Ellen Henrietta Swallow Richards -Chemist, Ecologist, and Water Sanitation Engineer (December 3, 1842 - March 30,1911)

My favorite scientist is Ellen Henrietta Swallow Richards. Unknowingly, I had followed in her footsteps as I too have a bachelor's degree in chemistry and a master's degree – two in my case, in environmental management and in hazardous waste management. I spent most of my career in the Environmental, Health, and Safety field. The first ten years of my career were spent performing physical, chemical, and microbiological analyses of wastewater. I am also active at women and minority issues. I too have a very supportive husband who is a retired mathematician at Lawrence Livermore National Laboratory (LLNL).

The scope and depth of Ellen Richards' work and influence on science is immeasurable! This was a person who became a pioneer and a trailblazer in every scientific field that interested her. She has been a pioneer in chemistry, water sanitation, home economics, nutrition, ecology, euthenics, mineralogy, and women's scientific education.

Her science journey began on December 3,1842 when Ellen Henrietta Swallow was born on a farm near Dunstable, Massachusetts. Her parents Peter Swallow and Fanny Gould Taylor both came from good families of modest means in New England. The primary school in Dunstable did not provide a strong education for girls, so her parents, who were former teachers, decided to homeschool her. Both parents believed in the value of a good education. Ellen grew up playing outdoors by herself since she was an

only child. She would watch wildlife in the woods and streams. She would observe the butterflies and moths, rabbits, and other animals frolicking in the meadows. She also grew flowers and vegetables in her garden. She knew all the names of the animals and plants in the woods and in the meadows. At this young age she understood that it was important to have fresh air, clean water, and good food.

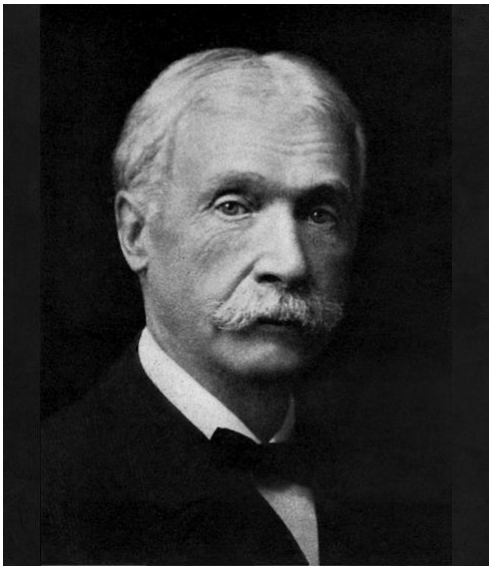
In 1859, the Swallow family moved to Westford, Massachusetts, a nearby town, so Ellen could enroll in a high school that accepted female students. Ellen enrolled at Westford Academy, the second oldest secondary school in Massachusetts and one of the oldest in the country. The curriculum included mathematics, composition, and Latin. Her proficiency in Latin helped her to study French and German also. This talent would later help her get a job as a language tutor. But after graduation from Westford Academy, her parents could not afford to send her to college. So, Ellen taught, tutored, and cleaned houses to save the $350 needed to enroll at Vassar College, then a women's college in Poughkeepsie, New York. At Vassar she was undecided which course she would take as her major. She was interested in both astronomy and chemistry. Her astronomy professor was Maria Mitchell, the first faculty member hired by Vassar. Maria Mitchell was the first female astronomer in the United States and the first American scientist to discover a comet. She was a great mentor to Ellen Richards. Ellen was also influenced by Charles Samuel Farrar, her chemistry professor. He was the first Chair of the Chemistry and Physics Department and taught at Vassar from 1865-1874. Ellen decided to major in Chemistry because it has practical applications to daily life. In 1870, Ellen graduated from Vassar and became the first woman in America to obtain a degree in Chemistry.

