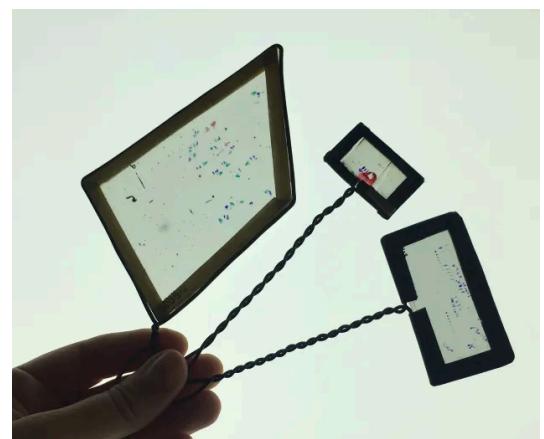
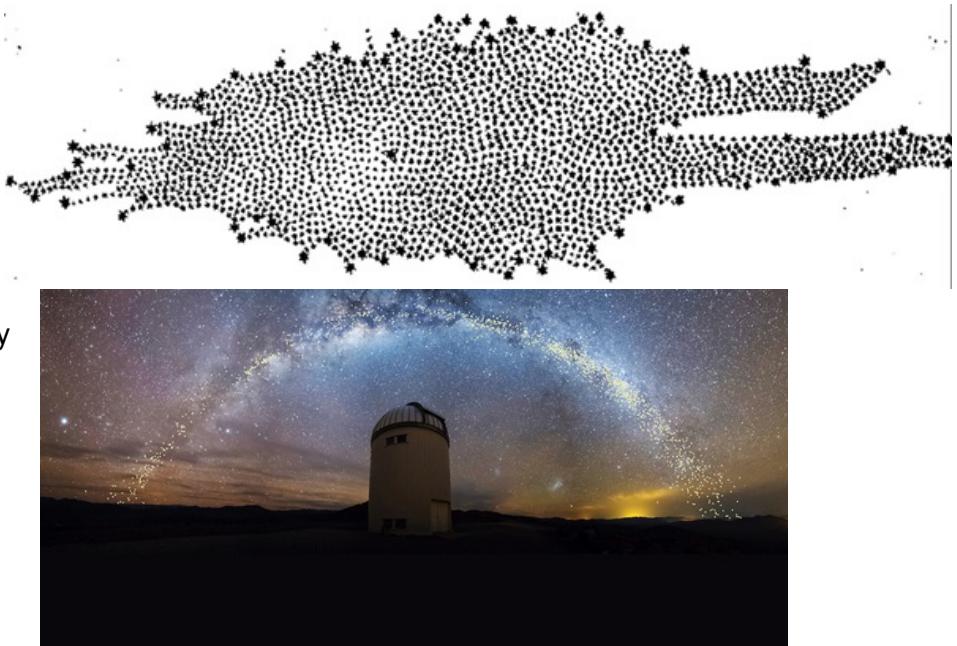


plate with a wire handle that could be moved around in front of a glass plate. Henrietta could compare the stars on the plate fragment, which had well-established brightnesses, to new stars she was cataloging. This helped to standardize brightness measurements and made it easier to determine if a star's brightness had changed. She named this tool a fly spanker because it resembled a flyswatter but it was "too small to do a fly much damage." [Source](#)

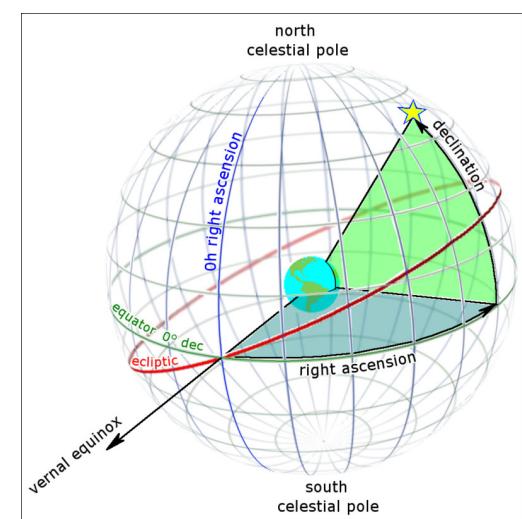
Milky Way (Page 20)-At the time of Henrietta's work, the Milkway was thought of as the entire Universe. Because of it's visibility across the night sky, many ancient civilizations had ideas of what the murky band of stars was and meant for our position within the universe, but it wasn't until 1781 when William Herschel and his sister Caroline mapped the first disklike, flat structure of the Milky Way based on observable star density (above right). It wasn't until the discovery of the Leavitt Law that any sort of distance could be attached to any of the formations observed. [Watch more](#) [Read more](#)



