

An explorative guide for educators on **HIDDEN FIGURES**

Highlighting Women in Science and STEAM Careers



Charlotte Morgan

Website: <https://steamhiddenfigures.weebly.com/>

2017-18

Original workshop developed by: April Muirhead and Jessica Joudrey

Faculty Assistance: Dr. M. Lynn Aylward and Dr. Randy Newman

Educator's Manual created by: April Muirhead

Educator's Manual edited by: Crystal Peach

Background Information

STEM / STEAM are abbreviations for: **Science, Technology, Engineering, Arts and, Mathematics**. These fields are often recognized by governments, industry, or education institutes as in-demand careers. Scientists, programmers, physicists, environmental planners, statisticians, and so forth, all belong within this sector. To work in many of these jobs may require many years of post-secondary education, a passion for the field, and "hard-work." However, due to known systemic factors, various people require substantial resiliency to overcome the barriers to succeed in these industries. One of these groups of people is women! Women make up 48% of the workforce, yet only 24% of women are represented in STEAM fields (Ignotogfsky, 2016).

It is important to have a diversity of people working in STEAM as these fields address complex problems that require an assortment of skills and perspectives. Women have been experiencing hardships accessing these careers for hundreds of years. It was once believed that women were not smart enough for science jobs, or, in some cases, that this work was too dangerous for women. Around the late 1800s and early 1900s, universities began to admit women for study towards bachelor's degrees in North America. Interestingly enough, 56% of today's post-secondary students are female, however, only approximately 35% of STEM graduates are female (Stats Canada, 2016).

To encourage young women to pursue STEAM careers, it is prudent to introduce youth to a variety of people who are involved in science, and provide them with information about what they have had to overcome to forge a successful career.

Contents

Background Information.....	2
About this Resource.....	3
Original Intent	3
How to Use	3
Objectives	3
Vocabulary/Concepts	3
Focus Questions	4
Workshop Agenda	4
References and Resources.....	5
Appendix	7
Meet and Greet Figures	7
Learning Centre Materials	27

About this Resource

Original Intent

This resource aims to empower young women to pursue STEAM careers despite the challenges that exist. These documents are a result of a two day retreat conducted by the Acadia University Women in Science (WISE) group, specifically the *Hidden Figures* 90 minute session. The *Hidden Figures* workshop told stories about women in STEAM who have made significant contributions to the science community but predominantly have not been recognized during their lifetime for these works. The stories of these scientists highlight both their struggles and determination, as well as their many contributions. The young women in the workshop learned about many important women in the STEAM community, as well as more about the careers that these women have pursued. Active learning stations complemented the workshop to help further the participant's knowledge in the subject and related careers. The careers with activities covered by the workshop included environmental biology, geology, cryptography, neuroscience, chemistry, astronautics, and engineering.

How to Use

This resulting resource serves as an educator's guide to lead such activities within their own context, including classrooms, youth groups, and so on. A diversity of women from different backgrounds and challenges are represented, which may resonate with a wider audience than the original purpose of just reaching female youth. These documents contain the stories, workshop agenda, activity notes, and further references to be adapted appropriately to a new audience.

Objectives

Hidden Figures incorporates a variety of sectors within STEAM, with the intent that participants will find a STEAM area that they are passionate about and/or may be introduced to novel interests that can later translate into post-secondary plans.

Vocabulary/Concepts

- Struggles of women in science
- Successful women in science
- Careers in science
- Environmental biology: integrates biological sciences to the study of the environment and the solution of environmental problems
- Paleontology: the study of the geological past including fossils
- Cryptography: the study of the techniques of secret writing, the methods of making and using secret codes
- Neuroscience: the study of the nervous system
- Chemistry: the investigation of substances and how they interact

- Engineering: the art or science of making practical application of the knowledge of pure sciences

Focus Questions

- What women have not been recognized for their contributions to STEAM and what were their contributions?
- In what ways did the determination of the women help them to strategically succeed?
- What are some options for pursuing careers in science?

Prior Knowledge

Participants should have a basic knowledge of educational routes post high school. For example, they should be familiar with the such terms as: diploma, certificate, community college, undergraduate degree, master's degree, and doctorate degree.