After graduation she started looking for a job in a chemical laboratory. She sent her application for industrial chemistry apprenticeships to companies all over the United States, but none was interested in hiring a woman. One of the laboratories who rejected her suggested she apply at the Massachusetts Institute of Technology (MIT). In 1871, MIT was an all-male school. That did not stop Ellen from applying and soon impressed the admissions board with her education. But the board members were afraid to open the doors to women, so they accepted her as a "special student". She did not need to pay tuition; but on the other hand, she was not put on any official roster as a student. She worked in the basement, separated from her male classmates so as not to

distract, or contaminate them. Her lessons were left and picked up at the door. But after a few months, her treatment improved after her intellectual abilities impressed her professors and fellow students. They soon started asking her for help in solving scientific and mathematical problems. And although she was not included in the official roster, Ellen's place in history was cemented. She will forever be known as the first female student at MIT and the first woman to be accepted by a school of science and technology in the United States.

Within three years, Ellen earned a second bachelor's degree in chemistry from MIT and a master's degree in chemistry from Vassar College. Her master's thesis at Vassar was an analysis of the amount of vanadium in iron ore. She has performed numerous experiments in mineralogy, including the discovery of an insoluble residue of the rare mineral samarskite. While some doubted Ellen's analysis, a Kentucky scientist devised a new method of analysis and he discovered samarium and gadolinium. Perhaps if Ellen was not busy doing the water surveys with Professor Nichols, she would have had time to analyze the insoluble residue. She would have been able to identify new elements in the earth's crust while she was still a student! She continued her study at MIT for two more years in hopes of earning a PhD, but the heads of the department did not wish MIT's first PhD to be awarded to a woman. It would be many more years before MIT would bestow its first PhD: to a man in 1907.

Marriage to Robert Hallowell Richards



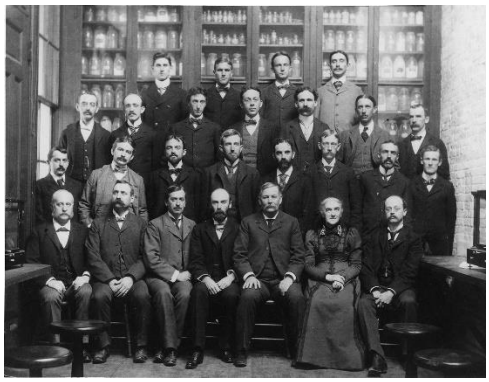
After her graduation from MIT, Ellen's former mineralogy professor Robert Hallowell Richards proposed to her. Robert Richards was a member of the first graduating class at MIT in 1868 and came from a prominent family in Maine. He was related by marriage to the founder of MIT. After graduating, he became a professor in mineralogy and later became the chairman of the Mining Engineering Department. Robert was impressed with the intellect of his student and decided to pursue her after her graduation. They became close after he found out that she was fluent in German and was able to translate mineralogy journals

written in German. He had always liked her when he first met her. He was not against women attending MIT, but he didn't approve of men and women studying together. His thoughts on co-education changed when she started helping him with the translations. He proposed right after graduation on June 6,1873 amidst the flasks, beakers, microscopes, and other laboratory equipment in the Chemistry Laboratory, but Ellen did not accept the proposal yet because she wanted to make sure she would still be able to become a professional scientist even after marriage. After two years and with an assurance from Robert that she will be able to keep working as a scientist, she finally accepted the proposal and they were married on June 4, 1875, at Boston's Union Chapel. For their honeymoon, they went to Nova Scotia with Robert's entire class of mining engineering students.

Women's Laboratory

After Ellen's graduation from MIT, the institute still would not accept female students. They said that Ellen Richards was an exception because she was highly intellectual, but they doubted that other women could stand the rigors of a science course as well as Ellen. In 1876, Ellen decided to start a Woman's Laboratory so women would have a place to conduct research. With funding from the Women's Education Association (WEA) of Boston, she taught science and laboratory techniques. She taught the women without a salary or title. The laboratory closed in 1883 after MIT started giving undergraduate degrees to women on a regular basis. In 1879, Ellen was still an unpaid assistant professor in chemical analysis, industrial chemistry, mineralogy, and applied biology.

