

(Photo courtesy of Pamela Swallow, with permission for use from the MIT Archives.)

That matter-of-fact determination was indicative of how Richards approached the rest of her life, breaking down barriers and establishing scientific movements because she believed it was important work. “Ellen was careful to ‘roil no waters,’” said Pamela Swallow, Richards’s biographer and first cousin, three generations removed. “She behaved with extraordinary tact, knowing how much depended upon her success. She wanted to not only open a door for herself, but to keep it open for other women to follow. Her strategy was to become very useful and to demonstrate how capable she was.”

Richards’s strategy might have been too successful: her name usually doesn’t leap to the top of most people’s lists of groundbreaking female scientists. And yet, the power of her accomplishments can’t be denied—the first U.S. woman to be accepted to a college of science and technology; the first female member of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME); a pioneer in applying science to improve community health and safety; and a founder of the ecology movement, with significant contributions to establishing early standards for clean water (in photo above, Richards and a colleague collect water samples).

Richards’s far-reaching influence in science and society were a revelation to Elizabeth Holm, 2013 TMS president, who first heard of Richards during a recent presentation on the history of AIME by its 2012–2013 president, George Luxbacher. Her curiosity piqued, Holm looked up Richards’s biography and “was amazed.”

“Ellen Richards was a pioneer in diversity who, in her own way, overcame seemingly insurmountable barriers to become an accomplished, professional member of the engineering establishment,” said Holm. “Hers was the battle that is fought every day, through quiet



Ellen Swallow Richards:

The Most Influential Scientist You Probably Never Heard Of (Until Now)

Lynne Robinson

The cave entrance loomed high above their heads—a hard and dangerous climb in the grueling sun. But they had heard the tales of unique calcite and iron ore stalactites and stalagmites that had formed inside and were eager to satisfy their scientific curiosity. Robert H. Richards, head of the Massachusetts Institute of Technology’s (MIT) Mining Engineering Department, had gathered the students and colleagues accompanying him on this adventure to strategize how best to access these geological wonders. That’s when he realized that his wife, who was also

part of the expedition, was nowhere to be found.

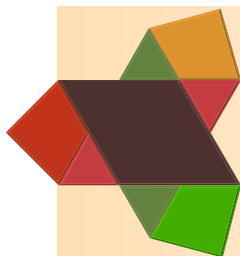
Ellen Swallow Richards had decided to see the cave for herself.

Weighed down by the heavy skirts and stays and petticoats that encumbered women in the late 1800s, she pulled herself, hand-over-hand, up a rope and was the first of the MIT party to enter the cave. Her husband soon followed, anxious that she had made such a perilous attempt on her own. Although a bump on the head had knocked her unconscious, she was just fine. “It was a very spicy adventure,” she later wrote.

perseverance and by having her example be the visible proof of what women could achieve.”

Holm, as the lead organizer for the First TMS Summit on Creating and Sustaining Diversity in the Minerals, Metals, and Materials Professions (see sidebar article), suggested convening the event in Richards’s honor as one way to cast a long overdue spotlight on her contributions. In addition, the TMS Board, under Holm’s leadership, established the Ellen Swallow Richards Diversity Award (see sidebar article) to honor individuals who have walked a similar path to Richards’s.

“This award offers a unique recognition opportunity,” said Holm. “We want to make sure that members of today’s professional community are aware of their colleagues who, like Ellen Swallow Richards, are role models in their determination and courage in the face of adversity. By celebrating their achievements, we hope to provide inspiration and affirmation to those professionals who are addressing challenges of their own, as well as those who want to become



“The only trouble here is they won’t let us study enough. They are so afraid we shall break down and . . . the reputation of the College is at stake, for the question is, can girls get a college degree without ruining their health?”

–Ellen Swallow Richards in a letter to her parents, while attending Vassar

involved in efforts to advance the cause of diversity and inclusion within our field.”

