Coeducation and Massachusetts Institute of Technology's Summer Mining School, 1879

By
Serenity Sutherland

In June 1879, a party of students and faculty in a summer mining school program at the Massachusetts Institute of Technology (MIT) left Boston by steamer for New Brunswick and Nova Scotia, Canada. Summer trips like this were fast becoming a tradition for mining engineering students at MIT. Compared with past excursions, however, this one represented a departure. For the first time four women students would study alongside male students, descending into the mines together.

At a quick glance, the 1879 MIT summer school seems quite distinctive and unusual, given the incorporation of women in the field as students—especially when considering that just barely a decade earlier, in 1871, MIT had admitted its first female student, Ellen Henrietta Swallow. Now Ellen Swallow Richards, wife of mining engineering professor Robert H. Richards, she was overseeing women's chemical education at MIT's Women's Laboratory. As the only woman faculty member on the trip, Richards' presence as chaperone provided an opportunity for female MIT students to gain valuable practical experience.[1]

How unique was this trip within the context of coeducation, and what could women students with limited professional opportunities after graduation hope to gain from such an excursion? Placing the trip's significance within the wider scope of women's educational and professional opportunities in technology and science in the late nineteenth century, combined with a close reading of the trip's field journal, will shed light on mining engineering practices and technologies that these women stu-

dents participated in and observed during their time in Canada.

The 1879 Massachusetts Institute of Technology field trip was not the first attempt at coeducation in a field school setting. Prior to MIT's experiment with a coeducational field school, the Anderson School of Natural History at Penikese Island, Massachusetts, a summer school run by Harvard scientist Louis Agassiz, admitted women.[2] Like Agassiz's Anderson School of Natural History, the 1879 MIT summer school had a female chaperone in the person of the main organizer's wife. Elizabeth Cabot Agassiz's attendance at the 1873 field school meant that other women could respectably travel and study with her well-known scientist husband. Ellen Richards' role with the 1879 MIT summer school fulfilled a similar need for propriety, and, like Elizabeth Cabot Agassiz, Richards hoped to do some of her own scientific research while on the trip.

The 1879 summer school provided women students at MIT with the opportunity to explore mining engineering, mineralogy, and "do" science in a practical setting. Students finished the trip with real-life experience studying specimens in the field, which was becoming more highly valued in the scientific community and reflected Louis Agassiz's directive that scientists should "study nature, not books."[3]

Beyond academic study, the student and faculty travelers encountered the challenges of eating and sleeping in unfamiliar places and operating in a space—the underground of the mines—far removed from the sterile and controlled laboratories of MIT. The physical demands of exploring mines and the logistical requirements of organizing proper sleeping arrangements for a group of young, unmarried men and women put coeducation and late-nineteenth-century gender norms to the test in vastly different ways than in the typical classroom.

Lynn Gordon and Barbara Solomon have reviewed the types of education offered to women at coeducational institutions. Unsurprisingly, given the newness of the coeducational experience in 1879, very few examples of coeducation in summer field schools exist prior to MIT's field school in Canada.[4] Scholars such as Ann Shteir, Nina Baym, and Barbara Sicherman have shown that before gaining access to coeducational opportunities, women pursued educational opportunities within the home as teachers, mothers, and older sisters. Kim Tolley argues that women at home played an authoritative role in family settings introducing science to younger children.[5] Sally Gregory Kohlstedt and Kim Tolley also discuss how science education for women moved from the home to coeducational schools in the mid-nineteenth century, but that science was always part of the curriculum, in some way, for women students.

As women attempted to enter coeducational spaces and join wider scientific communities beyond the academy, Debra Lindsay has found that women were usually denied formal membership within scientific institutions but that some found routes to inclusion through the male members of their families. Women who were married to men of science and part of a "scientific couple" could find themselves "ensconced within a community that formally excluded them."[6] Women's involvement in the MIT summer field school is an example of this type of "intimate exclusion." Through Ellen Richards' marriage and connection to Robert Richards, the women were included on the trip in an ad-hoc fashion.

Coeducation at an MIT field school would offer these women the chance to go where women usually did not (below ground), and to study topics most women barely glimpsed in the lab (mineralogy and mining engineering). Coeducation did not always mean that women received the same educational benefits as men, however, and while this trip would demonstrate much equality in what the women learned, in some cases gender expectations limited educational opportunities for women on the trip.[7]

Education of Women in Science: Coeducation and Women's Academies

Admitted as a "special student," Ellen Swallow attended MIT from 1871 to 1873 as its first female student. The MIT board agreed to admit her as a trial in women's education—she would attend the same classes as male students, but would not pay tuition. The board explicitly stated that Swallow's acceptance as "special student" was not meant to set a precedent for admitting future female students.[8] Ellen Swallow did not fully understand her status as a special student, at first believing the board had offered her tuition-free education due to her limited financial resources.[9]

Her special student status and the fact she was a woman meant that Ellen Swallow was not invited on the exclusively male summer excursions, so she decided to create a version of her own. In the summer of 1872 she took a "scientific vacation" to the St. Lawrence River with Mary Warren Capen, who taught mineralogy to high school girls in Boston. Swallow and Capen traveled alone, visiting mines and climbing rocks without the supervision of men, a remarkable approach to fieldwork for women. Reveling in her independence, Swallow remarked: "We have visited *alone* [*sic*] lead, copper, tin, silver, gold and iron mines, been courteously treated by all, not tenderly as ladies, but no one has put a bar in our way. We have taken a horse and driven about from place to place with hammer and chisel and botany press . . . we are strong and black as gypsies—being out doors [*sic*] all the time." Capen and Swallow lodged in clapboard houses used to store hay, ate meals of only biscuits and gulped down black "yarb" tea. Most importantly, they handled actual specimens and studied them "in their native beds."[10]

Traveling independently with a woman partner was clearly a pleasure for Swallow and she would repeat such trips later in her life, but not all nineteenth-century women travelers—on scientific vacations or otherwise—encountered welcoming men and relative safety. While she never mentioned any struggles or aggressive male behavior she might have experienced doing fieldwork, scholars such as Cynthia Burek and Martina Kölbl-Ebert note the issues female geologists faced while attempting fieldwork, including unsuitable clothing, sexual harassment, lack of institutional support, and inadequate chaperones.[11] Certainly unsuitable clothing would be an issue for Richards and her female students when they climbed up and down ladders into mines, hoisted themselves in and out of mine cars, and slept in hay barns.