First MIT Female Instructor



When MIT established a sanitary engineering program in 1890, Ellen was hired as MIT's first paid female instructor. In this capacity, Ellen, who previously had not been allowed to mingle with male classmates for fear she may distract or contaminate them, would now be teaching male students. Ellen taught sanitary chemistry, sanitary engineering, and air/water/food analyses. She remained the only MIT female instructor until her death.

Water Surveys

Ellen was tasked to do water surveys twice, first with Dr. William Ripley Nichols in 1872 when she was still a student and then with Dr. Thomas Drown in 1887. Most of the work was done at Lawrence Station which was established by the Massachusetts State Board of Health. The first survey was to test the water in the sewers, rivers, streams, and ponds to find out the extent of water pollution and to find additional sources of clean water. It took two years to complete the study and even before she graduated from MIT, Ellen established herself as one of the best water scientists in the world. In 1887, Dr. Thomas Drown replaced Professor Nichols and he and Ellen performed what is called the "The Great Sanitary Survey" for the Massachusetts State Board of Health. The survey's goal is to find out which waters in the state were polluted and the extent of the pollution. The survey resulted in the Normal Chlorine Map. The varying amounts of chlorine in the water samples taken from Massachusetts' rivers and other bodies of water revealed the extent of man-made pollution in the state. This was a useful water pollution indicator and became a standard model for water surveys in the United States and in the world.

The scale of the survey performed by Ellen and her assistants was so comprehensive, it led to the first state water-quality standard in America and the construction of the first modern wastewater treatment plant in Lowell, Massachusetts. Ellen served as the official water analyst for the Massachusetts State Board of Health from 1887 to 1897. She continued as an instructor at MIT until she died in 1911. Together with her colleague, A. G. Woodman she wrote a book on sanitary

engineering*: Air, Water, and Food from a Sanitary Standpoint (1900).* Ellen has written more than 15 books, articles and reports in environmental science and engineering.

Ellen did most of the water surveys but when the credits were given out, Hiriam Mills, the board of health politician who implemented the survey's recommendations was called the "The Father of Modern Sanitation", William Sedgewick, the young biologist Ellen trained was named 'The Father of Public Health" and Ellen Swallow got a footnote as "assistant to Edwin O. Jordan" one of her students a year or so before. As we will see later, Ellen's story is of one who has always been overlooked and not given credit for a lot of things she has done. For example, if you look at the history of the Marine Biological Laboratory on their website, you will not find any mention of Ellen Richard's name.

Long Distance Learning

After the Women's Laboratory closed, Ellen set her sights on educating women all over the United States, housewives who could not afford to pay for an education in Boston and women who lived in rural areas of the United States. She taught long distance learning through a new experiment called Society to Encourage Study at Home. Also known as the Silent University, this experiment was the idea of its founder Anna Eliot Ticknor, daughter of a Harvard professor. For Ellen, this is a way to teach science to women and girls. She and the other women instructors were not paid for their services and would sometimes donate their own money to help these women. Through her correspondence with her students, Ellen learned how average and poor people live all over the country. Her students talked about the difficulty of household chores, keeping the house clean from dust, washing clothes with soap that burned their hands, carrying water from the wells to the house. Ellen decided to write a book called *Health* which she sent to each student. She discussed the need for good nutrition, fresh air, exercise, and taking a little time to regenerate by taking a 30-minute walk by herself. Ellen then decided to write a new book that she could give to her students*: The Chemistry of Cooking and Cleaning: A Manual for Housekeepers.* Part I of the book explained the scientific principles in cooking, including the chemical composition of the food we cook and eat and chemical changes that cause food spoilage. "To understand something of the nature of these chemical substances and their common forms is a necessity for every housekeeper who would not be cheated of her money and her

time", wrote Ellen Richards. Part II of the book is about the chemistry of materials used in cleaning the house, the kitchen and silverware. Ellen wrote that the state of cleanliness must be attained in the least amount of time, money, and labor. The book is replete with tidbits of advice: "Ammonia is most excellent for cleaning glass (but not for brass, as it dissolves copper and copper salts)." Often chemical equations were included.