Workshop Agenda

1. **Opening:** Facilitators describe women in STEAM that have inspired them. Focus questions are displayed. Participants are asked to keep these questions in mind when completing the different activities. (~ 10 min)
2. **Meet and Greet:** Participants receive a package specific to a woman featured in *Hidden Figures*. The package will contain a name tag, a fact sheet with interesting details about the woman's life, and in many cases, an item connected to the individual.* The goal for the participants is to mingle and learn about as many different women as they can, as well as their contribution to STEAM. After the meet and greet, participants are given an opportunity to talk about their figure and share what they found interesting. (~ 15 min)
**See the Appendix for fact sheets and a list of suggested items.*
3. **Learning Centres:** Participants are divided into small groups of working pairs. They have the opportunity to visit various learning centres which are focused on different disciplines within STEAM careers (environmental biology, aeronautical science, paleontology, cryptography, neuroscience, chemistry, and engineering). A brief introductory tour of the centres can be completed by the workshop leaders and then student pairs can utilize their time as their interest persists. It is recommended that each student pair visit at least three stations. At each learning station, there are 1-3 short biographies of women who have made contributions to each specific field, as well as a short description of the career presented. Activities based on the specific field will be at each centre to ensure that the students get a hands on approach to learning. (~55 minutes)

- 4. Discussion and Wrap-Up:** After the students have had time to explore the stations, a wrap- up discussion should form. Students will be reminded of the focus questions. Ideally, students can share some details about a few women that they “got to know,” as well a subject or activity that interested them. During this time, a conversation about struggles women have faced in the past, as well as some of the challenges women face today when pursuing a career in science, is beneficial. (~10 minutes)

References and Resources

Below are list of fantastic references and resources that were used to put this document together. These resources would enhance both your knowledge and your students’ understanding of “Hidden Figures”: women who have made significant contributions to STEAM fields, but have received varying levels of recognition or credit . Furthermore, there are more resources outlined on specific Learning Centre documents.

Women in Science Books

- Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.
- Maggs, S., & Foster-Dimino, S. (2016). *Wonder women: 25 innovators, inventors, and trailblazers who changed history*. Philadelphia: Quirk Books.
- Swaby, R. (2015). *Headstrong: 52 women who changed science - and the world*. New York: Broadway Books.

Statistics

- Canadian statistics on women in science:
 - <https://www.statcan.gc.ca/pub/89-503-x/2015001/article/14640-eng.htm>

Websites

Note: Many of these websites have extensive social media sites as well.

- Women in archeology, paleontology, or geology:
 - <http://trowelblazers.com/>
- Women in STEM timeline:
 - <http://www.tiki-toki.com/timeline/entry/372409/Celebrate-Women-in-STEM/>
- Opportunities for women in engineering:
 - <https://www.engineergirl.org/>

- STEAM resources for girls:
 - <http://www.thinksteam4girls.org/>
- A Mighty Girl: Highlighting books, toys, movies, music on courageous women
 - <https://www.amightygirl.com>
- Canadian Women in Science:
 - http://science.gc.ca/eic/site/063.nsf/eng/h_97436.html
- Science Careers and Teacher Resources:
 - <https://www.sciencebuddies.org/>
- Opportunities for young women to explore science, trades & technology:
 - <http://techsploration.ca/participants/students/>

Appendix

Meet and Greet Figures

Meet and Greet Items

The following chart lists the women highlighted in the original *Hidden Figures* workshop, along with suggested items for their Meet and Greet package.

Hidden Figure	Item
Elizabeth Blackwell	Bar of soap
Rachel Carson	Book: <i>Silent Spring</i>
Lillian Chase	Acadia sticker
Mamie Phipps Clark	Doll
Marjory Stoneman Douglas	Book: <i>The Everglades: River of Grass</i>
Sylvia Earle	A pair of goggles
Annie Easley	Pictures of Centaur and a hybrid car
Ursula Franklin	Fake teeth
Jane Goodall	Monkey
Dorothy Hodgkin	Picture of mouldy bread
Grace Hopper	Toy moth or butterfly
Katherine Johnson	Toy rocket ship
Katia Krafft	Picture of a volcano
Hedy Lamarr	Popcorn and cellphone
May Britt-Moser	A GPS, compass or picture of a brain
Joan Beauchamp- Procter	Toy
Vera Rubin	Picture of stars
Wang Zenyll	Ball, mirror, flashlight

Elizabeth Blackwell

Medical Doctor
(1821 - 1910)



- Elizabeth was born in England and moved as a child with her family to the United States for her father's business.
- In 1938, her father died and she began her career as a travelling teacher.
- She met a woman with uterine cancer who felt better talking to a female physician, which inspired her to change careers.
- Elizabeth applied to multiple medical schools. Administrators allowed her potential classmates (all men) to vote yes or no for acceptance. They thought her application was a joke by a rival school and voted unanimously to admit her.
- In 1849, she became the first woman to receive a medical degree in the United States.
- During this time period, hand washing and other sanitary standards were not widely recognized. Elizabeth's thesis on Typhus, or "ship fever," and how proper hygiene prevents it from spreading, helped establish such regulations.
- She ultimately encouraged other women to enter the field of medicine.