The Lure of “Practical Science”

Glimpses of Ellen Swallow Richards’s drive to open science beyond the traditional boundaries of her time can be seen in her childhood on a small farm in Dunstable, Massachusetts. Born an only child in 1842, Richards was frail and sickly, prompting her parents, who were both teachers, to homeschool her so she wouldn’t be exposed to the diseases that ran rampant in the local one-room school. Her physician

recommended that she spend as much time as possible in the fresh air for her health, and she happily passed her days exploring the outdoors. Those early observations of nature ignited her passion for science, and her father, Peter Swallow, took notice.

“He recognized that his daughter was exceptionally bright and gifted (Figure 1), and believed that she deserved better than they could give her on the farm,” said Pamela Swallow. Peter Swallow sold his farm and moved his family to the nearby town of Westford so Richards could attend Westford Academy, one of the first co-educational secondary schools in the United States. The decision to sacrifice so much for a daughter’s education was highly unconventional for the time, given that the state of Massachusetts did not even require girls to attend school. Richards completed her studies at Westford in two years, while helping her father manage a general store that the family had bought to make ends meet.

Richards “desperately wanted to study more science,” said Pamela Swallow. After reading in *Godey’s Lady’s Book* that Vassar College in New York was hiring staff to teach science, Richards set her sights on furthering her education there. She worked as a school teacher, tutor, nanny, cook, and seamstress for three years to save the \$300 for one year’s tuition. When she finally took Vassar’s entrance examination, she placed in as a junior, despite having only two years of formal education.

Richards quickly made a name for herself as a passionate learner, of rare intellect, said Pamela Swallow.



Figure 1. From an early age, Ellen Swallow Richards loved nature and animals, while also displaying a tireless work ethic. “She never wasted a minute,” said Pamela Swallow. “She would even knit or read while walking to classes at Vassar.” (Family photo courtesy of Pamela Swallow.)

She developed her gift for scientific observation and precision under Maria Mitchell, the first American woman to work as a professional astronomer and Vassar's first appointed faculty member. It was her studies with Charles Farrar, Vassar's professor of chemistry and physics, however, that pointed her to her life's work. "Charles Farrar introduced her to the concept of applied chemistry, which really appealed to her," said Pamela Swallow. "Her goal from an early age was to be useful and to contribute to society. She saw that this more 'practical science' could be used to help others."

Armed with glowing recommendations from Farrar and Mitchell, Richards tried to secure a job as a chemist upon graduating from Vassar. Although her credentials were impeccable, no company was prepared to hire a woman. One firm did suggest she try to continue her studies in chemistry at the recently established MIT. The idea appealed to Richards and she submitted her application.

The "Swallow Experiment"

MIT—then known as Boston Tech—had never admitted a female student, and according to Pamela Swallow, had no intention to change. "The MIT president and admissions committee were astounded that they had received such a strong application from a woman," she said. "They were impressed with her recommendations and work at Vassar, but the thought of having a female study at MIT was appalling to many of them. They fought about it for weeks, until they finally decided to admit her as the 'Swallow Experiment.'" MIT's strategy to accept such an obviously gifted individual, while still maintaining social convention, was to bring Richards in as a "special student" who was not required to pay tuition. That way, Pamela Swallow explained, they did not have to keep an official record of her. In addition, the admissions committee noted in its minutes that it was "understood that her admission did not establish a precedent for the general admission of

females." In January 1871, Richards began her studies at MIT as the first American woman to be admitted to any university of science and technology.

Getting in to MIT proved to be only the first hurdle for Richards. Several professors refused to teach her, and she was segregated from the rest of the school in a basement laboratory reserved for mineralogy studies. "She was quite scorned, actually," said Pamela Swallow. "She was told to keep the door shut when there were students in the hall and her work was slipped to her under the door." Between the exceptional work that she slipped back under the door and her natural resourcefulness, Richards gradually gained ground with some of the faculty. "She won them over by becoming extremely useful," said Pamela Swallow. "She always carried a work kit and was the person they could come to for help—whether it was a broken suspender or a cut hand. When MIT had to let the cleaning

lady go during a budget cut, Ellen did the laboratory cleaning and kept the supplies in order. She did whatever she thought was needed to gain their trust and acceptance."