Co-Founder of Woods Hole Laboratory (now Marine Biological Laboratory)

In 1881, Ellen co-founded a new marine biology laboratory with her paleontology professor, Alpheus Hyatt. Ellen wanted the students at the Women's Laboratory to conduct research in a natural environment and she thought that marine biology is an important aspect of environmental science. After looking all over Massachusetts for a suitable place, Ellen chose Annisquam as the site of the Summer Seaside Laboratory. There, the students, both men and women, could study biology, invertebrate zoology, embryology, physiology, and habitat study. In 1888, the Summer Seaside Laboratory moved to Woods Hole, near the Hyannis area of Cape Cod. It was a better location since the water was purer and the marine life more abundant. The United States Fish Commission was also located in Woods Hole.

Co-Founder of AAUW

In November 28, 1881, she and Marion Talbot, one of her students at the Women's Laboratory assembled a group of 15 college educated women and founded the Association for Collegiate Alumnae, now known as the American Association of University Women (AAUW). At that first meeting, Ellen was the chair and Marion was the secretary. The goal of the new organization was to provide scholarships to women for both undergraduate and graduate programs.

Co-Founder of Home Economics

Ellen was also interested in applying scientific principles to topics that involve women at home e.g. nutrition, proper clothing, physical fitness, sanitation, and practices that would allow women to pursue other interests aside from cooking and cleaning. Ellen knew that if women understood the principles of sanitation and germs, the more they could prevent disease and infection at

home. She thought that if paid employees received on the-the-job training, housewives should also receive education in the science and economics of the home. Cooking and cleaning were just practical applications of chemistry. In 1882, Ellen wrote the book *The Chemistry of Cooking and Cleaning: A Manual for Housekeepers*. In 1890, she established the New England Kitchen of Boston. This demonstration kitchen offered cooking demonstrations, instructions on proper housekeeping techniques, and nutritious, science-based meals for visitors – just like what Elizabeth Zott did in her fictional cooking show *Supper at Six*. In 1894, Ellen's demonstration kitchen was shown at the Chicago World's Fair, thus giving her a global audience.

In 1908. The American Home Economics Association (AHEA) was established in Lake Placid, New York. There Ellen was elected as its first president. AHEA goal was to improve the living conditions in the home, institutional household, and the community. Ellen wanted to call it "Home Science" or "Home Ecology" to emphasize that running a home includes knowing scientific principles e.g. composition and nutritive values of food, effects of fresh air on the human system, the danger of sewer gas, and contaminated water. But Melvil Dewey proposed Home Economics because he felt that the term would be a better fit to his Dewey Decimal System for libraries. The conference voted to accept Dewey's proposal.

Introduced the term Ecology to America

On November 30,1892, speaking at a large gathering at the Vendome Hotel in Boston, Ellen spoke of a new science she called *"Oekology"* which she says is the interaction and interrelationship between the environment and organisms. A German scientist, Ernst Haeckel, came up with the word *oekologie* in his book *Morphology of Organisms*. Haeckel defined oekologie to be the total relations of the animal to both its inorganic and organic environment. Ellen was fluent in German, so it is no surprise that she read the book. Haeckel moved on to concentrate on to other branches of science, but the book made an impression on Ellen. So, she wrote to Haeckel for permission to use the term in America. She said it is the responsibility of all people, not just specialized scientists, to protect the quality of the environment. She envisioned that oekology - or ecology as it is known today - would be an interdisciplinary science involving biology, chemistry, limnology, oceanography, and nutrition. But most scientists wanted to protect their own fields, so ecology was not as immediately successful as she had

hoped. But Ellen's ideas about ecology and the environment have proven to be prophetic. Now ecology is taught as an interdisciplinary science.

