OF NATURAL SCIENCE, WOMEN'S HISTORY, AND MONTESSORI'S THEORY OF KNOWLEDGE

Kathleen Allen, *now retired from teaching, taught in Montessori elementary classrooms for more than 40 years. She has an AMI elementary diploma and holds a BA in English literature, an MA in history, and is currently pursuing a PhD in the humanities at Union Institute and University in Cincinnati, OH. She worked closely with Dr. John Wyatt on revisions and the implementation of The Keepers of Alexandria program in elementary classrooms and has been a key implementer of this program for two decades.*

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by Kathleen Allen

Kathleen Allen's reverence for the stories of women naturalists spanning from the seventeenth through the twentieth centuries, and their parallel scientific interest in the documentation of life cycles through art and narratives, gives support to the child in history and nature that is so central to Montessori formal research and discipline. The parade of nearly a dozen short bios, from Beatrix Potter to Rachel Carson, frames not only a fresh outlook on science but also brings a soft feminist philosophical outlook while highlighting Montessori's connections to the natural world.

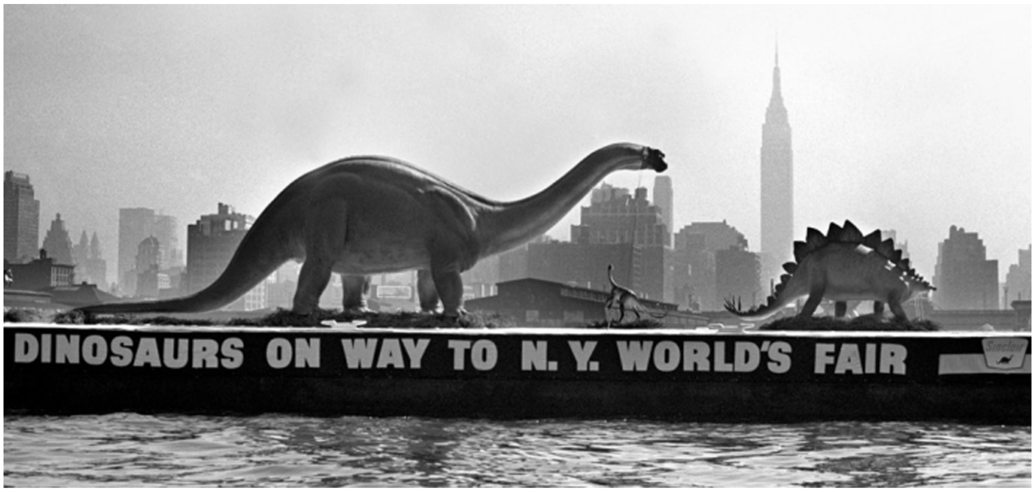
This chapter is based on a talk presented at the NAMTA conference titled Montessori History: Searching for Evolutionary Scientific Truth *in Cleveland, Ohio, April 20–22, 2018.*

Introduction

Every thing has a history. Every one has a history. And what is history but stories? I am fascinated by both the small stories and the grand stories. A couple of years ago, I retired from my Montessori classroom, and what did I do? I became a student again. I am currently pursuing a PhD in interdisciplinary studies with a concentration on history and writing at Union Institute and University in Cincinnati. This program is sort of Cosmic Education for grownups. The field I am most interested in currently is the history of women scientists. While this talk will definitely address its title "Of Natural Science, Women's History, and Montessori's Theory of Knowledge," I intend to keep it relaxed and low-key. Having entered the world of high academia, I prefer now to share little stories and a few images with you.

We are here in the Cleveland Museum of Natural History. This museum has many fascinating stories to tell, including that of Donald Johanson, who, in 1974, was named the curator of physical anthropology at the museum. And that was the year Johanson discovered "Lucy," the fossil of *Australopithecus afarensis* in Ethiopia, an extinct hominin dated to between 3.9 and 2.9 million years ago.

The most interesting connection I did not know that I have to this museum is the famous stegosaurus "Steggie" who sits out front. This life-size model is the second stegosaurus to reside on the grounds. The original stegosaurus, which lasted through thirty years of climbing children, has been replaced with Steggie 2, who has recently been repainted with more accurate coloring. My connection is to that original stegosaurus, which was created for the 1964 New York World's Fair, for the Sinclair Oil Company exhibit called Dinoland. These dinosaurs were made in the studio of Louis Paul Jonas, a prominent sculptor and creator of wildlife dioramas for museums. My brother, who was in high school at the time, worked at this studio in Hudson, New York, near our home. These life-size dinosaurs were carried by helicopter to a barge on the Hudson River and traveled south to New York City. The Cleveland Museum of Natural History then commissioned Jonas Studios to make an exact second stegosaurus from the World's Fair mold for display.