Richards was eventually permitted to attend classes with the rest of the student body. The academic rigor suited her and she was soon tutoring many of the male students. She was particularly interested in geology and mineralogy, Pamela Swallow said, possibly due to her introduction to the field in the basement laboratory. "She had a particular talent for analyzing rocks and minerals, and even as an undergraduate, gained an international reputation as an assayer," she said. In 1873, MIT formally "adopted the recommendation . . . that Miss E. H. Swallow be allowed to present herself as a candidate for the Degree of the Institute, and to take the examinations necessary for the Degree in Chemistry."

The "Swallow Experiment" (Figure 2) had clearly been a success, but the

The First TMS Summit on Creating and Sustaining

DIVERSITY IN THE MINERALS, METALS, AND MATERIALS PROFESSIONS (DMMM1)

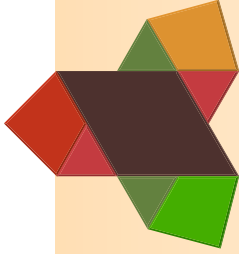
Honoring the First Female Member of AIME: Ellen Swallow Richards

Be Part of Building a More Inclusive Minerals, Metals, and Materials Community

The title is a little long, but the order is quite tall.

The First TMS Summit on Creating and Sustaining Diversity in the Minerals, Metals, and Materials Professions (DMMM1): Honoring the First Female Member of AIME: Ellen Swallow Richards is set to take place July 29–31 at the National Academy of Sciences Building in Washington, D.C. More than a meeting to discuss issues related to diversity, a key goal of the summit is to develop actionable strategies and practical resources for creating a culture of inclusion in the workplace. Attendance will be capped at 300 individuals to ensure optimum interaction and learning. Check the DMMM1 website at www.tms.org/diversitysummit for updates and registration details.

Sponsored by TMS, DMMM1 is co-sponsored by AIME, the National Academy of Engineering, the Society for Mining, Metallurgy, and Exploration, and the Society of Women Engineers. It is endorsed by the American Association of Engineering Societies, the American Institute of Chemical Engineers, and the Association for Women in Science.



“I often think that all the difficulties we encounter only give us the more strength if we keep hold of our work, and we must not now give up while in the prime of life. It is best to keep trying, and by and by the opportunity will come. If we have given up, then we shall not be ready for it when it does come.”

—Ellen Swallow Richards, in a letter of encouragement to a student

MIT administration was not convinced that it could be replicated. “Ellen approached them about admitting other female students, and they informed her that she was a unique case—no other woman could possibly match her caliber,” said Pamela Swallow. Undeterred, Richards convinced MIT to allow her to convert an old gymnasium into a laboratory that would offer courses to women, with money that she had raised from the



Figure 2. Two years after entering MIT’s five-year program, Richards graduated with a B.S. in chemistry. Concurrently, she earned her master’s degree from Vassar, based on her thesis of the chemical analysis of vanadium. (Family photo courtesy of Pamela Swallow.)

Women’s Education Association of Boston. The Women’s Laboratory at MIT opened in 1876—with Richards as its unpaid “assistant instructor” (Figure 3). Her students thrived and, as Richards reported to the MIT administration, “The capability of women to carry through a severe course of scientific education without injury to body or mind is now established.” MIT’s leadership eventually agreed, and in 1883, voted to discontinue the Women’s Laboratory “and students will be admitted . . . without distinction of sex.”

“The Work Mattered Most”

A year after the Women’s Laboratory closed, MIT appointed Richards as an instructor in “sanitary chemistry”—paid this time—and gave her charge of what would become one of the nation’s first public health laboratories. This gave her the

distinction of being MIT’s first female faculty member. She would go on to be the only woman officially teaching at MIT during her lifetime.

Based on the quality of a water pollution survey that Richards had worked on with William Ripley Nichols, the Massachusetts State Board of Health commissioned MIT’s new sanitary chemistry laboratory to conduct a comprehensive study of the state’s drinking water in 1887. Over a two-year period, Richards and her assistants analyzed more than 20,000 water samples for what was considered the most significant indicator of environmental impact at the time—chlorine from salt used in food and for industrial purposes. From these data, Richards developed standards for acceptable chlorine levels and created the “Normal Chlorine Map” that visually plotted the extent of pollution throughout the state. The results spurred Massachusetts to establish the first water quality standards and municipal sewage treatment plant in the country, and the Normal Chlorine Map became the model for similar studies conducted throughout the world for years to come.