Coined the term Euthenics -the Science of Controllable Environment

Ellen came up with another idea for an interdisciplinary science. She called this new science "euthenics" from the Greek word*" euthenein",* meaning to flourish, thrive or to be in a good state. Euthenics deals with the development of human well-being by improvement of living conditions. She stressed the importance to employers of making employees healthy and happy. For example, if the employees are sick from bad air and contaminated water, they will not be able concentrate and do their jobs well. In 1910, she wrote a book *Euthenics, The Science of Controllable Environment: A Plea for Better Living Conditions as a First Step Toward Higher Human Efficiency.* Euthenics just like ecology would eventually catch on, but Ellen was ahead of her time.

New England Kitchen and Healthy School Lunches

Ellen realized that many people had poor health caused by their poor diets. She decided to address the problem with practical education in nutrition and cooking practices. So, she opened a community kitchen to show people how to prepare healthy and low-cost meals. On January 1, 1890, she and her friend Mary Hinman Abel opened the first New England Kitchen. It was quite successful! People from all walks of life came to buy these homemade meals. The New England Kitchen became the country's first health food restaurant, the first large-scale nutrition laboratory, and the first take-out restaurant. It was so successful that Ellen was invited to show the kitchen at the 1893 World Fair in Chicago. Ellen set up a new kitchen at the fair. She named it after Count Rumford, a physicist and philanthropist known as the founder of the science of nutrition. Like the New England Kitchen, the Rumford Kitchen became very popular with the people attending the fair.

Ellen also helped provide healthy lunches to Boston schools. She campaigned to provide healthy and nutritious lunches at schools using the principles of her New England Kitchen. She thought that young people, as society's future, should not be poisoned with bad air and poor food. Soon her healthy meals were being used at schools, colleges, hospitals, orphanages, factories, prisons, and asylums. Ellen wrote books on nutrition, food materials and their adulterations, and how to prepare good luncheons for rural schools without a kitchen.

Mineralogy

Her interest in mineralogy was inspired by her travels with her husband who was the chairman of the Mining Engineering Department at MIT. Ellen is credited with finding an unknown residue on samarskite. Later a Kentucky scientist identified the residue as two new elements: samarium and gadolinium. She also published a new method for determining nickel content in pyrrhotites and mattes. She applied this method to ore from the Coppercliffe Mine. She found 5% nickel content in its copper ore. That started the nickel industry in Ontario!

For her master's thesis at Vassar, Ellen analyzed vanadium in iron ore. Her professor Robert Richards was impressed because vanadium was hard to find and its presence difficult to prove. Because of her analytical capability, she was able to successfully isolate 0.2% vanadium in the ore. Ellen also taught mineralogy at the Boston Museum of Natural History to children, teachers, and Harvard undergraduates. She was the first woman elected to the American Institute of Mining and Metallurgical Engineers.

Finally, a Doctor of Science degree!

In October 1910, Smith College granted Ellen an honorary Doctor of Science degree. Ellen finally received that degree she had always wanted to get. This degree was so elusive only because she was a woman! MIT did not want its first PhD to go to a woman.

Her Legacy

Ellen died on March 30,1911 at 68 years old. Her contribution to science and the scientific education of women cannot be equaled. She left her imprint on almost every aspect of life, from sanitation engineering to chemistry, mineralogy, ecology, nutrition, environmental science, euthenics, home economics and scientific education of women. After her death, the Ellen Richards Research Prize was established. It was an international award for women in science and was the first science prize awarded to women. In 1973, on the celebration of the hundredth anniversary of Ellen's MIT graduation, MIT established the Ellen Swallow Richards professorship for distinguished female faculty members.

In 1928, on the 86th anniversary of Ellen's birthday, her former students Frances Stern and Samuel E. Prescott organized a tribute to their mentor by dedicating the Ellen Swallow Richards Memorial Tablet, a bronze bas-relief of Ellen's face created by the Boston sculptor Baska Paeff. Surrounding the tablet are books, photos, and other memorabilia of Ellen Richards.