Star Name—Alpha Leonis 3982,

Beta Orionis 1713, etc. (Page 20)- The star naming system used by the women at the Harvard Observatory was established by Johann Bayer in 1603 to create a cleaner system to identify specific stars than comparing the ancient Greek and Arabic names previously used. The brightest star of a constellation would be the "Alpha," and others would be categorized accordingly based on its brightness in comparison. In 1712, John Flamsteed began numbering stars in each constellation from west to east in order of right ascension, which helped expand specificity outside of the 24 greek letters. As telescopes improved and more and more stars were identified, the naming systems were constantly being adjusted to account for the changes. But as I understand it, "Alpha Leonis 3982" would be one of the brightest stars in the Leo constellation, and the location of it within the constellation was attributed to the number following. [Read more](#)

Declination (Page 20)- the number of declination refers to the "latitude" of a star, and right ascension to longitude. Positive coordinates are north and negative are south of the celestial equator. From mid-latitudes, the celestial equator stands midway between the horizon and overhead point, while from the poles the celestial equator encircles the horizon. [Read more](#)



Magnitude (Page 21)- A star's magnitude is equivalent to its brightness, but it is an inverse scale, meaning the smaller the number, the brighter the star. [Read more](#)

Heel (Page 25)- A command used for leash-training dogs instructing the animal to remain in line with the handler with their focus on the person, not tugging in front or lagging behind.

Small Magellanic Clouds (Page 26)- Ferdinand Magellan, the Portuguese explorer, was the first to identify the Small and Large Magellanic Cloud systems in the sky in the early 1520s, but it was discovered much later (far after Leavitt) that these are actually two of our closest neighboring galaxies to the Milky Way. The Cepheids that Henrietta measured the pulsation of were within this galaxy formation. [Read more](#)

Cepheid Stars (Page 26)- a type of variable star identifiable by its pulsations in brightness (magnitude) and diameter (amplitude). The pulsations, as Henrietta discovered, are regular across periods (usually from 1-100 days) and helped define what the “true luminosity” (intrinsic brightness) of the star was, giving a standard which allowed astronomers to measure distances between bodies in space using their movements in comparison to other stars (See **Statistical Parallax** (Pg. 58)) [Read more](#) [Read more](#)

Relativity (Page 29)- In 1905, Albert Einstein graduated his PhD and published 4 papers, most famously including his relation of mass and energy ($e=mc^2$) and special relativity. The impact of the discovery would undo the foundation of Newtonian assumptions of universal constants other than the speed of light. The theory of general relativity wasn't released until 1915, which asserted that space, and therefore light, bends when something massive like a planet, star, or black hole creates a divot in spacetime (a new concept he introduced) that helped explain gravity as a reaction rather than a mysterious force and explained long standing problems like Mercury's bizarre orbital patterns and why different observers can observe the same things at different times.

[Read more](#) [Read more](#)

➡ **Einstein's Revolution: Crash Course History of Science #32**

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Isaac Newton (Page 29)- The original father of physics, his three Laws of Motion created the foundation for modern physics in 1686:

1. An object at rest remains at rest, and an object in motion remains in motion at constant speed and in a straight line unless acted on by an unbalanced force.
2. The acceleration of an object depends on the mass of the object and the amount of force applied.

3. Whenever one object exerts a force on another object, the second object exerts an equal and opposite on the first.

He also created his theories of gravitation in 1666:

1. Universal Attraction: all objects with mass exert a gravitational pull on all objects with mass
2. Mass Dependence: The more massive the object, the stronger the gravitational pull
3. Distance Dependence: Gravitational pull weakens the further the object
4. Action-Reaction: For every gravitational pull there's an equal and opposite pull (led to the Laws of Motion)

All of his laws assumed the constant nature the universe being static and unmoving, which was later also changed by Einstein's general relativity.