Ellen Swallow recognized early in 1872 that her scientific travels went beyond gaining scientific experience and finding suitable specimens, the main concerns for her male colleagues. She knew that her success in fieldwork proved that her scientific skills and her ability to physically traverse difficult terrain were equal to those of men. It not only meant that *she* could do it, but that *all* women, if properly trained to study science, could undertake intense research conditions. In a letter to a friend she confessed that her small scientific journey was "not at all rivaling Agassiz, you know, for it's only 'two women,' but just to see whether 'two women' could do anything." She was happy to report upon return from her scientific vacation that "Yes, they can."[12] If two women could achieve these accomplishments, it logically followed that nothing should stop any woman with an interest in science and the physical ability to withstand fieldwork from undertaking scientific research in the field.[13]

Swallow's reference to Agassiz in her letter describing her trip with Capen illustrates Agassiz's influence on her thinking about women in education, as well as the importance of his scientific procedure. She followed Louis Agassiz's approach of learning scientific principles through studying scientific objects, not just reading about them in books. However, the propriety of women searching for specimens was a contested issue. Almira Hart Lincoln Phelps, author of textbooks in the fields of geology and biology in the 1820s

and 1830s, advised young women to recognize their physical limitations. "To the hardier sex, who can climb mountains and penetrate marshes, many strange and interesting plants will present themselves, which cannot be found except in their peculiar situations; of these you must be content to obtain specimens without seeing them in their native wilds."[14] By the 1870s, Ellen Swallow Richards and her students directly refuted such thinking by climbing mountains, descending into mines and slogging through marshes to find specimens of their own.

Richards founded a Women's Laboratory at MIT and opened it in 1876. Richards raised money from the Boston Women's Education Association (WEA) for the construction of an annex at MIT to house the Women's Laboratory. She also secured all of the lab equipment personally, travelling to Jena, Germany, where she "expected to spend lots of money" for instruments for the new laboratory. She excitedly wrote to a friend that her plans for the Women's Laboratory had "prospered beyond my expectations."[15]

Richards recognized the lack of professional training opportunities for women in mineralogy and mining and she worked to interest members of WEA in supporting such training. In the first report to her Women's Laboratory stakeholders at the WEA in 1877, Richards noted that scarcely any of her twenty-five female students understood the essentials of mineralogy, writing:

> Mineralogy or the determination of mineral species by the blowpipe is rarely if ever taught in colleges. Smith College will be an exception to the rule. Scientific schools usually give a course of it, but until within a few years [ago] the so called [*sic*] mineralogists were collectors who had learned to distinguish the common varieties by sight. Most of the dealers in minerals are still of this clan. I suppose very few women in the country understand this very fascinating subject and yet there is not another in which women would so readily excel for it requires nice distinctions of color, lustre and other appearances.[16]

Richards's belief that women were best at deciphering coloring in minerals relied on essentialist arguments for women's involvement in science that would become popular later in the nineteenth and early twentieth centuries, when advocates argued for women's involvement in scientific work due to their intrinsic natures and physical features: small hands, eyes for detail, and compassionate personalities. Making claims for "women's work" in the 1870s seemed a good entering wedge into science, as Margaret Rossiter has shown, but such gendered arguments about the types of work in which women would naturally excel hurt women's advancement in science in the long run.[17]

Students who joined the Women's Laboratory were registered as "special students" the same as Swallow, but, unlike Swallow, were expected to pay tuition in order to ensure the lab could be financially successful. In its first year, the Women's Laboratory enrolled twenty-three students with varying abilities to pay the tuition. Richards wrote in a report to the WEA:

> Of the 23 only 5 (as far as I am able to judge) have been in a condition to pay the fee without sacrifice and self denial [*sic*]. This makes the number who spend much time in Laboratory quite small. They study as much as possible outside and gain as much as they can in an afternoon. While this increases the <u>usefulness</u> [*sic*] of the Laboratory it materially lessens its income.[18]

Thus, one significant institutional context for women's inclusion in the field school is the MIT Women's Laboratory that Richards started with the help of the fundraising of the WEA. Without this network of women, the female students would not have been at MIT in the first place and

would not have traveled to the 1879 field school in Canada. In 1882, MIT began admitting women students as regular students. This somewhat defeated the purpose of the Women's Laboratory, and in 1883 MIT closed that facility.

MIT Summer Mining Trips

The MIT summer trips began in 1871, when Robert Richards and President John Runkle took a group of mining engineering students to Colorado so they could "see how things were actually done" outside of their MIT laboratories.[19] Not only did the students get the chance to practice their studies, they also found the field schools to be a great networking tool. As one student recalled, the summer schools' "value as a means of instruction was very great . . . they strengthened the ties between teacher and pupil, they introduced the student to managers of mines and works, which frequently led to subsequent employment, [and] they showed the latter that the student was a useful sort of person, and could be trusted."[20]

Nearly all of what is recoverable by historians about MIT's 1879 summer school comes from a travel journal written by male mining engineering student Fred W. Clark. His 1879 journal is part daybook and part field book. The first section describes vividly where the travelers slept, what they ate, and interesting things that they saw, while the second part of the book served as a professional record of the mining and mineralogy "works" they visited, including the technology, working conditions, and geological composition of the mines.

According to the preface of Clark's journal, "it was expected that each member of the party would keep a journal or note book throughout the trip for future reference." Clark's is the only known surviving travel journal from the trip.[21] It is through Clark's eyes that we see what coeducational fieldwork looked like on the trip. Clark took pains to enter events beyond his own experiences, however, including side trips and important specimen finds, even if he did not personally benefit from them. Clark gleaned his material for journal entries by listening to the nearly daily evening meetings when the team members gathered and reported their findings and important events of the day. Thus, while Clark is our main witness, the input of other team members informs his writing.

The female students on the trip were Sarah Dawson and Mary Palmer, students in chemistry and mineralogy, respectively; Florence Cushing, a graduate student in chemistry; and Evelyn M. Walton, concentrating in *six* areas: math, French, physics, biology, geology and chemistry. The male students on the trip were the writer of the travel journal, Fred Clark, a senior; Richard Dodge, a senior; and Webster Norris and Arthur Winslow, both sophomores. The male professors included Robert Richards, John M. Ordway, professor of metallurgy and industrial chemistry, and the homeopathic physician Dr. R. M. Barrows.

Clark described his fellow women travelers as properly ladylike at times and at other times wildly adventurous. They were vigorous and active, just as excited to don boots and traipse around in the bowels of a muddy mine as they were to visit Grand Pre, Nova Scotia, and wax romantic about Henry Wadsworth Longfellow's poem, *Evangeline*—all of which they did on their summer trip.

For a time, historians of the nineteenth century failed to clearly portray women in male-dominated spaces such as a mine. Many women's historians of the 1980s and 1990s viewed nineteenth-century womanhood through the lens of "true womanhood" which emphasized purity, piety, domesticity, and submissiveness as the key characteristics of femininity.[22] In the setting of the summer trip and in women's education in general, true womanhood—a phrase nineteenth-century women also used to describe themselves—was often used as a shield against accusations of indecency.

As women's roles began to fluctuate and expand after the Civil War, with increased opportunities for education, reform work, and political

involvement through campaigns for suffrage, the protection of the respectability of middle-class "true womanhood" became increasingly useful for middle-class women pushing educational and professional boundaries in the latter half of the century. True womanhood, then, as with gender itself, was not a rigid category, and in the case of the women on the summer field trip, it served as a malleable technique employed to protect primarily white, middle-class femininity.

The work of Sally Zanjani shows that women who worked in mines hazarded their claims to respectability if they had lower economic status, were racially non-white, or had questionable sexuality. Much work on the history of women in mining falls into two categories: women outside of middle-class respectability due to their ethnicity, economic status, or sexuality; and professional-class women who followed their mining and engineer husbands into mining country.[23] The women on the 1879 summer trip fit neither categorization as Cushing, Dawson, Palmer, Walton, and Richards were working in the Women's Laboratory as scientific researchers, and all but Ellen Richards were single students in school.