Museums are an incredible source of knowledge and wonder, and it is our responsibility to introduce children to museums early on. Modern museums combine the best in science and history and amazement. In my exploration of this museum, I noticed an exhibit on pterosaurs. Besides the marvels of these giant winged creatures, note this beautifully written text, enticing the potential visitor:

> They flew with their fingers. They walked on their wings. Some were gigantic, while others could fit in the palm of your hand. Millions of years ago, the skies were ruled by pterosaurs—the first vertebrates to achieve flight. Not dinosaurs, birds, or bats, pterosaurs were flying reptiles that lived in the world of dinosaurs 220 to 66 million years ago.

I also noted that like many museums of its kind, the museum's name includes the words "natural history." Just how is natural history defined by this museum? The founding goal was "to perform research, education, and development of collections in the fields of anthropology, archaeology, astronomy, botany, geology, paleontology, wildlife biology, and zoology." Other definitions of natural history or the natural sciences include the categories of: physics, chemistry, Earth science, ecology, oceanography, and meteorology. Natural history is generally the earlier term, centered on observation of plants and animals in their environments, whereas natural science grew out of that foundation with the addition of the scientific method and increasing empiricism. All of this grew from the "natural philosophy" of the ancients. When we talk about natural history, we really just mean natural phenomena, those things of nature. There are generally two key branches, life science and physical science, and all derives from the depths and heights of nature.

Dr. Montessori was a natural historian and she clearly directed us to support the child's innate interest in nature. In *The Advanced Montessori Method: Spontaneous Activity in Education,* she wrote:

> I would therefore initiate teachers into the observation of the most simple forms of living things, with all those aids which science gives; I would make them microscopists; I would give them a knowledge of the cultivation of plants and train them to observe their physiology.
>
> I would direct their observations to insects, and would make them study the general laws of biology. And I would not have them concerned with theory alone, but would encourage them to work independently in laboratories and in the bosom of free Nature.

Nature Study

I have been rather immersed in the late nineteenth and early twentieth centuries lately. There were powerful educational shifts during this time, including, of course, Montessori's theories. This period, also known as the Progressive Era, usually considered to be from 1890 to 1920, was, to put it simply, a response to the ills of society brought on in part by increasing industrialization, the growth of urban areas, and burgeoning population. With this came a reawakening to the importance of natural history, which itself arose out of a confluence of factors, including: the philosophy of the transcendentalists, the poetry of romanticism, the foundational nature studies by Louis Agassiz, whose quote "Study nature, not books" became a rallying cry, the Industrial Revolution, and the Depression of 1893, which led to the movement of people from farms to cities.

As a result, many children were growing up without the critical connection to the natural world; they were not staying on the farms and continuing the family traditions of cultivating the land. There was a growing consciousness concerning children and nature. The thought was that children must now be introduced to the natural world in their schools. Thus the Nature-Study Movement came into being. As an aside, this illustration of woodland bolete mushrooms was painted by Beatrix Potter.

Beatrix Potter

Anna Botsford Comstock (1854–1930) American

For my PhD I am studying a major figure in what became known as the Nature-Study Movement. Her name is Anna Botsford Comstock.

She was born in 1854 in western New York State, graduated from Cornell University in 1885 with a bachelor of science degree in natural history with a focus on entomology (the study of insects) and became the first female professor at Cornell. She wrote a 938-page book, *Handbook of Nature Study,* which was self-published in 1911, and is still in print. She married a fellow entomologist, her former professor, John Henry Comstock. Together they wrote many books on insects that Anna illustrated with her detailed wood engravings. They had no children, but frequently hosted their students for dinner parties and poetry readings at their home.