References and Resources

Elizabeth Blackwell.(2017, January 10). *Famous Scientists*. Retrieved from:

<https://www.famousscientists.org/elizabeth-blackwell/>

Elizabeth Blackwell Biography. (2018). *A&E Television Networks*. Retrieved from:

<https://www.biography.com/people/elizabeth-blackwell-9214198>

Ignotofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Rachel Carson

Marine Biologist, Conservationist, and Author
(1907 - 1967)



The American Environmental Protection Agency (EPA) was created as a response to her work.

- At the age of 11 she won a writing contest. Her work was published in St. Nicholas magazine.
- She published the book, *Silent Spring*, in 1969.
 - It explained that a chemical, DDT (dichlorodiphenyltrichloroethane), was bioaccumulating in food chains, resulting in a loss of songbirds and many other organisms.
 - DDT is a pesticide that was commonly used in used agriculture.
 - Chemical companies claimed that her book was propaganda and spent \$250,000 trying to discredit Rachel.
- Rachel continued to stand up for what she believed in despite having cancer. She spoke in front the United States Senate. Her perseverance resulted in the Environmental Protection Agency in the United States, inspiring an environmental movement around the globe.

References and Resources

- Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.
- Lear F. (2000). The life and legacy of Rachel Carson. Retrieved from: www.rachelcarson.org
- Michals, D. (2015). Rachel Carson. Retrieved from: <https://www.womenshistory.org/education-resources/biographies/rachel-carson>
- Swaby, R. (2015). *Headstrong: 52 women who changed science - and the world*. New York: Broadway Books.

Lillian Chase

Acadia Alumni (1916) and Doctor
(1894 - 1984)



- Lillian was born in Nova Scotia.
- She is an alumni of Acadia University (1912-1916).
- Lillian was the Joke Editor for Acadia's school newspaper, The Athenaeum.
- She earned a medical degree from the University of Toronto and went on to work with Frederick Banting and Charles Best on diabetes research.
- Lillian was a founding member of the Canadian Diabetes Association.
- In 1932, she was the first woman elected president of the Regina General Hospital.
- During her time at Acadia she played hockey, basketball, and tennis.

References and Resources

Acadia University Library Archives Print material

Acadia University Communications. (2014). Lillian Chase. Voices of Acadia, 2. Retrieved from:

https://issuu.com/acadiacommunications/docs/voices_ii_lores

Acadia University Archives. (2006). Turn out & Cheer! Sports in Wolfville, 1870 - 1950 - Lillian Chase. Retrieved

from: <http://archives.acadiau.ca/sites/default/files/archives/sporthistory/athletes/female/chase.html>

University of Regina. (n.d.) Lillian Chase. Retrieved from:

http://esask.uregina.ca/entry/chase_lillian_ca_1894-1987.html

Mamie Phipps Clark

Psychologist and Civil Rights Activist
(1917 - 1983)



- Despite slavery being abolished in 1865 in the United States, African Americans (and Canadians) still face injustices today.
- Mamie was born in 1917 in an area of Arkansas where racial segregation was prominent. She, along with other black students, attended a poorly funded segregated school.
- Mamie felt she had a good childhood but realized there were gaps in her education.
- She was able to complete her master's degree at Howard University. Her thesis was on "The Development of Consciousness of Self in Negro Pre-school Children." She furthered her education by earning her PhD from Columbia.
- Mamie proved that segregation negatively impacts black children's self-esteem. In her study, it was clear black children identified with a black doll. However, black students attending segregated schools thought the black doll was ugly and bad, and even thought that they themselves were bad. This study helped end segregation in public schools in 1954.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Oral History Research Office Collection of the Columbia University Libraries. (2006). Notable New Yorkers - Mamie Clarke. Retrieved from:
<http://www.columbia.edu/cu/lweb/digital/collections/nny/clarkm/index.html>

Weiss, A. (n.d.) Mamie Phipps-Clarke 1917-1983. Retrieved from:
<http://faculty.webster.edu/woolfm/mamieclark.html>

Marjory Stoneman Douglas

Writer and Conservationist
(1890 - 1998)



Her work helped to create Everglades National Park in Florida.