This Memorial Tablet became the centerpiece of the Ellen Swallow Richards Lobby which was dedicated by MIT in 1980. The Ellen Swallow Richards Lobby located at the intersection of MIT Buildings 2&4 was established to honor the memory of Ellen Richards. At the dedication ceremony, former MIT alumna e.g. Florence Hope Luscomb, a women's suffragist and lifelong activist for social and civil liberties, Marjorie Pierce, former president of the MIT Women's Association and who helped create the Ellen Swallow Richards Chair for Science Endowment and Susan E. Schur, former President of the Association of MIT Alumnae (AMITA) and who chaired the 1973 celebration of 100 years of women graduates from MIT talked about Ellen Richards influence on their life and career.

The Ellen Swallow Richards Lobby at MIT honors the remarkable life and career of this pioneer scientist. We are all indebted to her tireless efforts in giving women a scientific education and for breaking that glass ceiling so that women scientists will have an easier time in the future. DC Comics featured Ellen Swallow Richards in its Wonder Women of History series. Ellen's biography was #50 in the series. Wonder Woman indeed!

https://wonder-woman.fandom.com/wiki/Wonder_Woman_v1_50

W*onder Women of History* is a feature that ran in *Wonder Woman* comics and *Sensation Comics* from 1942 to 1954. Ranging from one to five pages, each entry tells the story of real women who made a mark on history. The concept was created by Alice Marble, the book's associate editor, who wrote them until at least issue #17 when she stopped receiving credit. They are told in comic panel form from Wonder Woman's perspective (signed at the end by Diana Prince).

HER SCIENCE JOURNEY:

1842 – Ellen was born in Dunstable, Massachusetts

1859 – Moved to Westford, Massachusetts to attend Westford, Academy

1868- Enrolled at Vassar College

1870- Became first woman in America to receive a bachelor's degree in chemistry and first woman to be accepted at a scientific institution (MIT)

1871-Started school at MIT

1872-Peformed water survey with Professor William Ripley Nichols while still a student at MIT Analyzed samarskite where she found an insoluble residue later on identified by another scientist as samarium and gadolinium

1873- Received another bachelor's degree in chemistry from MIT and a master's degree in chemistry from Vassar

1875- Married Professor Robert Hallowell Richards

1876-The Women's Laboratory opened and Ellen also taught correspondence courses

1878- Became a fellow for the American Association for the Advancement of Science (AAAS)

1879- Became the first woman elected to the American Institute of Mining and Metallurgical Engineers

1881- Started the Summer Seaside Laboratory with her Paleontology professor Alpheus Hyatt. This would later become an internationally famous laboratory called Marine Biology Laboratory.

1882- Co-Founded the Association of Collegiate Alumnae with one of her students Marion Talbot. It is now known as the American Association of University Women (AAUW).

1884-Became the first woman instructor of MIT when she was appointed instructor in sanitary chemistry

1887-Performed the “Great Sanitary Survey” with Dr. Thomas Drown

1889 -MIT Women’s Association formed with Ellen Richards as its first President

1890- Opened the New England Kitchen with Mary Hinman Abel

1892 -Ellen introduced the term oekology to America

1893- Attended the Chicago World Fair. Introduced the Rumford Kitchen to a global audience.

1894-Started school lunch program in Boston

1908- American Home Economics Association (AHEA) was established with Ellen as its first president

1910-Received an honorary Doctor of Science degree from Smith. Wrote the book *Euthenics, The Science of Controllable Environment*

1911- Died on March 30 at her home in Jamaica Plain, Massachussetts

1928 -Ellen Swallow Richards Memorial Tablet Dedicated

1980- Ellen Swallow Richards Lobby was established

2009-President Barack Obama honored Ellen Richards as one of five “Women Taking the Lead to Save our Planet” during Women’s History Month

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The photos in this blog came from the MIT Museum and from the following websites:

12. https://www.sciencehistory.org/education/scientific-biographies/ellen-h-swallow-richards/

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