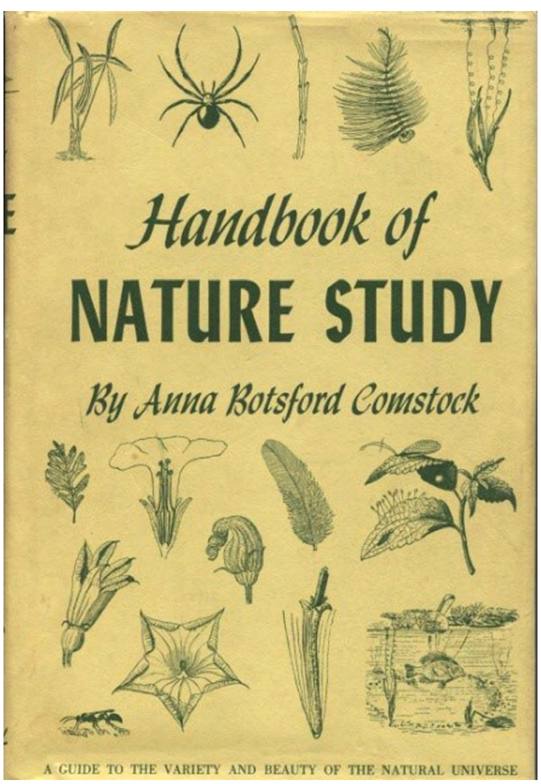
Anna lived what she taught. She was a gardener, a beekeeper, and a keen observer of the natural world around her. She was known for taking her college students out on field studies, to observe the insects in their habitat. One student remembered her catching butterflies:

Anna Botsford Comstock

> [Mrs. Comstock] kirtled up her skirt almost to her knees. . . At the first sunlit clearing Mrs. Comstock gave a cry of joy and seizing her net from me, darted after a lovely, black-and-white striped swallowtail. "It's a zebra, a zebra," she cried, and presently managed to catch the butterfly, as it settled on a tall, waving flower.

At the beginning of her handbook, Anna defined nature study:

> Nature Study is, despite all discussions and perversions, a study of nature; it consists of simple, truthful observations that may, like beads on a string, finally be threaded upon the understanding and thus held together as a logical and harmonious whole. Therefore, the object of the nature-study teacher should be to cultivate in the children powers of accurate observation and to build up within them, understanding. (1)



Anna developed the nature study program at Cornell and trained many teachers in her long career.

As an aside, I was also excited to discover that one of our preeminent woman scientists grew up reading Anna's *Handbook of Nature Study*—Rachel Carson. Here's a line from Rachel that echoes Montessori:

> Against this cosmic background the lifespan of a particular plant or animal appears, not as drama complete in itself, but only as a brief interlude in a panorama of endless change. (11)

Rachel Carson

Now compare these two quotes by Anna Botsford Comstock and Rachel Carson to Dr. Montessori's lines in *From Childhood to Adolescence:*

> There is no description, no image in any book that is capable of replacing the sight of real trees, and all the life to be found around them. Something emanates from those trees which speaks to the soul, something no book, no museum, is capable of giving. The wood reveals that it is not only the trees that exist, but a whole, interrelated collection of lives. (19)

While my studies have centered upon Anna Botsford Comstock, I have also begun to focus more generally on women scientists, especially those whose history has been lost or forgotten. The stories of women scientists are often underrepresented and it is important to bring them out of the shadows. Therefore, I am going to tell some little tales of a few women of science that are interesting to know. And, as we go along, we must keep in mind that Dr. Montessori was a scientist; therefore, all our Montessori work is based on science.

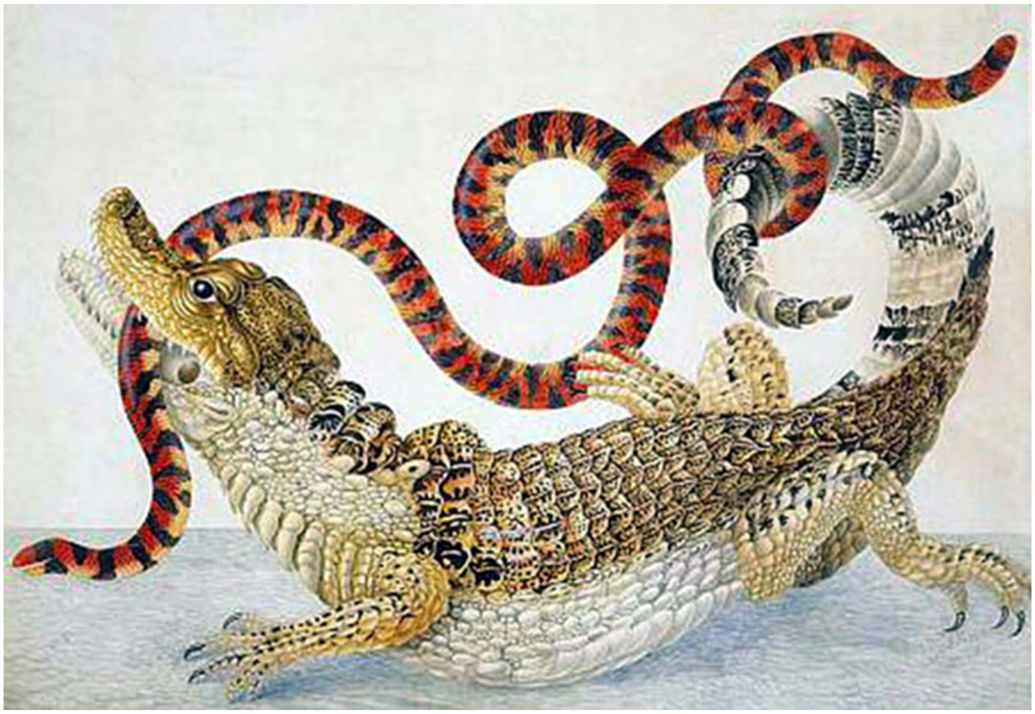
Maria Sibylla Merian (1647–1717) Swiss-German