Richards was in the midst of fighting to establish her career as a scientist, and while she sometimes "followed" her husband on mining expeditions, she did so to pursue collaborative research with him and his colleagues, frequently publishing her results. In 1879 she became one of the first women accepted into the American Institute of Mining Engineers. Throughout her life, her accomplishments in the fields of mining engineering and mineralogy included her identification of a faster and more efficient way to precipitate nickel from ore (which she published in 1877 in "A New Method to Determine Nickel in Pyrrhotites and Mattes"), her textbook for children, *First Lessons in Minerals*, and her oft-practiced work as an assayer on mining trips throughout the United States and Canada.[24] Such work proves that Richards did more than just follow her husband as his assistant. She had her own research agenda and just as often traveled on her own or with other women.

The 1879 Field School Program

After the steamer carrying the students reached St. John, New Brunswick, on the afternoon of July 1, members of the team began preparing for their visit to the Albert Mine, south of the village of Hillsborough in the southeastern part of New Brunswick. The miners were extracting "albertite," also known as "solid petroleum" or asphalt, discovered by Abraham Gesner in 1820 and mined locally between 1854 and 1884.[25] The team was ready to work, but received a disappointment when unable to visit "the pit" because the superintendent of the mine was absent from work that day. Even if the students could not visit the mine, the pedagogy of the summer trip included observation both above and below ground, so students got to work examining those mining processes that they could observe.

All members of the team had certain duties and responsibilities expected of them. Students took turns as captain and assigned specific research categories to their classmates. Students were to learn all they could through observation of subjects such as hoisting, pumping, working conditions and wages, lighting and ventilation, and the product being mined. Later, in the evening or during the next available inactive time, the captain would call a meeting and ask each member to give a report on his or her respective subject while the rest of the team took notes. This way, went the pedagogical approach, each student learned all there was to know at every mine. The women on the trip were also made captains and Clark reported no gender distinctions concerning who got what assignments while at a mine.[26]

The professors assigned nine learning objectives for each mine. These were primarily within the scope of mining engineering students' interests, but with some emphasis on mineralogy and chemistry. In category one, students focused on

geological features such as rock formations, deposits, footwalls, hanging walls, strikes and dips. In the second category, students examined the construction of shafts, levels, slopes, horse or mule stalls, pillars, and the approximate dimensions of each. Category three looked at hoisting, drum engines, cages, cars, the cost of running the transportation systems, and the dimensions of each. The fourth category examined pumping, the size of pipes, the kinds of pumps and valves used to lift water, and the cost of the pump and pumping activities. Categories five and six looked at the working conditions of the men, the lighting provided, the amount of time required to get into the mine and out (miners were typically not paid for travel time in and out of mines), how many men were employed, their wages, if they were content or "roving," married or single, and if there was any mention of strikes. Category seven included safety issues such as lighting, ventilation, the amount of air required by law per cubic foot of the mine per man, the types of fans used, and the cost of operating and maintaining the blower. Categories eight and nine looked at the final product and assessed the mine's productivity in view of governmental licensing and the cost-benefit ratio of operating the mine.[27] Students found the answers through observing the mine and interviewing workers and management. Not only did the women descend into the mine, they talked with the miners, putting voice to their presence in all-male spaces.

All of the above categories required previous training in science or social science, including physics, engineering, advanced mathematics, social relations and reform, geology, mineralogy, and hydrology. Two of the students, Palmer and Dawson, were studying mineralogy and may have been more interested in the mining aspects of the trip, but the other two female students, Cushing and Walton, expressed interest in chemistry and physics, rather than mineralogy. The single discipline uniting all four female students was chemistry, but little on the list of learning objectives reflected chemistry. Additionally, members of the party found specimens of geological and mineralogical interest to ship back to MIT. Analyzing the specimens found during their fieldwork was when the women's chemical training became applicable and gave them future research work to look forward to in the Women's Laboratory at MIT.

Educational outcomes also focused on students learning the managerial and professional aspects of mining engineering. The students were not expected to learn how to do the actual hard work of removing and processing ore. Their focus was on the management of machinery, men, mine conditions, and how to supply a steady stream of product. The actual work of mining was below their socio-economic status. In fact, Clark joked that some of the students tried their hands at mining, "but did not succeed very well."[28]

This occupational difference between the miners and the students was more than trivial. Class dimensions played a role as the middle-class American students toured Canadian mining towns asking questions and scribbling in notebooks. For work-a-day miners, the students' presence—especially in the company of women, whom some considered "bad luck" in mines—may have further alienated the miners from the future managers. Women descending into Canadian mines was not commonplace. Scholars of Canada's mining history have found little evidence of women entering Nova Scotia's and New Brunswick's mines for wage work. Men and boys labored underground, while women contributed to the mining enterprise domestically by keeping house, raising children, and sustaining social and cultural life.[29]

Although they were unable to enter the Albert Mine on July 2, the students kept busy and found "many fine fossil fish and other curiosities" above ground. The superintendent's son did everything he could to explain the workings of the mine, but the students were disappointed that not all their questions were answered. Even still, they toured one of the three shaft houses and visited the shipping and washing facilities that cleaned

the mined product. To make up for the lack of the excitement, several of the students "rode home on the engine" of the train, although Clark did not record which students rode on the engine.

Going Underground

On July 4, the group had a trying, exhausting, and thrilling day that helped to unite it. It was the first day the group would go "below," into the Joggins Mine, located in northwestern Nova Scotia beside the Bay of Fundy. Upon reaching the coal mine, each member of the party was given an "open miners lamp" to complete his or her outfit of rubber coat, hammer, and geology bag. Joggins is an excellent geological site, with many layers of strata and with abundant minerals and fossils. The coal veins, however, are much less abundant and only three profitable beds were being mined at the time.[30] The summer students paid less attention to the economic feasibility of the mine, however, as the excitement of the descent into the mine took over the day's journal narrative. Small coal cars took the students down, an adventure that Clark described in detail:

> Two cars are lowered at a time. Matting was placed in the cars and three of us climbed in[to] each car... Mr B. [the mine superintendent] cautioned us to lie low and put our hands up when we passed under the canvas flap. This is a curtain hung across the shaft [that] turns the incoming air current into the air level whence it passes through the back balance. We were lowered slowly. Nothing could be seen ahead. Entrance grew smaller and smaller. After passing under [the] curtain we saw lights ahead and were soon pulled into the level.[31]

Cramming into coal cars was an experience quite different than anything possible at the MIT Laboratories. The women students received an advanced education about the mine from top to bottom, car ride and all. After touring the bowels of this mine, which Clark described as "quite dry," the group returned to the hotel, packed its bags, and left at 4:00 p.m. via open wagons for the town of Parrsboro, Nova Scotia, thirty-five miles away, a hasty departure due to an encroaching storm.