While the Normal Chlorine Map became famous in some scientific circles, Richards did not, commented Pamela Swallow, even though her immediate supervisor, Thomas M. Drown, was quick to give her credit



Figure 3. The MIT Women’s Laboratory offered a curriculum that covered chemical analysis, industrial chemistry, mineralogy, and applied biology. (Photo courtesy of Pamela Swallow, with permission for use from the MIT Archives.)

for the work. “She liked the leadership roles she was given, but she wasn’t really looking for fame,” she said. “She viewed herself as a pioneer and was suited to that role. Instinctively, she knew how to use different strategies to maneuver through areas traditionally reserved for men, and she managed to earn their respect and admiration without drawing attention to herself. It was the work that mattered most to her.”

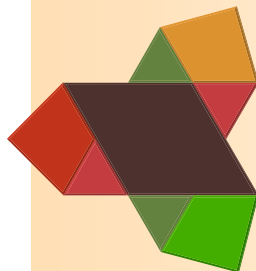
Richards’s commitment to using science as a force for social good extended beyond her water studies to touch almost every aspect of life in the 1800s. She is considered the founder of home economics, based on her advocacy to apply scientific principles to food, indoor air quality, shelter, sanitation, and other topics that directly affected families and their homes.

Her research into the impact of industrialized society on the environment laid the groundwork for the field of ecology—a term that she actually coined to describe the interrelated systems of nature. And, she used her skills as a chemist and talents as a communicator to reveal the potential fire hazards of manufacturing practices, as well as hidden toxins in fabric, wallpaper, and grocery staples.

Richards’s staunchest supporter throughout her multi-faceted career was her husband, Robert Richards (Figure 4), himself an inductee of the U.S. Mining Hall of Fame and one of the first presidents of AIME. They had met while she was an undergraduate at MIT, but being a professor, Robert Richards was not permitted to court her, said Pamela Swallow. He proposed as soon as she graduated, but she chose to hold off on the wedding for two years, out of concern that social expectations would force her to give up her work as a married woman. Robert Richards’s intentions, fortunately, were that they would be partners in work as well as life. “He wanted them to be pioneers together,” said Pamela Swallow.

Richards’s work with her husband focused on the chemistry

Award Celebrates Role Models in Advancing Diversity



“We never can tell how our lives may work to the account of the general good, and we are not wise enough to know if we have fulfilled our mission or not.”

—Ellen Swallow Richards

Like Ellen Swallow Richards, many scientists and engineers have quietly helped break down barriers to full participation in the minerals, metals, and materials fields through example and action. The Ellen Swallow Richards Diversity Award, established by the TMS Board in 2013, intends to bring this important work to light so that others can learn and be inspired to do the same. Made possible through a generous donation to the TMS Foundation by Jeffrey Wadsworth and his wife, Geraldine McCulley Wadsworth, the annual award recognizes an individual who reflects Richards’s pioneering spirit in overcoming adversity to pursue a career in minerals, metals, and/or materials or in helping others to overcome such challenges to pursue their careers.

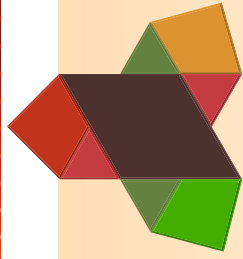
“We believe it is vital to recognize that we are failing to achieve our potential in the minerals, metals, and materials community without full, diverse, representation,” said Jeffrey Wadsworth, Chief Executive Officer and President, Battelle Memorial Institute, Inc. “One way to make the point that this is possible is to highlight the leaders and pioneers from the past, who achieved it under conditions far more adverse than we face today.”

Wadsworth noted that both he and his wife, having had careers in science and engineering, “observed the lack of diversity in our fields, and the problems and biases that accompanied that situation. Conversely, the more diverse the participants are in a discussion, the more rich the discussion, and the better the outcome—It’s that simple,” he said.