Maria Sibylla Merian has a magnificent story to tell. Her superb scientific illustrations and her studies of insects have recently been rediscovered. Maria was Swiss in heritage, grew up in Germany, but spent much of her life in the Netherlands (when she wasn't adventuring.) Both her father and stepfather were artists, so she had an advantage: "Maria was able to learn drawing, watercolor, and still-life painting, and copperplate engraving from her stepfather along with his male pupils." Her uncle was in the silk trade, so Maria Sibylla had the privilege of many hours observing the caterpillars and moths in order to accurately illustrate them:

> Maria Sibylla was to say later [in her most famous book *Metamorphosis Insectorum Surinamensium*] that she had begun her observations when she was only thirteen: "From my youth onward I have been concerned with the study of insects. I began with silkworms in my native city [in Germany]; then I observed the far more beautiful butterflies and moths that developed from other kinds of caterpillars. This led me to collect all the caterpillars I could find in order to study their metamorphoses... and to work at my painter's art so that I could sketch them from life and represent them in lifelike colors." (Davis 143)

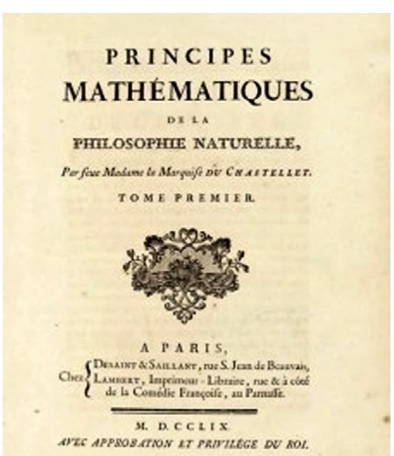
Maria's studies of butterfly metamorphosis were to be extremely significant, as the general seventeenth century superstition was that witchcraft or magic was somehow involved. In a children's biography, Maria Sibylla speculatively concludes: "When people understand the life cycles of creatures that change forms, they will stop calling small animals evil. They will learn, as I have, by seeing a wingless caterpillar turn into a flying summer bird."

In 1665 at the age of 18, Maria Sibylla married her step-father's apprentice. By 1692, she was divorced, and raising her daughters, Johanna and Dorothea, on her own, supporting her family with sales of her art. During all this she continued her work in entomology and botanical illustration. Her major adventure came in 1699 when she and her younger daughter Dorothea, also an illustrator, sailed off to the Dutch colony of Surinam in South America, partially funded by a grant from the city of Amsterdam, and the rest from a sale of her artwork. Maria Sibylla was 52 and Dorothea was 21. This was a scientific expedition to explore and record in art the insect, animal, and plant life of this exotic locale in South America. The plan was to spend five years traveling around, but serious bouts with malaria meant they had to return after two years. However, the artistic work and scientific observations that resulted from this expedition are exceptional and her art and writing have now been widely published.



Maria Sibylla Merian - Plate 69 from Dissertation in Insect Generations and Metamorphosis in Surinam, 1719, Sterling, Susan Fisher - 'Women Artists: The National Museum of Women in the Arts' - Abbeville Press Publishers, 1995.