The group's hotel, the Ottawa House, lay two and a half miles beyond Parrsboro and on the road between a "heavy rain storm set in." After a mile of sodden travel, the group sought shelter in a barn, but some members of the party were already thoroughly wet. After a break in the weather, the group drove on and members walked alongside the carriage at intervals to try to stay warm. They "tried singing and solving conundrums to keep up courage." However, the rain, fog, and dampness followed them all the way to their destination, where they awakened the landlord and landlady with their late arrival at 10:45 p.m. According to Clark, "this fourth will long be remembered by the members of this party." This fourth also helped reinforce that "the ladies" were game for keeping up in the dank mines and the rotten weather just as much as the men.

Following its exhausting July 4, the team planned a more relaxing day of mineral hunting and sailed to a nearby island for a picnic and mineralogy expedition the following day. After the men "fixed up a table," the "ladies set it up" while the men went hunting for minerals. This gendered delegation of work contrasts with the previous day's gendered blurring of work. The women missed the first phase of mineral hunting, a true disadvantage, as Clark proclaims "we were wild over the beautiful minerals obtained." Even though the ladies were able to search for minerals after dinner, the trip concluded at 7:00 p.m., in time to catch the tide back to the hotel, certainly producing a much smaller bounty for the ladies than the men had the opportunity to gather.[32] Missing the early part of mineral hunting not only diminished the women's chance to learn in the field, but also reduced the number of specimens

they were able to analyze upon returning to the Women's Laboratory. This example of women's gendered work as food preparers underscores how coeducation for women students still relied partly on traditional gender roles.

The next few days of touring mines were fairly uneventful for the team. On July 8, the group visited Nova Scotia's Springhill Coal Mine, a site of three future mining disasters, and toured the shaft of the collieries and visited the ventilating furnace, located ten feet underground with a stack rising forty feet above the surface. The shaft slopes were 35 degrees with a 400-foot slope. Clark described the location as "exceedingly hot" and the air "very bad."[33] At the next stop, the iron mines at Londonderry, Nova Scotia, the group found the "furnaces out of blast, the mines not being worked, and the men in the rolling mill on short time." Despite not being able to view the mine in operation, group members toured the inside of a furnace undergoing repairs and visited the ore sheds. Later that evening, Robert Richards prepared a quiz for the students on furnaces and mills.[34]

On a rainy July 9, the group visited another of the Acadia mines in Londonderry. The students entered the mine by walking up "the automatic incline by which the ore is lowered." Then they walked half a mile into the hill and climbed "into several of the stopes some of which were quite difficult to enter." The walking and time spent in the mine resulted in "a musty looking party" when they emerged. "Hat, coats, shoes & pants covered with iron rust and a mixture of it and candle grease on the hands." At 4:00 p.m., again in a rainstorm, the group headed back to Londonderry in wagons, one covered and one not. The ladies rode in the covered wagon, while the men used the ladies' sunshades for umbrellas in the open wagon.

Professional Paths

Sloshing through the rainstorm together is a nice visual allegory for the muddy waters of professionalization the male and female students would experience when they returned to Boston and graduated. For the male students, their training at MIT was a clear path to professions as engineering superintendents, surveyors, mining company executives, government employees, and even professors at the nation's mining schools. For the female students, such career paths were largely unattainable. Some would become high school teachers of science, perhaps a select few would become professors at women's colleges, but they did not assess the mines they visited in Canada as potential places of employment as the male students did.

Indeed, the male students would become professionally successful. Journal writer Fred Clark worked as a mining engineer for ten years, then would become a professor in the mining and metallurgy department at MIT for six years. After his father's death in 1902, Clark returned to his birthplace of Chicago to run the family business, the Clark Construction Company, and would be involved in constructing many national landmarks: the Art Institute of Chicago and the U.S. Navy Yard at Charleston, South Carolina, being just two.[35] Webster Norris worked on the chemistry and engineering of rubber for over thirty years, returning to MIT in 1893 to offer lectures for a class.[36] Arthur Winslow served on MIT's Members of the Corporation and on the Visiting Committee for the Department of Mining and Geology. He also published "Winslow's Stadia Tables" and achieved professional membership in the Geological Society of America, the American Institute of Mining Engineers, and the Colorado Mine Operators' Association, becoming president of the last in 1902.[37]

The women, in contrast, are difficult to trace in the historical record, likely due to name changes after marriage. Florence Cushing, the only female student traceable from the 1879 trip, never married or had children. She would remain a correspondent of Ellen Richards' and be her personal assistant in the 1880s and 1890s. Cushing, a graduate of Vassar College as well as of MIT's

Women's Laboratory, also became involved in the WEA and the Association of Collegiate Alumnae (ACA, later the AAUW), following in the footsteps of her mentor Ellen Richards, who helped organize the ACA in the 1880s. Cushing also served on the Vassar Board of Trustees, and on the boards of the Nantucket Maria Mitchell Association and the Society for Promoting Scientific Research among Women. In addition to being Richards' assistant, Cushing worked with the Boston School Board to help secure a new building for students at the Girls' Latin School in the late 1890s.[38]

Cushing's professional opportunities, in contrast to her male colleagues on the trip, demonstrate that she worked primarily outside of the fields of mining engineering and chemistry, following a path that would continue to rely on Ellen Richards' connections with other women academics. She found a "border" space for her scientific work that existed outside of the traditional career paths that men followed; this speaks to hers and other women's creativity and agency in finding professional work, but also illustrates that MIT trained its male students for specific careers, while women had a less clear and open path to professions, instead cobbling together professional opportunities.

More Mines

Another late night followed the wet wagon ride with sunshades, as the party attempted to find lodgings at Truro, Nova Scotia. A landlady turned the damp, odd party away, explaining: "Can't accommodate all of you. Can accommodate some of you." They ventured further into town and found more available quarters, finishing their supper after 11 p.m.[39] At another boarding house later on in the trip only three bedrooms were available, so the women and professors slept in the rooms while the male students crammed into a parlor, sleeping on "rows of cane bottom chairs," the floor, a small sofa, and an arm chair. While Clark admitted to sleeping "tolerably well," he confessed that "we fellows on the floor were glad when daylight appeared."[40]

The group continued to tour coal mines in Nova Scotia and soon found a working mine that provided one of the best visits of its tour. The Acadia colliery contained coal that was largely bituminous (about 50-75 percent carbon content) and had a vein nearly thirteen feet thick. The coal was extracted using the room-and-pillar method.[41] Clark's journal entry describing the descent into the Acadia was one of his most detailed:

> This shaft is vertical. The coal is raised by two cages, having two platforms each carrying two cars. . . . We prepared to go down. Waterproof, overcoats and shoes were put on. All superfluous articles were left in the office. Two stools were placed on [the] lower platform of [the] cage, a board put across and six of the party took seats, then Mr. Frazer [the superintendent] stepped on, cautioned us not to move and down we went at a lively rate. It was so dark we could not see our hand when passed before [our] eyes. The cage was filled with spray which came in from all sides. It was sent up immediately for the rest of the party and we were conducted to the cabin to "get our eyes," as Mr. Frazer termed it. The cabin was a little room off the side of the main level.[42]

In addition to touring the underground "cabin," the group saw the safety-lamp room, where the lamps were lit and locked for the miners, and the stalls where mules and horses lived underground, a place, according to Clark, very foul, dank, and unclean.