- In 1947, Marjory published the book, *The Everglades: River of Grass*.
- At the time, wetlands were viewed as a nuisance and people did not have the insight to see their value. Marjory recognized the importance of the swamp as wetland that provides important ecosystem functions.
- In 1969, she started the Friends of the Everglades organization.
 - The Everglades has habitat for alligators, manatees, and many species of fish and birds.
 - This organization protected the land from the US Army Corps of Engineers. Their agricultural dams were hurting the ecosystem.

References and Resources

Douglas, M. S., & Fink, R. (2017). *The Everglades: river of grass*. Sarasota, FL: Pineapple Press, Inc.

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

WETA, Washington, DC and the National Parks Film Project. (2009). Marjory Stoneman Douglas (1890-1998). Retrieved from <http://www.pbs.org/nationalparks/people/behindtheparks/douglas/>

Sylvia Earle

Marine Biologist, Explorer, and Aquanaut
(1935 -)



"No water, no life, no blue, no green." - Sylvia Earle

- During the time astronauts first began exploring space, Sylvia was exploring deep into the ocean.
- Throughout her PhD work, Sylvia scuba dived and collected 20,000 algae samples.
- In 1979, Sylvia wore a person-sized submarine suit to complete the deepest untethered dive for that time.
- Her work educates people about the Earth's oceans.
 - Her focus has been on overfishing and pollution, as these are creating areas where life cannot be sustained.

References and Resources

- Earle, R. (2009, February). My wish: Protect our Ocean. Retrieved from:
https://www.ted.com/talks/sylvia_earle_s_ted_prize_wish_to_protect_our_oceans
- Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.
- National Geographic. (n.d.) Explorer in residence: Sylvia Earle. Retrieved from:
<http://www.nationalgeographic.com/explorers/bios/sylvia-earle/>

Annie Easley

**Computer Programmer, Mathematician, and Rocket
Scientist
(1933 - 2010)**



*"When people have their biases and prejudices, yes, I am aware. My head is not in the sand. But my thing is, if I can't work with you, I will work around you. I was not about to be so discouraged that I'd walk away. That may be a solution for some people, but it's not mine."
- Annie Easley*

- Annie began working at NASA in 1955. That was before it was even called NASA! (It was called NACA Lewis Research Centre.) She was inspired by the twin sisters who were human computers (people who completed computations) at that institution. Annie felt she could do the job too and that was the start of her 34 year career.
- Over time, computers took over calculations and Annie transitioned into a computer programmer. Her work helped to analyze different power technologies that lead to the Centaur upper-stage rocket project. This project has helped launch spacecrafts, communication, and weather satellites. Her work is now used in hybrid vehicles.
- During her career at NACA/NASA, she completed her math degree without help from her employer. She took unpaid leave to finish and paid tuition herself, whereas many of her male co-workers received financial support.
- Annie was a driven person, not only at work, but in her personal life as well. She volunteered immense amounts of time tutoring underprivileged children and teaching other African Americans how they could pass the discriminatory Jim Crow voting test. This test was an unfair examination targeting Black citizens in an effort to prevent them from voting.

References and Resources

- Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.
- Lee, N. (2015, February 13). Annie Easley helped make modern spaceflight possible. Retrieved from <https://www.engadget.com/2015/02/13/annie-easley/>
- Rocket Women (2016, March 31). NASA's female pioneers - Rocket women from history you should know. Retrieved from <https://www.nasa.gov/feature/annie-easley-computer-scientist>

Ursula Franklin

Physicist
(1921 - 2016)



- Ursula was born in Germany, but became a Canadian citizen.
- She left Germany after World War II. A Holocaust survivor and peace activist, Ursula was very opposed to the violence and oppression in Germany at the time. She was especially involved in promoting women's rights.
- Ursula studied the physical and chemical behaviour of metallic elements as a metallurgist.
- The first female professor at the University of Toronto (1967), Ursula was also a physicist, and author.
- Ursula studied the build-up of the radioactive isotope strontium -90 in Canadian children's teeth from nuclear weapon testing. A treaty among 135 countries resulted, banning nuclear detonations in water, air, and space.

References and Resources

CBC News. (2016, July 25). Peace and Justice – A Celebration of Ursula Franklin. Podcasts retrieved from:
<http://www.cbc.ca/radio/ideas/peace-and-justice-a-celebration-of-ursula-franklin-1.3694050>.