For a seventeenth century woman and her daughter to undertake a challenging expedition across the seas shows Maria Sibylla's determination and independence. As a scientist and explorer, she was intruding into the male world. Because she directly observed insects, she was able to accurately paint them and to describe their life cycles. She kept copious notes of her observations. She was adaptable even in her art, as women were not allowed to paint in oils according to guild rules. So, she worked in watercolors and gouache. Even today her illustrations are admired for their beauty and detail.



PRINCIPES
MATHÉMATIQUES
DE LA
PHILOSOPHIE NATURELLE,
Par feue Madame la Marquise du Chastellet.
TOME PREMIER.

A PARIS,
Chez Desaint & Saillant, rue S. Jean de Beauvais, Lambert, Imprimeur - Libraire, rue & à côté de la Comédie Françoise, au Parnasse.

M. DCCLIX.
AVEC APPROBATION ET PRIVILEGE DU ROI.

Émilie du Châtelet (1706–1749) French

Émilie du Châtelet was a French mathematician, physicist, and natural philosopher. Her father was a noble and served as the principal secretary to Louis XIV. Emilie grew up in a privileged, highly educated household. In addition to her broad academic studies, especially in mathematics, science, and literature, she learned to ride and to fence. She also learned to play the harpsichord, to sing, to dance, and to gamble. She studied French, Latin, Italian, Greek, and German. When she was 18, her parents arranged her marriage to a marquis, who was 34. She had four children, but two died as infants. By the time Émilie was 26, she was studying algebra and calculus. She later became Voltaire's companion and they set up a scientific laboratory in his home. Their studies focused on physics and mathematics.

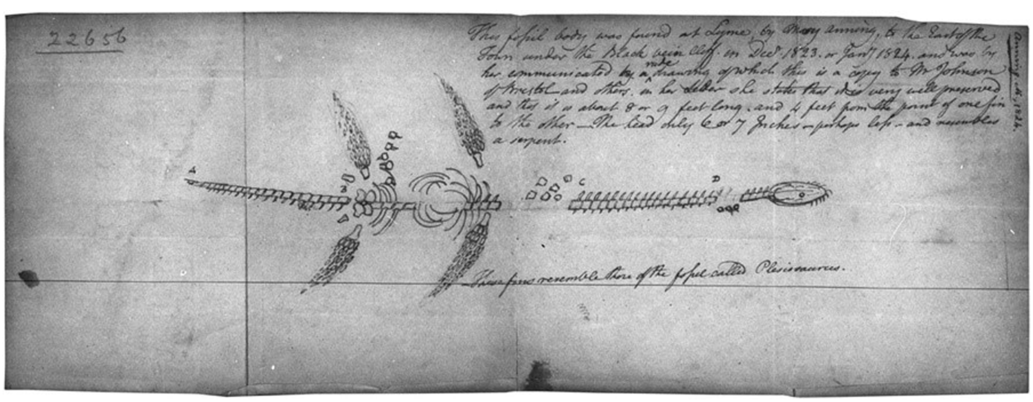
Emilie's best known contribution to knowledge is her translation of Isaac Newton's *Principia* from the original Latin complete with her own extensive commentary from her understanding of Newtonian physics. Emilie died in 1749 shortly after completing her book, which was published 10 years later.

Mary Anning (1799–1847) British

On the 19th of August 18oo, a powerful storm, raging with a fury of wind and rain, suddenly scattered the observers during a military display in a field near Lyme Regis, West Dorset, England, about 160 miles southwest of London on the English Channel coast. A woman and three small children found shelter under a towering elm tree. A slash of lightning struck the tree and only the youngest child survived. This fortunate toddler, Mary Anning, was to become one of the most famous fossil hunters of her time. Later some locals claimed the lightning strike was the reason she became such an undaunted collector.

With little formal education, Mary Anning had a scientist's curiosity and a researcher's doggedness. She faced hardships and sadness as her family was poor. Her father died when he fell off the cliffs while hunting fossils when she was only 10. Fossil collecting was her livelihood. Mary had apprenticed in fossil collecting with her father and surviving brother, and later under the tutelage of amateur paleontologist Elizabeth Philpot, one of the three maiden Philpot sisters who lived nearby. She loved what she did, even though as a young girl she began to collect the "curiosities" on the beach only in order to sell them to help support her family. She worked hard clambering along the dangerous cliffs of the Jurassic Coast, as it became known, seeking fossils of ammonites and belemnites. She also discovered an ichthyosaur, two plesiosaurs, and a pterosaur. Now, her fossil discoveries are displayed in many museums, but only recently have these been correctly attributed to her.