On the way back to their hotel, some party members again rode home on the train's engine. Altogether, there were six men on the trip, including the faculty. Would a woman or a faculty member be most likely to ride home on the engine?

A newspaper clipping from South Carolina's *Charleston News and Courier*, apparently written by one of the students, describes the group: "Most of our party preferred to ride on the locomotive rather than the car, and the rate at which we tore over the road, blowing the whistle and ringing the bell, was truly astonishing to the natives who turned out in crowds to look at us." Recognizing that they looked ridiculous, the author attributed it to the fact that they were "armed with hammers and chisels," carrying sacks filled with rocks and minerals.[43]

Whether riding on the engine or traveling in the cars, the women students found the traveling time an interval for leisure, relaxation or catching up on notes in their assigned categories. For longer rides, the students played games of "Twenty Questions" or solved conundrums. While waiting for trains, they also played catch with rubber balls, one time using a farmer's potatoes when a ball could not be found. Clark often commented that groups of people stopped to watch them while they engaged in games, sat in groups talking about mines or waded ashore after reaching a destination at high tide.

The scenes Clark described of the men and women students leisurely enjoying a game of ball or solving puzzles belie the picture of male students treating female students with contempt on coeducational campuses that scholars like Barbara Solomon and Lynn Gordon have noted.[44] In such a small group, where the women worked as hard as the men, ambivalence or hateful thoughts toward female students likely dissipated as the women proved themselves to be ambitious, bright colleagues and peers.

The trip was educational for all the students, but thrill and adventure were part of its appeal as well. Some of the mines that the group visited went beyond adventure and were quite unsafe, even by the meagre mining safety standards of the day. At the Albion Colliery in Stellarton, Nova Scotia, the group toured a mine working the eleven-foot-thick McGregor seam.[45] Contemporaries regarded Stellarton's mines as potentially hazardous due to the geological composition of the coal beds. A mining manual of the era states that "a peculiarity of this [Albion] seam, and one that adds much to the risk attending these operations, is the frequent occurrence of vertical fractures in the coal locally termed 'lypes.'" The rock was "occasionally slightly open" and formed fissures that could frequently fracture and become "slickensided," a smoothly polished surface caused by friction.[46] Such rock could fall at any time. The Stellarton Mine in the Albion seam was clearly unsafe, but the students either reveled in their daredevil tour or were unaware of the danger. A descriptive July 11 journal entry illustrates the thrill of danger at Stellarton's mines:

> After examining a portion of the surface works, we were provided with lamps, half of the party having open lamps and half safety lamps. This mine is worked by slope shafts having a dip of 21°. The pumping shaft is used for walking in and out of the mine . . . with rude steps the whole distance. Along the level we noticed the boarded-up entrances to the old back balance with a red board marked "Danger" on each. . . . Two miners were at work, one lying on his back, working . . . and the other kneeling. These miners used open lamps. We next went across [a] back balance [an incline] and entered [through a door]. Before opening the door all the open lamps were [ex]tinguished and left outside. The roof was supported just behind [the] miners by heavy timber posts. A little further back the timbers were bending and some of them were crushed. Further back the roof had fallen in and a large body of fire damp [methane] had accumulated. The overflow passed out through and to the ventilating shaft. We went back to [the] balance, climbed [up]. [The mine superintendent] showed that there really was fire

> damp present. He turned down the lamp which made the flame very small, then the lamp was held near the roof. A pale blue flame could be seen playing about inside of the wire gauze. He remarked that there was nothing but the wire screen between us and eternity. The experiment was repeated several times.

For some of the students, the experiment was a fun diversion and they tried to light the methane when they saw some bubbling up through water in the mine, "we set it on fire as it escaped." Clark commented rather thankfully that there was not enough of it to cause an explosion.[47]

In addition to education and adventure, the summer trip offered a leisurely pursuit when students had the option of traveling to Grand Pre, Nova Scotia. However, not all members of the trip were interested in the activities planned:

> Many wished to stop at Grand Pre [for] a few hours to see the former homes of the Acadians celebrated in Longfellow's *Evangeline*. It was finally decided that those who preferred minerals to romance should remain [at Stellarton] till 12 o'clock and those who, *under the circumstances*, preferred romance to minerals should take the 9 o'clock train [italics added].[48]

Clark confessed that he was one of only two who preferred minerals to romance and that all of the ladies and most of the men traveled to Grand Pre. Clark described the group developing friendships and enjoying leisure together. When the group that traveled to Grand Pre returned, Clark remarked that "the rest of the party expressed themselves highly delighted with their visit. The ladies brought away bouquets of flowers to press and keep as mementoes."[49]

That Clark refers to the flowers as "mementoes" rather than "botanical specimens" alludes that he found the trip more frivolous than academic. It is also possible that Clark saw the trip to Grand Pre as outside of his own goal—finding suitable employment in mining engineering. For the women, who were very unlikely to find professional opportunities as mining engineers, visiting Grand Pre was a chance to shape the summer field school more toward their own interests and potential opportunities.

Limited Legacies

Clark's travel journal also suggests how the women at the summer mining school were presented with the opportunity to travel to places that would have been difficult for them to arrange on their own. This unique opportunity was not sustained, however, and women students would not go on another summer mining school trip until the twentieth century.[50] Clark helped develop summer schools in future years and perhaps he did not deem the 1879 summer trip to be convincing evidence that women ought to, or should be permitted to, study with men at summer school.[51]

Equally likely is that MIT administrators did not believe coeducational summer schools were necessary for the kinds of work women could do. The gendering of late nineteenth- and early twentieth-century science generally pointed women more toward the chemistry of cooking and cleaning, home economics, and medicine. Women employed in laboratories did the work of counting, cataloging, and detailing. As Margaret Rossiter has argued in "Which Science? Which Women?" however, individual stories of exclusion and inclusion in scientific fields have never been "the same for all women in science or even for those in *one* science," home economics and mining engineering especially.[52] Statistics from the National Science Foundation show that mining engineering remained a very masculine field and is so today.[53]

While Clark and the other men may have felt annoyance with the women, and likely with each other as the trip wore on and everyone developed likes, dislikes, and frustrations with each other,

the group formed a strong bond and was sorry to see it end. On July 19 the students and faculty arrived back in Boston. Clark wrote:

> The whole party was exceedingly quiet. No conundrums, no games, talking very quiet and subdued. The [ocean] swell may have had something to do with it but I presume it was mainly the thought of separating from each other that made us so quiet. We brightened up on nearing the Hub and reached eagerly for the "old dome [of MIT]." We reached the dock about quarter after one[,] shook hands, bid each other good bye and then all dispersed.[54]

While there were not many coeducational field schools beyond MIT, some did exist. Florence Bascom at Bryn Mawr organized field trips to the Grand Canyon for women students in 1906. Women became a more prominent presence in botany laboratories and in summer institutes, such as at Woods Hole, Massachusetts, and Cold Spring Harbor on Long Island, New York.[55] And, until 1883, the Women's Laboratory at MIT would continue to produce qualified female students who taught and practiced science in a number of settings.