Raymond K. (2007). Ursula Franklin. *Canadian Encyclopedia*. Retrieved from:
<http://www.thecanadianencyclopedia.ca/en/article/ursula-franklin/>

Valpy, M. (2017, July 27). Ursula Franklin was renowned for her devotion to science, pacifism and education. *The Globe and Mail*. Retrieved from: <https://www.theglobeandmail.com/news/national/ursula-franklin-canadian-scientist-and-activist-had-a-passion-for-peace/article31123033/?service=amp>

Jane Goodall

Animal Rights Activist
(1934 -)



- Born in England, Jane is a primatologist, ethologist, anthropologist, and a UN Messenger of Peace.
- She is known to be the world's leading expert on chimpanzees.
- Jane discovered that chimps present "human-like" actions such as kissing, hugging and tickling. She also found that chimps are capable of rational thought and emotion.
- Through her work, the science world has found many similarities between chimps and humans, pointing more and more towards the science of evolution.
- She is an animal rights activist and campaigns against medical testing on animals, harmful farming and zoos, as well as animal sports.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Jane Goodall Biography. (2018). *Biography*. Retrieved from: <https://www.biography.com/people/jane-goodall-9542363>

The Jane Goodall Institute of Canada. (n.d.) All About Jane. Retrieved from: <https://janegoodall.ca/who-we-are/all-about-jane/>

Dorothy Hodgkin

Chemist
(1910 –1994)



In England, Dorothy was nicknamed "Gentle Genius."

- A British born chemist, Dorothy won the Nobel Prize in Chemistry in 1964. She was the third woman to win this prize.
- Dorothy developed protein crystallography, a technique to determine the atomic and molecular structure of a crystal.
- Her work was incredibly important for science, since many things can take a crystal form; this revealed the structure and functions of many molecules such as vitamins, drugs, proteins, and even DNA.
- Dorothy discovered the structure of penicillin, which is still one of the most commonly used antibiotics.

References and Resources

Ferry, G. (2018). Dorothy Hodgkin. *Encyclopedia Britannica*. Retrieved from:

<https://www.britannica.com/biography/Dorothy-Hodgkin>

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

The Nobel Foundation. (1964). Dorothy Crowfoot Hodgkin – Biographical. Retrieved from:

https://www.nobelprize.org/nobel_prizes/chemistry/laureates/1964/hodgkin-bio.html

Grace Hopper

Computer Scientist
(1906-1992)



Grace had a backwards clock in office as a reminder that there are multiple ways things work..

- Nicknamed "Amazing Grace," she was one of the first programmers of the Harvard Mark 1 computer.
- Grace invented one of the first compilers. This is computer software that works like a translator, in that it is able to translate computer code from one language to another.
- Her programming languages led to the development of a highly regarded computer programming language (COBOL) that is still in use today.
- Grace served in the United States Navy from 1943- 1986 and became a Navy rear admiral.
- She created the term "debugging" after a moth got caught in a computer.

References and Resources

A&E Television Network.(2018). Grace Hopper Biography. Retrieved from:

<https://www.biography.com/people/grace-hopper-21406809>

Ignotofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Wellmark, L. (2017). *Grace Hopper, Queen of Computer Code*. New York: Sterling Publishing.

Katherine Johnson

Mathematician

(1918 -)



"[The other women] didn't ask questions or take the task any further. I asked questions; I wanted to know why. They got used to me asking questions and being the only women there."

- Katherine Johnson

- An African American physicist and mathematician, Katherine was known as a "computer" at NASA, before electronic computers were used.
- She made contributions to the space programs at NASA with the applications of early electronic computers.
- Katherine calculated trajectories and launch windows for many spaceflights at NASA which were critical to the success of the missions, including the mission to the moon.
- She received the Medal of Freedom in 2015.
- Katherine was the main subject of the recent movie "Hidden Figures."