Today there is an increasing interest in and respect for Mary Anning's fossil collecting and her contribution to scientific knowledge. Some of her biographers have found it hard to imagine that a lower class, poorly educated girl could have had an impact on a male-dominated scientific community, but she did. What she began as an economic need soon became a passion. Being passionate about one's work is often listed as one of the traits of a creative personality. Mary was also persistent, energetic, and non-conforming, as scientists at the time were generally men.



A pen and ink sketch of a Plesiosaur by Mary Anning, 1824

Mary's story is a prime example of a tale that appeals to children. Here is a girl who had many disadvantages and little good fortune. Somewhere within her, there was a drive to know, to learn, to discover the next important fossil, to look upon what had been hidden in the rocks for millions of years. Hers is a story for children to hear, to begin to understand.

Dr. Montessori has something to say about fossils:

> Remains found in rocks allow the imagination to reconstruct past times, and realise an almost incredible age for our Earth. A million years becomes the unit, and twenty-five

million years a mere episode of world-history. Such studies as geology and astronomy help us to conceive an eternity within infinity. They are the most fascinating subjects of our day, and children can and do feel their fascination. (*To Educate the Human Potential* 40)

Ada Lovelace (1815–1852) British

Another woman whose story is being revived is that of Ada Lovelace, who came from a noble heritage and followed a unique path. Ada was the only legitimate child of Lord Byron, the well-known British poet. She was raised by her mother Anne Isabella Milbanke, who split with Byron within months of Ada's birth. Ada was solely brought up by her mother, never knowing her father. Her education was focused on mathematics and science because her mother did not want her to become a dreamer like her father. Ada's mother wanted her to be calm and rational, not emotional and creative like her father. She hoped the study of math and science would suppress her daughter's imagination. So, Ada was given a world-class scientific education. Her imagination was not harmed in the least.

Ada was fascinated by the machines of the industrial revolution and visited factories. She was intrigued by the Jacquard loom, which could be set up to weave any pattern desired. Ada found out how the loom worked:

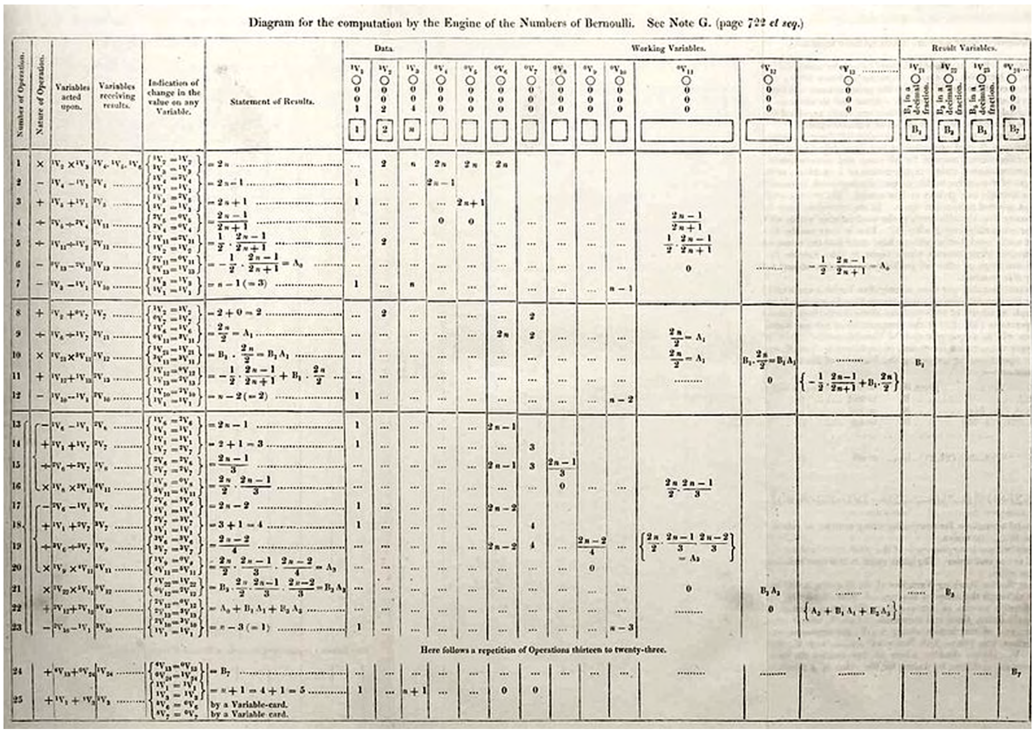
> The design was translated into a pattern of holes punched into heavy paper cards. Long chains of these cards were fed into the loom, giving it instructions. To change the design, you only had to change the cards. Ada was amazed. It was a brilliant idea—and not just for weaving cloth. Why not use punched cards to direct other machines for other purposes? (Stanley)