Women at MIT would remain a very small proportion of the university's population until after World War II. Amy Sue Bix finds that at MIT there were "never more than 65 [women] students at any time out of a total student population of just under five thousand."[56] In her Women's Laboratory, Richards trained just over one hundred students. Reflecting on the legacy of the Women's Laboratory in 1894, Richards noted that while the number of women who studied with her may have been small, she felt proud of the work that they had found after their laboratory training. "Of the 102 women who studied in the Woman's Laboratory, 1876-83, 41 are now actively engaged in educational work, occupying some of the highest positions and exerting a powerful influence on all branches of education."[57] Women were always a small percentage of the student body at MIT, which makes their one-time inclusion on this trip a remarkable anomaly in the history of education at MIT.

The 1879 MIT summer mining school paints a fuller picture of the types of coeducation in science and technology made available for a brief time to female MIT students. It highlights the limitations that MIT's women students accepted as part of their entrance into the world of science education. It also illustrates how women navigated those restrictions by taking advantage of personal relationships (Ellen Richards' marriage to trip-organizer Robert Richards) and institutional connections (Ellen Richards' status as an alumna of and instructor at MIT) to increase professional opportunities for themselves and other women. Furthermore, with so few sources available about women's experience in mines, this essay provides a unique, albeit isolated, glimpse of the dangers, excitements, and learning opportunities presented to these select women who ventured underground into these Canadian mines.

Serenity Sutherland is an Assistant Professor of Communication Studies at SUNY Oswego. She is currently working on a digital documentary editing project for the papers of Ellen Swallow Richards, as well as developing for publication her dissertation, "Discovering Science for Women: The Life of Ellen Swallow Richards, 1842-1911." She won a research grant from the Mining History Association in 2013 and used the funds to research the mining summer field trip journals at MIT. *The author would like to thank the anonymous reviewer and the editor of the Mining History Journal for such thorough comments and edits.*

Notes:

1. Robert H. Richards Papers, MC 116, 1879 Travel Journal, "Circular Number 1, May 17, 1879," (pasted in), Massachusetts Institute of Technology, Institute Archives and Special Collections (hereafter referred to as "1879 Travel Journal").
2. For Agassiz's summer field school on Penikese Island see: Kim Tolley, *The Science Education of American Girls: A Historical Perspective* (New York: Rutledge, 2003), 112-7; Emmanuel D. Rudolph, "History of the Botanical Teaching Laboratory in the United States," *American Journal of Botany* 83, no. 5 (May 1996): 661-71; Joan N. Burstyn, "Early Women in Education: The Role of The Anderson School of Natural History," *Journal of Education* 159, no. 3 (Aug. 1977): 50-64. Other women later in the century also attended field schools, although more research is needed in this area. For instance, paleontologist Carrie Barbour did much work for the Morrill Geological Expeditions that took place in the 1890s and she travelled on at least two trips to complete fieldwork; see: Lois B. Arnold, "The Double Standard in American Science Education: An Historical Perspective," *Journal of College Science Teaching* 7, no. 5 (May 1978): 295.
3. Sally Gregory Kohlstedt, "Nature, Not Books: Scientists and the Origins of the Nature-Study Movement in the 1890s," *Isis* 96, no. 3 (Sep. 2005): 324-52. Furthermore, as Christine Ogren shows, professional development during the summer became a trend for teachers from the 1880s onward. The work accomplished during the 1879 MIT summer trip also can be seen as part of professional development. Christine A. Ogren, "Out-of-Class Project: American Teachers' Summertime Activities, 1880-1930," *History of Education Quarterly* 56, no. 1 (Feb. 2016): 8-35.
4. For the history of women and coeducation see: Patricia Foster Haines, "For Honor and Alma Mater: Perspectives on Coeducation at Cornell University, 1868-1885," *Journal of Education* 159, no. 3 (Aug. 1977): 25-37; Linda Gordon, *Gender and Higher Education in the Progressive Era* (New Haven: Yale University Press, 1990); Barbara Solomon, *In the Company of Educated Women: A History of Women and Higher Education* (New Haven: Yale University Press, 1985); Mary Kelley, *Learning to Stand and Speak: Women, Education and Public Life in America's Republic* (Chapel Hill: University of North Carolina Press, 2006); Andrea Radke-Moss, *Bright Epoch: Women and Coeducation in the American West* (Lincoln: University of Nebraska Press, 2008); Christine A. Ogren, *The American State Normal School: "An Instrument of Great Good"* (New York: Palgrave Macmillan, 2005); Margaret A. Nash, *Women's Education in the United States, 1780-1840* (New York: Palgrave MacMillan, 2005). For examples of coeducation at specific institutions see: John Rury and Glenn Harper, "The Trouble with Coeducation: Mann and Women at Antioch, 1853-1860," *History of Education Quarterly* 26, no. 4 (Win. 1986): 481-502; Charlotte Williams Conable, *Women at Cornell: The Myth of Equal Education* (Ithaca, NY: Cornell University Press, 1977). For women in summer schools see: Burstyn, "Early Women in Education," 50-64; Tolley, *Science Education of Girls,* and a collection of essays in *The Role of Women in the History of Geology*, C. V. Burek and B. Higgs (eds.). For the construction of gender stereotypes see: Joan W. Scott, "Gender: A Useful Category of Historical Analysis," in *Gender and the Politics of History* (New York: Columbia University Press, 1999), 28-50.
5. Ann B. Shteir, *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760-1860* (Baltimore: Johns Hopkins University Press, 1996); Nina Baym, *American Women of Letters and the Nineteenth-Century Sciences: Styles of Affiliation* (New Brunswick, NJ: Rutgers University Press, 2001); Barbara Sicherman, *Well-Read Lives: How Books Inspired a Generation of American Women* (Chapel Hill: University of North Carolina Press, 2010); Barbara T. Gates (ed.), *In Nature's Name: An Anthology of Women's Writing and Illustrations, 1780-1930* (Chicago: University of Chicago Press, 2002); Kohlstedt, "Nature, Not Books;" Tolley, *Science Education of Girls*.
6. Sally Gregory Kohlstedt discusses this transition during the Civil War time period in "Parlors, Primers, and Public Schooling: Education for Science in Nineteenth-Century America," *Isis* 81, no. 3 (Sep. 1990): 424-45. Tolley, *Science Education of Girls*; Debra Lindsay, "Intimate Inmates: Wives, Households, and Science in Nineteenth-Century America," *Isis* 89, no. 4 (Dec. 1998): 631-52.
7. Scholars of the history of education have debated whether or not nineteenth-century men and women had curricular differences in their educational experiences. Margaret Nash finds that for the Antebellum period there may have been curricular differences, but "such differences were minor compared to the distance the white middle class wanted to create between itself and people of color and people of other classes." Kim Tolley argues that while early in the nineteenth century science was a "girls' subject," direct competition between the sexes increased in the latter half of the nineteenth century, as professionalism within science became a driving force. Nash, *Women's Education in the United States*, 4; Tolley, *Science Education of Girls*, 65.
8. "Records of the Meetings of the MIT Corporation," 14 Dec. 1870, AC 278, Institute Archives and Special Collections, MIT Libraries, Massachusetts Institute

of Technology, Cambridge, MA.