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Shetterly, M.L..(2017). Katherine Johnson Biography. NASA. Retrieved from

<https://www.nasa.gov/content/katherine-johnson-biography>

The Editors of Encyclopaedia Britannica. (n.d). Katherine Johnson American mathematician. *Britannica*. Retrieved from: <https://www.britannica.com/biography/Katherine-Johnson-mathematician>

Katia Krafft

Volcanologist
(1942 - 1991)



"For me the danger is not important... Among the volcanoes I forget everything." - Katia Krafft

- Katia was a French volcanologist who was a pioneer for filming, photographing, and recording volcanoes.
- Her footage of the effects of volcanic eruptions was a large factor in gaining the attention of people who faced volcanic threats in their towns.
- Her work has, in more than one instance, convinced many people that evacuation was necessary during volcanic eruptions.
- She would get as close as possible to lava flows from active volcanoes, even just feet away on multiple occasions.
- Katia died in pyroclastic flow (current of hot gas and volcanic matter) in Japan after a large current unexpectedly came out of a small channel.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Schohn, A. (2017). Katia & Maurice Krafft. Retrieved from: <http://onaessayedeleperdre.com/katia-maurice-krafft/>

Hedy Lamarr

Inventor and Film Actress
(1914-2000)



- Hedy (formerly Hedwig) left her millionaire husband in Austria and moved to Paris, London and the United States after he wanted her to quit her acting career.
- She continued acting and was popular during her time. In the evenings she would putter with inventions.
- Hedy wanted to help with World War II. In particular, there was an issue with radio-controlled torpedoes that were going off course due to their signals being jammed. She discussed the problem and solution with a composer at a dinner party. Together, they discovered radio signals could change in the same manner that pianos change notes. Thus, they created a frequency hopping spread spectrum (FHSS) and patented it in 1949. Unfortunately, the US military did not use this technology until the 1960s.
- The background for this innovation is used today in smartphones, GPS, Wi-fi, and Bluetooth devices.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Swaby, R. (2015). *Headstrong: 52 women who changed science - and the world*. New York: Broadway Books.

The Biography.com website. (2018, March 26). Hedy Lamar biography. Retrieved from:

<https://www.biography.com/people/hedy-lamarr-9542252>

May-Britt Moser

Neuroscientist
(1963-)



- Born in Norway, May-Britt is a psychologist and neuroscientist.
- She is the Head of the Department of the Centre for Neural Computation at the Norwegian University of Science and Technology.
- May-Britt discovered different cells that are important to memory and encoding of space, like an inner GPS.
- She won the Nobel Prize in Physiology or Medicine in 2014.
- A civil rights activist, May-Britt is adamant that a woman can be both a successful scientist and have a family.

References and Resources

Gorman, J. (2013, April 29). A Sense of where you are. *The New York Times*. Retrieved from: https://www.nytimes.com/2013/04/30/science/may-britt-and-edvard-moser-explore-the-brains-gps.html?_r=0

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Nobel Media AB. (2014). May-Britt Moser – Facts. Retrieved from: https://www.nobelprize.org/nobel_prizes/medicine/laureates/2014/may-britt-moser-facts.html

Vera Rubin

Astronomer
(1928 - 2016)



Vera Rubin was 22 when she created the theory that the universe is rotating.

- Vera was the only graduate from Vassar College in 1948. She intended to do her master's degree at Princeton, however they did not admit women to their astronomy program. Instead, she went to Cornell University.
- She determined that dark matter was creating a gravitational pull that impacted how the galaxies move and that most of the universe is made of dark matter: an invisible mass we cannot observe. Her calculations provide strong evidence for dark matter, which scientists are still trying to understand further today.
- She mentored many female astronomers.

References and Resources

Associated Press. (2016, December 26). Vera Rubin, astronomer who helped find evidence of dark matter, dies at 88. *The Guardian*. Retrieved from: <https://www.theguardian.com/science/2016/dec/26/vera-rubin-pioneering-astronomer-dark-matter-died-aged-88>

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Joan Beauchamp Procter

Zoologist
(1897 - 1931)



- Born in London, Joan was a zoologist, and a world renowned herpetologist. (Herpetology is the study of reptiles and amphibians.)
- She was the first female Curator of Reptiles at the London Zoo and was an expert on handling dangerous animals including pythons, crocodiles and Komodo dragons. She created a good relationship with these animals by giving them a good care and feeding routine.
- It was highly unusual during this time period to see a woman with these animals.
- Joan had chronic health issues which led to her early death at the age of 34.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

ZSL London Zoo. (2014, March 7). ZSL Celebrates Dr. Joan Procter for International Women's Day. Retrieved from: <https://www.zsl.org/zsl-london-zoo/news/zsl-celebrates-dr-joan-procter-for-international-womens-day>

Wang Zhenyi

Astronomer, Poet, and Mathematician
(1768 - 1797)