Later Ada met Charles Babbage, the mathematician and inventor, who had designed a calculating machine he called a Difference Engine. Ada and Babbage were to become friends and collaborators. Ada's life continued—she married and had three children, but never lost sight of her interests. At this time Charles Babbage had a new machine he was working on, a steam-powered mathematical Analytical Engine, using Jacquard's idea of punched cards. In effect, this invention was to be the "first fully programmable all-purpose digital computer." But Babbage needed to raise money. Ada stepped in to help Babbage by translating an article about the engine from French to English so it could be published. Her "Notes by the Translator" in this article "were almost three times as long as the original article—and far more important. Yet she wasn't credited by name, only the initials A. A. L."

> [Ada] was perfect for the job. She understood how the engine worked. She was a good writer. And she had the vision to see, better even than Babbage himself, how much more a computer could do besides just processing numbers. It could work with

> any kind of symbol, from words to musical notes. Ada imagined the Analytical Engine writing text, composing music, reproducing images—even playing games like checkers or chess. (Stanley)

But the machine needed the proper mathematical input in order to do what Babbage wanted it to do. Ada took on this task by creating an algorithm "to program the machine to compute a complicated series of numbers called 'Bernoulli numbers'" (Robinson).



Ada combined her mathematical talents with her imagination and creativity and came up with a proposal to make the engine work. Unfortunately, Ada died at the age of thirty-six (she was buried next to her father). The engine was never built. The work of Babbage and Ada was forgotten for a long time but was rediscovered by such brilliant minds as computer pioneers Alan Turing and Howard Aiken. Ada represents the interdisciplinary dimensions of the creative mind: the distinct interplay of the reasoning mind and the imaginative mind.

Two other women I have recently stumbled upon are Florence Bascom and Alice Ball. Florence Bascom (1862–1945) was the first woman to receive a PhD from Johns Hopkins University and the second woman in America to receive a PhD in geology. Like many other early women scientists, Florence had to sit behind a screen during college lectures. Her research furthered our understanding of the origins and formation of the Appalachian Mountains, and she geologically mapped a good portion of the United States. In 1896 Florence was the first woman to be hired by the US Geological Survey. Note her working attire, complete with a compass in her hands. She is dressed in the standard female attire for the time: hat, shirtwaist, long skirt, necktie.

Alice Ball (1892–1916) was an American chemist who faced many obstacles to becoming a scientist. She was the first woman and the first woman of color to receive a master's degree (in pharmacological chemistry) from the University of Hawaii and later became a chemistry professor there. At the age of 23 Alice created the first effective injectable treatment for leprosy.

Now a little interlude: The photo below shows one of the main obstacles in the way of women scientists of this time. This is the first Solvay Conference in 1911 in Brussels. The institute was held as a gathering of the most illustrious figures in physics and chemistry. Marie Curie is the only woman there. In 1927 she was still the only woman there. Also present were Albert Einstein, Ernest Rutherford, and Max Planck.

Florence Bascom

Alice Ball

Hope Jahren (born 1969) American

Hope Jahren is an American geochemist and geobiologist who is currently a professor of geobiology at the University of Oslo, Norway. Her studies have focused on Eocene fossil forests. In 2016 her book *Lab Girl* was published and is a memoir of her experiences as a woman scientist interwoven with luscious passages about botany. An example:

> A seed knows how to wait. Most seeds wait for at least a year before starting to grow; a cherry seed can wait for a hundred years with no problem. What exactly each seed is waiting for is known only to that seed. Some unique trigger-combination of temperature-moisture-light and many other things is required to convince a seed to jump off the deep end and take its chance—to take its one and only chance to grow. A seed is alive while it waits. Every acorn on the ground is just as alive as the three-hundred-year-old oak tree that towers over it. Neither the seed nor the old oak is growing; they are both

just waiting. Their waiting differs, however, in that the seed is waiting to flourish while the tree is only waiting to die. (30)