“In sponsoring the Ellen Swallow Richards Diversity Award, we are able to make a personal commitment to advocate for values that we feel strongly about,” Wadsworth continued. “That is, to constantly be aware of the need to provide opportunity to all. Through role models, we can emphasize how achievement is possible even in the face of adversity. We need to learn from that and advance.”

The inaugural Ellen Swallow Richards Award will be presented at the First TMS Summit on Creating and Sustaining Diversity in the Minerals, Metals, and Materials Professions in July. Nominations are now being accepted through April 1 for the 2015 award presentation. Visit the TMS Professional Honors and Awards website for information on nomination requirements at awards.tms.org or contact Deborah Price, TMS Awards and Recognition Specialist, at price@tms.org.





“The well-educated young woman of 1950 will blend art and sciences in a way we do not dream of; the science will steady the art and the art will give charm to the science. This young woman will marry—yes, indeed—but she will take her pick of men, who will by that time have begun to realize what sort of men it behooves them to be.”

—Ellen Swallow Richards, *“The College Woman in 1950”*

of ore analysis, and she frequently accompanied him on his field studies with students to mining sites throughout the United States. In 1877, she published “A New Method to Determine Nickel in Pyrrhotites and Mattes,” which secured her recognition as a Fellow of the American Association for Advancement of Science. “Applying this method to ore from the Canadian Coppercliffe lode, she kicked off the nickel industry around Ontario, with her determination of five percent nickel in the sample,” said Barbara J.

Arnold, President, PrepTech, Inc., and a presenter on Richards’s impact on extractive metallurgy at the upcoming Diversity Summit. For these and other contributions to mining and mineralogy, AIME elected Richards as its first female member in 1879.

Arnold intends that Richards join her husband in the Mining Hall of Fame and is in the process of updating the nomination that Frank Aplan, Distinguished Professor Emeritus, Penn State University, had first submitted in 1999. “She didn’t really want the limelight. She always tried

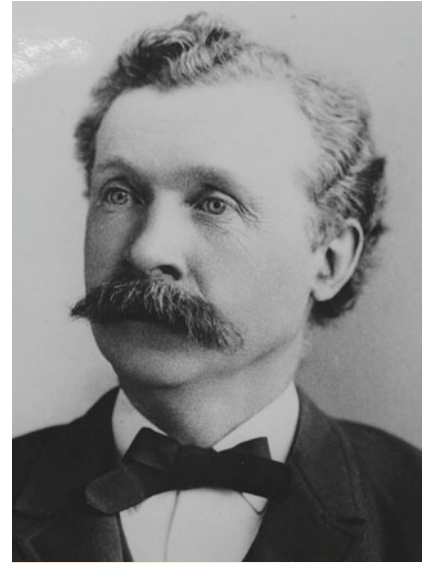


Figure 4. “Robert Richards was extremely proud of his wife, and constantly impressed by her intelligence and capabilities,” said Pamela Swallow. (Photo courtesy of Pamela Swallow, with permission for use from the MIT Archives.)

to empower others. But I think she would realize that today we need her as a role model,” said Arnold.

While widespread recognition eluded Richards in life (Figure 5), Pamela Swallow is hopeful that initiatives such as the Diversity Summit and award established in her honor will introduce her to a new generation of female scientists and engineers. “She made it clear that there was a place for women in science,” she said. “She was wise and careful, but stood her ground when it mattered and was able to accomplish great things by her example. Everything she did was tied into her knowledge and passion for science, and her desire to make science accessible to all.”

Lynne Robinson is the contributing editor to *JOM*. *JOM* also gives special acknowledgement to Pamela Swallow for the information, insights, and images that she contributed to this article. Additional information was obtained from the MIT Institute Archives, <https://libraries.mit.edu/archives>.



Figure 5. Richards at work in her office at MIT. “When she passed away in 1911, MIT held its flags at half mast, and the men who carried her casket were former MIT presidents and trustees—many of them the same people who argued against her being admitted as a student,” said Pamela Swallow. (Photo courtesy of Pamela Swallow, with permission for use from the MIT Archives.)