- Wang was born into a family of academics. Her grandfather taught her math and astronomy.
- During her time, people did not have a full understanding of eclipses. Thus, Wang created her own model using a lamp, mirror and globe that was tied to the ceiling using strings. This showed that the moon (mirror) blocks the view of the sun (lamp) during a solar eclipse, and the earth (globe) blocks the view of the moon during a lunar eclipse.
- Although she found math a challenge, Wang preserved and learned complicated arithmetic. She published a 5 volume guide for beginners titled, *Simple Principles of Calculations*.
- She was well travelled and witnessed many injustices. She used this knowledge to write political poetry.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Scientific Women Net. (n.d.) Wang Zhenyi. Retrieved from: <http://scientificwomen.net/women/zhenyi-wang-98>

Appendix

Learning Centre Materials



Environmental Biology Learning Centre

Activity Overview

Participants at this station are provided a variety of organisms that are easily collected such as: invertebrates (mosquito larvae, tadpoles, insects), plants (twigs, flowers, leaves), or even fungi (mushrooms, lichens, etc.). Alternatively, pruners, nets, and small shovels may be on hand for participants to gather specimens nearby for themselves. Using the colouring tools and/or technology available, students may sketch what they have in front of them. To allow the students a deeper view into microbiology, they may use a dissecting microscope or hand lens. The objective of this activity is to show that science research requires a diverse amount of skills.

Hidden Figure Connection

- Maria Sibylla Merian: an illustrator that proved to everyone that butterflies go through metamorphosis.
- Robin Wall Kimmerer: an indigenous ecologist that emphasizes the importance of getting to know the natural world around you in order to have a deeper appreciation for it.

Materials:

- Specimens
 - invertebrates, plants, fungi etc.
- Hand drawing tools
 - pencils (e.g. Prismacolor brand), paint, sketch paper, etc.
- Digital drawing tools
 - iPad, tablet, computer
 - Apps (Paint, Procreate, Tayasui Sketches)
- Magnifier
 - hand lens, magnify glass, dissecting scopes
- Field Guides
- Books:
 - Kimmerer, R. W. (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants*. Minneapolis, MN: Milkweed Editions.
 - Kimmerer, R. W. (2004). *Gathering Moss: the natural and cultural history of mosses*. Corvallis: Oregon State Univ. Press.
 - Merian, M. S., Brafman, D., & Schrader, S. (2008). *Insects & flowers: the art of Maria Sibylla Merian*. Los Angeles: The J. Paul Getty Museum.
 - Todd, K. (2007). *Chrysalis: Maria Sibylla Merian and the Secrets of Metamorphosis*. Orlando, FL: Hartcourt Inc.
- Career Profiles:
 - [Entomologist](#)
 - [Botanist](#)
 - [Marine Biologist](#)
- Activity Instructions
- *Hidden Figures* Handouts



Environmental Biology Centre

Robin Wall Kimmerer suggests that in order for people to want to help plants they need to get to know them up close. Here is your chance!

At this station, you can create your own scientific illustration(s). There are coloured pencils and paper for hand drawings, or you can try using technology to sketch a specimen.

There are leaves, flowers, invertebrates, and lichens to use. You may also use the pruners or just go outside to collect/look at a specimen of your own choosing.

If you are interested in microbiology, there is a microscope on hand too. The workshop facilitators can assist as needed.

Maria Merian's work is still inspiring and helping scientists today to learn about the world around us. Who knows? Maybe your drawings will too!



Maria Sibylla Merian

Born in Germany in 1647

Scientific Illustrator and Entomologist



Portrait of Maria Sibylla Merian - an engraving by Jacobus Houbraken [botanicalartandartists.com]

In the 1600s, people believed that insects spontaneously appeared from their environment (mud, air, water, garbage, etc.) and most people thought that these organisms were gross and uninteresting.

Maria, however, was different; at an early age, she collected plants and insects and painted them.

When Maria was 52 years old, both her and her youngest daughter travelled to Suriname, South America. To pay for her travel costs, Maria sold her drawings along the way. When she arrived she collected and sketched a variety of species from vegetables, insects, reptiles and so forth. This adventure was very risky, as it was uncommon for women to be travelling alone during this time period, and travelling for science was unheard of. The heat, rain, and poisonous creatures would have been enough to deter most people.

Unfortunately, two years into her exploration Maria contracted malaria. However, she had adequate illustrations already drawn to create her masterpiece, *The Metamorphosis of the Insects of Suriname*. The book, published in 1705, demonstrated the life cycle of a butterfly from caterpillar to butterfly through scientific notes and illustrations.