How often is it that I find that the writings of these women scientists remind me of the writings of Dr. Montessori. In truth my Montessori years are deeply embedded now and I refer to her work often in my PhD studies. The following quote, found in *From Childhood to Adolescence,* is one of my favorites and reflects Montessori's lens on science, replete with factual knowledge framed in lovely prose:

In its entirety, the world always repeats more or less the same elements. If we study, for example, the life of plants or insects in nature, we more or less get the idea of the life of all plants or insects in the world. There is no one person who knows all the plants; it is enough to see one pine to be able to imagine how all the other pines live. When we have become familiarized with the characteristics of the life of the insects we see in the fields, we are able to form an idea of the life of all other insects. There has never been anyone who has had all the insects of the universe available to his view. (*From Childhood to Adolescence* 18)

Robin Wall Kimmerer (born 1953) American

My second contemporary woman scientist is Robin Wall Kimmerer, a plant ecologist and professor of environmental and forest biology at the State University of New York College of Environmental Science and Forestry in Syracuse, New York. She is deeply influenced by her Native American heritage and serves as the director of the Center for Native Peoples and the Environment. She describes herself as a "traveler between scientific and indigenous ways of knowing."

Her research centers on the habitats within the Adirondack Mountains in upstate New York. Her book. *Gathering Moss: A Natural and Cultural History of Mosses*, published in 2003 is another of my favorites:

Mosses are the amphibians of the plant world. They are the evolutionary first step toward a terrestrial existence, a halfway point between algae and higher land plants. They have evolved some rudimentary adaptations to help them survive on land, and can survive even in deserts. But, like the peepers, they must return to water to breed. Without legs to carry them, mosses have to recreate the primordial ponds of their ancestors within their branches. (21)

When I was looking for a parallel quote from Montessori's writings, this one stood out to me:

> The evolution of the plants of Earth is estimated to have taken about 300,000,000 years, from algae, mosses and lichens, through ferns to ever more complex forms of strength and beauty. Vegetation has accomplished its adventure with joy, conquering the Earth, aspiring to the heavens, gripping the soil with strong roots to support noble pillars, roofed with interlacing branches and leaves opening millions of hungry mouths in the sunshine for carbon dioxide. In living and growing to perfection they thus did their cosmic task, and accomplished a further one in death, for dead vegetation was transformed into Earth's inexhaustible supplies of coal. What could the men of our own day have accomplished without that coal, stored for him? (*To Educate the Human Potential* 47)

Just like the child in the elementary environment, I often find myself following a trail of intriguing crumbs of research, not exactly a wild goose chase, but adding interesting tidbits. Dr. Montessori noted in *From Childhood to Adolescence* in reference to preparing students for going out "We have him observe, for example, that moss is found mainly on the north side of trees in a forest." Now, I always heard that as a child, and just remembered it as an important fact. But I looked into where mosses grow and I found it has much more to do with the proper conditions of moisture and shade. Mosses are not sensitive to directionality. The north side of trees generally has better conditions. And in the Southern Hemisphere it is the south side of trees.

Lynn Margulis (1938–2011) American

Now I have saved one of my very favorites for last. Lynn Margulis died in 2011, and one of my greatest regrets is that I never got to meet her, even though her last professorship was at the University of Massachusetts in Amherst, Massachusetts, only a couple of hours from my home. I followed her scientific career and read and learned from her books. She was a radical thinker, persistent in her research, and faithful to her theories. I don't want to say too much more about Lynn because we will see the documentary about her tonight [the film *Symbiotic Earth* was screened at the April 2018 Cleveland conference].

Conclusion

Let me conclude with three reflections:

First, the words of Dr. Montessori in connection to the forgotten women of science:

> Let us in education ever call the attention of children to the hosts of men and women who are hidden from the light of fame, so kindling a love of humanity; not the vague and anaemic sentiment preached to-day as brotherhood, nor the political sentiment that the working classes should be redeemed and uplifted. What is first wanted is no patronising charity for humanity, but a reverent consciousness of its dignity and worth. (*To Educate the Human Potential* 27)

Second, these words from Teilhard de Chardin:

> The day will come, when after harnessing the ether, the winds, the tides, gravitation, we shall harness for God the energies of love. And, on that day, for the second time in the history of the world, man will have discovered fire. (86)

And lastly, I am reminded of my gratefulness for all those elder Montessorians who guided me, encouraged me, and gave me role models for my work. I am also thankful for the lessons I learned from all the children I was privileged to spend my days with in my long years of teaching.

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