9. David Kaiser, *Becoming MIT: Moments of Decision* (Cambridge: MIT Press, 2010), 23-4; Caroline Louisa Hunt, *The Life of Ellen H. Richards* (Boston: Whitcomb & Barrows, 1912), 80-7; MIT Board of Corporation, 14 Dec. 1870, AC 278, Archives and Special Collections, MIT Libraries (https://wayback.archive-it.org/7963/20190702115916/https://libraries.mit.edu/ archives/exhibits/esr/esr-womenslab.html).
10. Hunt, *Life of Richards*, 238-9.
11. C. V. Burek and M. Kölbl-Ebert, "The Historical Problems of Travel for Women Undertaking Geological Fieldwork," in *The Role of Women in the History of Geology*, C. V. Burek and B. Higgs (eds.), (Geological Society: London, 2007), 115-22.
12. Hunt, *Life of Richards*, 238-9.
13. A rich historiography exists on women in science and technology; readers should consult the essays in *Removing Barriers: Women in Academic Science, Technology, Engineering, and Mathematics*, Jill M. Bystydzienski and Sharon R. Bird (eds.), (Bloomington: Indiana University Press, 2006), as well as foundational works such as: Margaret Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: John Hopkins University Press, 1983); Londa Schiebinger, *The Mind Has No Sex?: Women in the Origins of Modern Science* (Cambridge: Harvard University Press, 1989), and *Nature's Body: Gender in the Making of Modern Sciences* (New Brunswick, NJ: Rutgers University Press, 2004), and "The History and Philosophy of Women in Science: A Review Essay," *Signs* 12, no. 2 (1987): 305-32; Carolyn Merchant, *The Death of Nature: Women, Ecology and the Scientific Revolution* (New York: Harper One, 1990); Ruth Oldenziel, *Making Technology Masculine: Men, Women and Modern Machines in America, 1870-1945* (Amsterdam: Amsterdam University Press, 1999); Pnina G. Abir-Am and Dorinda Outram, *Uneasy Careers and Intimate Lives: Women in Science, 1789-1979* (New Brunswick, NJ: Rutgers University Press, 1987); Sandra Harding, *The Science Question in Feminism* (Ithaca, NY: Cornell University Press, 1986), and *Whose Science? Whose Knowledge?: Thinking from Women's Lives* (Ithaca, NY: Cornell University Press, 1991); Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven, CT: Yale University Press, 1985), and *Secrets of Life, Secrets of Death: Essays on Language, Gender, and Science* (New York: Routledge, 1992); Lindsay, "Intimate Inmates;" Tolley, *Science Education of Girls*.
14. Tolley, *Science Education of Girls*, 102.
15. Ellen Richards to Anna Mineah, 1 June 1876, Folder 1, Ellen Swallow Richards Papers, Archives and Special Collections Library, Vassar College Libraries.
16. Ellen S. Richards, First Annual Report to Women's Education Association (c. 1877), Folder 9, Collection on the Massachusetts Institute of Technology's Women's Laboratory, AC 298, MIT Institute Archives and Special Collections (https://wayback.archive-it.org/7963/ 20190702115916/https://libraries.mit.edu/archives/exhibits/esr/esrwomenslab.html).
17. Rossiter, *Women Scientists in America*, 72. Maria Mitchell, too, made sex-differentiated claims in response to a debate with Louis Agassiz, Mary Livermore, and Thomas Wentworth Higginson. According to Sally Kohlstedt, Mitchell argued that "childhood training developed in girls certain skills and characteristics which made women meticulous observers of natural phenomena." Sally Gregory Kohlstedt, "Maria Mitchell: The Advancement of Women in Science," *New England Quarterly* 51, no. 1 (Mar. 1978): 50.
18. "Transcription of first report by Richards to the Women's Educational Association," Massachusetts Institute of Technology, Women's Laboratory, 1876-1883, Women's Laboratory Collection, 1867-1922 (AC 298), MIT Institute Archives and Special Collections.
19. "Robert Hallowell Richards," *Technology Review* 10, no. 3 (1908): 249-59, quote 251-2.
20. "Robert Hallowell Richards," 252.
21. Robert Rakes Schrock, *Geology at MIT 1865-1965, The First Hundred Years*, v. 2 (Cambridge: MIT Press, 1982), 255.
22. Barbara Welter argued in "The Cult of True Womanhood: 1820-1860" (*American Quarterly* 18 (Sum. 1966): 151-74) that antebellum, white, middle-class women were excluded from male-dominated businesses, government, politics, and education because society placed them on a pedestal that prescribed genteel, Victorian behavior. Objections to the cult of true womanhood as the essence of nineteenth century Victorian womanhood abounded in the 1980s, as scholars examined proscriptive literature and advice manuals for evidence of the "true woman." See: Frances B. Cogan, *All-American Girl: The Ideal of Real Womanhood in Mid-Nineteenth-Century America* (Athens: University of Georgia Press, 1989); Mary Kelley, "The Sentimentalists: Promise and Betrayal in the Home," *Signs* 4 (Spr. 1979); Laura McCall, "'The Reign of Brute Force Is Now Over': A Content Analysis of *Godey's Lady's Book*, 1830-1860," *Journal of the Early Republic* 9 (Sum. 1989): 217-36; Sarah Wadsworth, "Louisa May Alcott, William T. Adams, and the Rise of Gender-Specific Series Books," *The Lion and the Unicorn* 25, no. 1 (Jan. 2001): 17-46. For gender and women's work outside the home, see: Karen Blair, *The Clubwoman as Feminist: True Womanhood Redefined* (New York: Holmes and Meier Publishers, 1980); Anne M. Boylan, *The Origins of Women's Activism: New York and Boston, 1797-1840* (Chapel Hill: University of North Carolina Press, 2002); Bruce Dorsey, *Reforming Men and Women:*

Gender in the Antebellum City (Ithaca, NY: Cornell University Press, 2006); Barbara Reeves-Ellington, Kathryn Kish Sklar, and Connie A. Shemo (eds.), *Competing Kingdoms: Women, Mission, Nation and the American Protestant Empire, 1812-1960* (Durham, NC: Duke University Press, 2010).