[Read more](#) [Watch more](#)

Luminosity (Page 32)- The total energy a celestial object emits per second, which is an intrinsic measure of its power output determined by its temperature and size. Its key difference from brightness is that luminosity is absolute, not "apparent" aka observable— luminosity is the energy emitted which isn't affected by the distance between observer and star.

Lancaster (Page 33)- The town in Massachusetts where she was born before moving to the Midwest as a child.

Not changes, just changes form... (Page 38)- in 1789, the Law of Conservation was recognized as the discovery that mass is neither created nor destroyed in chemical reactions. In other words, the mass of any one element at the beginning of a reaction will equal the mass of that element at the end of the reaction, including energetic output. [Read more](#)

A star finding fiend... prominent astronomers at Princeton (Page 40)- though not confirmed as a real quote, this is probably related to the major astronomers Henry Norris Russell and Ejnar Hertzsprung who led the Princeton Astronomy department and used Henrietta's discoveries to compile the Hertzsprung-Russell Diagram, a scatter plot of stars based on their luminosity and absolute magnitudes. These publications came out just after this moment in the play between 1911-1913. [Read more](#) (See [Hertzsprung](#))

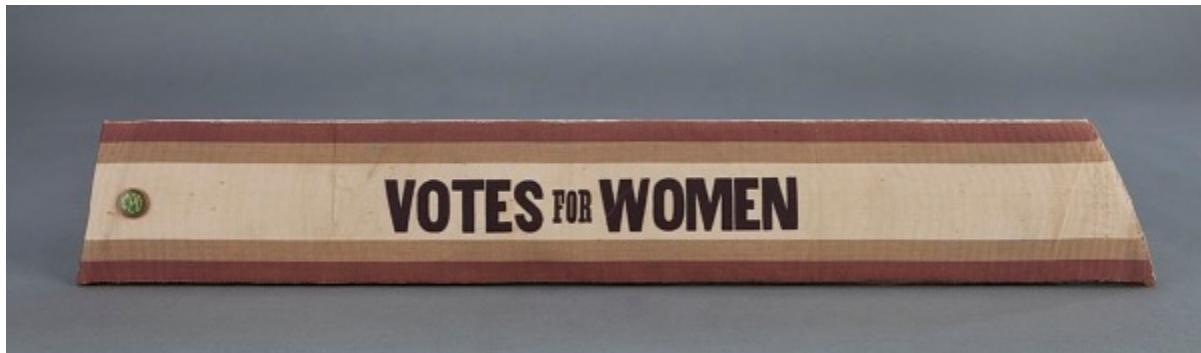
Hymn vs. concerto (Page 41)- a hymn is typically a simplistic melody in four part harmony utilized almost exclusively in churches, whereas concertos and symphonies were held to a higher esteem and artistic regard. There had been female composers, but none particularly famous at the time and many contemporaries of Henrietta and Margie had not hit yet.

It's tonal (Page 41)- Henrietta sees the patterns in the data from the stars as musical and melodic, but it isn't until the 1970s that the "sonification" of astronomical data helped scientists make sense of some of the most subtle variations in celestial data. [Learn more](#)

Read your work...The Period-Luminosity Relation (Page 44-45)- More commonly referred to nowadays as Leavitt's Law, the findings were published in 1912 and revolutionized cosmology by setting the first "standard candles" (object of known intrinsic brightness) of the universe. She discovered that "there is a direct correlation between a star's magnitude (degree of brightness) and the length of time it is most luminous. The brighter the star is overall, the longer the period of luminosity. Since the cepheids in the Magellanic Clouds were all about the same distance from Earth, Leavitt concluded that the period, or time it took to complete one cycle of dimming and brightening, was related to the star's magnitude, not distance. Yet magnitude itself allowed you to calculate distance." The discovery became known as the "yardstick of the universe."

[Read more](#) [Read more](#)

Back from a protest...They gave her a sash (Page 47)- In May of 1910, 10,000 women gathered in New York's Union Square to protest in favor of women's suffrage—the largest thus far in the nation. 1910 was also the year that the National American Woman Suffrage Association began a targeted, focused effort to get women's suffrage on individual state ballots. Though Massachusetts did not see victory, it would make sense that Annie would join the effort for her local elections. The women's suffrage movement in England, which spurred on the American counterpart, were using purple, gold, green, and white sashes that read "Votes for Women" since the mid to late 19th century. [Read more](#). [Read more](#)