23. Sally Zanjani's *A Mine of Her Own: Women Prospectors in the American West, 1850-1950* (Lincoln: University of Nebraska Press, 1997) presents a history of women prospectors throughout the nineteenth and twentieth centuries. For histories of middle-class women following their husbands into mining country see: Darlis A. Miller, *Mary Hallock Foote: Author-Illustrator of the American West* (Norman: University of Oklahoma Press, 2002); Rodman W. Paul (ed.), *A Victorian Gentlewoman in the Far West: The Reminiscences of Mary Hallock Foote* (San Marino, CA: Huntington Library Press, 1992). For histories that discusses the day-to-day lives of women in mining towns see: Mary Murphy, *Mining Cultures: Men, Women, and Leisure in Butte, 1914-41* (Chicago: University of Illinois Press, 1997); Ronald M. James and C. Elizabeth Raymond (eds.), *Comstock Women: The Making of a Mining Community* (Reno: University of Nevada Press, 1998). Within the context of women's labor and Nova Scotia's mines in the early twentieth century see: Steven Penfold, "'Have You No Manhood in You?': Gender and Class in the Cape Breton Coal Towns, 1920-1926," *Acadiensis* 23 (Spr. 1994): 21-44; D. A . Muise, "The Industrial Context of Inequality: Female Participation in Nova Scotia's Paid Labour Force, 1871-1921," *Acadiensis* 20, (Spring 1991): 3-31.
24. Ellen Richards, *First Lessons in Minerals* (Boston: Rockwell and Church, 1882); Margaret S. Cheney and Ellen Swallow Richards, "A New and Ready Method for the Estimation of Nickel in Pyrrhotites and Mattes," *American Journal of Science* 3, no.14 (Sep. 1877): 178-81.
25. Gwen L. Martin, *Gesner's Dream: The Trials and Triumphs of Early Mining in New Brunswick* (Fredericton, NB: Canadian Institute of Mining, Metallurgy and Petroleum, 2003), 100.
26. "1879 Travel Journal," 2.
27. "1879 Travel Journal," pasted page added.
28. "1879 Travel Journal," 50.
29. Robert McIntosh, *Boys in the Pits: Child Labour in Coal Mines* (Montreal: McGill-Queen's University Press, 2000), see 90-6 for women's involvement in mines. McIntosh references Britain's Mines and Collieries Act of 1842 that excluded women *de jure* from working underground, however, the practice likely continued.
30. John Rutherford, *The Coal Fields of Nova Scotia,* (New Castle Upon Tyne: A. Reid Printing, 1871), 5.
31. "1879 Travel Journal," 31-2.
32. "1879 Travel Journal," 37.
33. "1879 Travel Journal," 42. For the 1891 disaster see: Robert A. H. Morrow, *Story of the Springhill Disaster* (St. John, NB, R. A. H. Morrow, 1891).
34. "1879 Travel Journal," 48.
35. F. W. Clark Papers, Newberry Library, Chicago; "Annual Report of the President and Treasurer of the Massachusetts Institute of Technology, Dec. 11, 1889," Presidents' Reports, Archives and Special Collections, MIT Libraries, 27.
36. Massachusetts Institute of Technology, *Annual Report of the President and Treasurer, December 13, 1893* (Cambridge: John Wilson and Son, 1893), 47.
37. Massachusetts Institute of Technology, "Reports of the President and Treasurer Presented at the December Meeting of the Corporation," *Bulletin of the Massachusetts Institute of Technology* 48, no. 2 (Jan. 1913): 5, 7; "Eight Alumni Are Up for Corporation," *The Tech* 27, no. 25 (27 Nov. 1907), 1.
38. Robert J. Aley, S. L. Halloway, Edwin Twitmyer, William H. Tibbals, and A. Megahan, "Educational Intelligence," *Journal of Education* 44, no. 25 (Dec. 1896): 436-8.
39. "1879 Travel Journal," 49-50.
40. "1879 Travel Journal," 68.
41. Rutherford, *Coal Fields of Nova Scotia*, 21-2.
42. "1879 Travel Journal," 51-2.
43. "1879 Travel Journal," 83. The newspaper clipping from the *Charleston* [SC] *News and Courier* was pasted into Clark's journal.
44. Solomon, *Company of Educated Women*, 81; Gordon, *Gender and Higher Education*, 22.
45. R. Drummond, *Minerals and Mining Nova Scotia* [*sic*] (Stellarton: Mining Record Office, 1918), 135-7.
46. Rutherford, *Coal Fields of Nova Scotia*, 21. The U.S. Bureau of Mines' *Dictionary of Mining, Mineral, and Related Terms* (Wash. D.C.: USGPO, 1968, 665) defines lype: "Scot. An irregularity in the mine roof. A projecting rock in a mine roof that may fall at any time."
47. "1879 Travel Journal," 56-7.
48. "1879 Travel Journal," 65.
49. "1879 Travel Journal," 66.
50. "Trip of M.I.T. Students to the Mines and Mineral Localities of Nova Scotia, July, 1884," *The Tech* 4 no. 2 (5 Nov. 1884): 18-20. For a description of previous and future MIT summer trips see: Schrock, *Geology at MIT*, v. 2, 251-3.
51. F. W. Clark Papers, Newberry Library, Chicago. Clark's own daughter would pursue higher education at the all-women's Vassar College, so possibly he at least thought that she should be educated.
52. Rossiter, *Women Scientists in America*, 51-72; Margaret Rossiter, "Which Science? Which Women?" *Osiris* 12 (1997):169-85, quote 173, italics original. For more on the development of home economics out of women's scientific work see: Sarah Stage and Virginia B. Vincenti, *Rethinking Home Economics: Women*

and the History of a Profession (Ithaca: Cornell University Press, 1997); Marjorie East, *Home Economics: Past, Present, and Future* (Boston: Allyn and Bacon, 1980).

53. Rossiter, "Which Science? Which Women?", 175-6. Women in engineering today continue to be at the lowest end of achieving gender equality percentages of all employment categories measured by the National Science Foundation, with less than 19.5 percent in 2006 and 18.8 percent in 2016 in the "engineering and related technologist or technician" category, and 11.8 percent in 2006 and 12.9 percent in 2016 in the category of "engineer," the two lowest percentages of women's employment in the data set, ages sixteen or over. National Science Foundation "Women, Minorities and Persons with Disabilities in Science and Engineering," Table 9-2: https://www.nsf.gov/statistics/2017/nsf17310/static/data/tab9-2.pdf. For the history of women in engineering see: Amy Sue Bix, "From 'Engineeresses' to 'Girl Engineers' to 'Good Engineers': A History of Women's American Engineering Education," *National Women's Studies Association Journal* 16 (Spr. 2004): 27-49.
54. "1879 Travel Journal," 72.
55. On Florence Bascom see: Lois Arnold, *Four Lives in Science: Women's Education in the Nineteenth Century* (New York: Schocken Books, 1984); Lois Arnold, "Becoming a Geologist: Florence Bascom in Wisconsin, 1874-1887," *Earth Sciences History* 18 (1999): 159-79. On Woods Hole Laboratory: Emanuel D. Rudolph, "History of the Botanical Teaching Laboratory in the United States," *American Journal of Botany* 83, no. 5 (May 1996): 661-71.
56. Amy Sue Bix, *Girls Coming to Tech! A History of American Engineering Education for Women* (Cambridge: MIT Press, 2014), 21. For breakdowns of what specifically women students studied from 1880-1940 see: Marilyn A. Bever, "The Women of MIT, 1871-1941: Who They Were, What They Achieved," M.A. Thesis, Massachusetts Institute of Technology, 1976.
57. Women's Laboratory, 1867-1922, Folder 20, Collection on the Massachusetts Institute of Technology Women's Laboratory, AC 298. Massachusetts Institute of Technology, Institute Archives and Special Collections, Cambridge, MA.