The ones that matter do (Page 48)- This could be referring to prominent astronomers globally such as Sir Arthur Eddington, Max Plank (of the Plank Constant), and Max von Laue who famously defended Einstein's work against early critics and non-believers. Famously, Eddington went on to prove Einstein's general theory of relativity in 1919 measuring light during an eclipse and providing key evidence of Einstein's correctness. [Read more](#)

Kepler (Page 48)- a late 16th century astronomer and mathematician who determined three planetary laws that he called "harmonies": "(1) the [planets](#) move in elliptical [orbits](#) with the [Sun](#) at one focus; (2) the time necessary to [traverse](#) any arc of a planetary [orbit](#) is proportional to the area of the sector between the central body and that arc (the "area law"); and (3) there is an exact relationship between the squares of the planets' periodic times and the cubes of their mean distances from the Sun (the "harmonic law").

Pain sweeps over her abdomen (Page 50)- Henrietta died of stomach cancer, so the initial symptoms would have probably been centralized to her stomach.

1918 (Page 53)

Census (Page 53)- Despite happening regularly every 10 years, there was a 1918 census after the passage of the Selective Service Act in May of 1917 to make sure that every man between the ages of 18-45 was conscripted into the army in the wake of joining WWI after the declaration of war with Germany. [WWI Timeline](#)

Astronomy Circular (Page 53)- Probably referring to the Astronomical Journal, which was a regular monthly publication of important astronomical findings founded in 1849 by the American Astronomical Society. 1918 would have been too early for the International Astronomical Union Circulars, which began in 1920. [Learn more](#)

Grand Observation (Page 54)- This phrase doesn't seem to be tied to any specific person or group, but seems to refer to Henrietta's agnosticism that believes that science helps reveal a larger sense of purpose and belonging that isn't directly tied to a "god" per se, but leaves room for an entity that is bigger than our understanding.

Head of Stellar Photometry (Page 55)- Henrietta was named Head of Stellar Photometry shortly before she died, making the title largely symbolic.

Hertzsprung (Page 57)- Danish astronomer Ejnar Hertzsprung is best known for his part in creating the Hertzsprung-Russell diagram, which plotted the temperature (and color) of stars against their luminosity. His research was primarily focused on the apparent color of stars relating to their temperature. He is also credited, as is referenced here, with determining the distance to stars using their magnitudes as reported by Leavitt. [Read more](#) [Read more](#)

Statistical Parallax (Page 58)-Statistical parallax is a method used to determine the distances to nearby stars by analyzing the apparent motions of those stars relative to more distant background stars. It is a statistical approach that relies on the collective motion of a group of stars to infer their distances from Earth. [Read more](#)

Hubble (Page 58)- Edwin Hubble revolutionized the way science perceived the universe by proving that there are celestial bodies far outside of our galaxy. He studied what was previously referred to as the "Andromeda Nebula," until he found Cepheid stars like the ones Henrietta studied within the mass. Using her research and the new methods of measurement, he was able to determine that these stars were far outside of our galaxy and were part of its own galaxy. His role in confirming the existence of millions of other galaxies is the reason the deep space telescope was named after him. [Read more](#)

Whitman Poem (Page 58)- This is the full text of the poem, which was originally published in 1865 in the collection *Drum Taps* and was republished several times after that as part of other collections [Learn more](#)

Annie gets a vote (Page 61)- the 19th Amendment to the US Constitution was finally ratified in 1920 and granted women the right to vote

A man from Sweden calls...Nobel Prize (Page 61)- in 1924, a mathematician named Gösta Mittag-Leffler nominated Henrietta's findings for the Nobel Prize, but her nomination was withdrawn when they realized she had died in 1921 and they did not award it posthumously

Harness the atom- referring to the intense study in the late 1930s-early 1940s of nuclear fission for the use of creating energy, and the atomic bomb

Orbit the earth- The Russian craft, Vostok 1, was the first to orbit the earth in 1961 taking 108 minutes

Stand on the moon- The American craft, Apollo 11, was the first to land on the moon and put a human on the surface in 1969

Telescope named Hubble-The Hubble Space Telescope was released into space from the Discovery in 1990. After issues were discovered with the telescope's mirror, they sent astronauts to fix the issues mid-orbit in 1993. An orbiting telescope allowed scientists to avoid some of the major light distortion of ground telescopes by getting past the earth's atmosphere. [Read more](#)