Her work has influenced many, such as Carl Linnaeus, who used her drawings to help him classify insects into groups.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

GrrlScientist. (2013, April 2). Maria Sibylla Merian: artist whose passion for insects changed science. *The Guardian*. Retrieved from: <https://www.theguardian.com/science/grrlscientist/2013/apr/02/maria-sibylla-merian-artist-insects-science>

Maggs, S., & Foster-Dimino, S. (2016). *Wonder women: 25 innovators, inventors, and trailblazers who changed history*. Philadelphia: Quirk Books.

Swaby, R. (2015). *Headstrong: 52 women who changed science - and the world*. New York: Broadway Books.

Tyrrell K. (n.d.). About Maria Sibylla Merian. Retrieved from: <http://www.botanicalartandartists.com/about-maria-sibylla-merian.html>



Duroia eriopila (from *Metamorphosis insectorum Surinamensium*, Plate XLIII) [botanicalartandartists.com]



Robin Wall Kimmerer

Born in United States in 1953

Plant Ecologist and Writer



Dr. Kimmerer is a scientist at the SUNY College of Environmental Science and Forestry in New York. She is also a renowned writer and teacher. Her work consists of studying moss and incorporates traditional ecological knowledge to help in restoration.

As a citizen of Potawatomi Nation, she grew up learning many indigenous teachings about plants. Although important, this way of knowing is often neglected in science classes and programs. Dr. Kimmerer works towards bridging this gap to help restore our relationship with land.

Dr. Kimmerer has written two books, including: *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* (2013) and *Gathering Moss: the natural and cultural history of mosses* (2004).

References and Resources:

Kimmerer, R. W. (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants*. Minneapolis, MN: Milkweed Editions.

Kimmerer, R. W. (2004). *Gathering Moss: the natural and cultural history of mosses*. Corvallis: Oregon State Univ. Press.

Milkweed Editions. (n.d.). Braiding Sweetgrass. Retrieved from: <https://milkweed.org/book/braiding-sweetgrass>

State University of New York. (n.d.) Robin W. Kimmerer faculty page. Retrieved from: <http://www.esf.edu/faculty/kimmerer/>



Bio-Chemistry Learning Centre

Activity Overview

Participants at this station will extract DNA from their cheek cells. This activity is adapted from *Planet Science* (<http://www.planet-science.com/categories/experiments/biology/2012/03/extract-your-own-dna.aspx>) and *StudyLib.Net* (<http://studylib.net/doc/6903115/lab--dna-extraction-from-human-cheek-cells>).

Hidden Figure Connection

- Alice Ball: a chemist that enhanced a treatment for leprosy.
- Rosalind Franklin: an x-ray crystallographer that took a picture of DNA showing the double helix.

Materials

- Lab supplies
 - water, soap, Dixie cups, salt, food colouring, rubbing alcohol, petri-dishes
 - stir bar/pipette, beaker/cup.
 - microscope (optional)
- Book
 - Maddox, B. (2003). *Rosalind Franklin: the dark lady of DNA*. New York: Perennial/HarperCollins.
- Career Profiles
 - [Biochemist](#)
 - [Environmental Chemist](#)
 - [Crystallography](#)
- Activity Instructions
- *Hidden Figures* Handouts



EXTRACT YOUR DNA

In this activity you will be able to see cheek cell DNA.

Harvest your cheek cells:

1. Fill the measuring cup to 500 ml of water.
2. Add 1 tbsp of salt* to the water.
3. Mix the salt into the water.
4. Pour 3 tbsp of water into a Dixie cup.
5. Gargle the salty water for 1 minute, then spit it back into your Dixie cup.

**Salt helps to rub off cheek cells and helps bring together the DNA.*

Break down the cell and nucleus membranes:

6. Put a small drop of soap into your Dixie cup and gently stir for 2.5 minutes. Don't stir too vigorously - this will break the DNA into smaller fragments.

Precipitate the DNA out of the salt solution:

7. Pour 100ml of rubbing alcohol into another measuring cup or beaker. Stir 3 drops of food colouring into this beaker/cup.
8. Carefully pour some of this mixture into your gargled water.
9. Wait for about 3 minutes. Translucent pieces of DNA should appear. The blue provides a great contrast.

Extension:

10. If you want to view it under the microscope there are petri dishes available. The facilitators can help as needed.

Clean up:

11. Clean up the station! Unused salty water can be used for another group and left over blue alcohol solution can be saved as well.

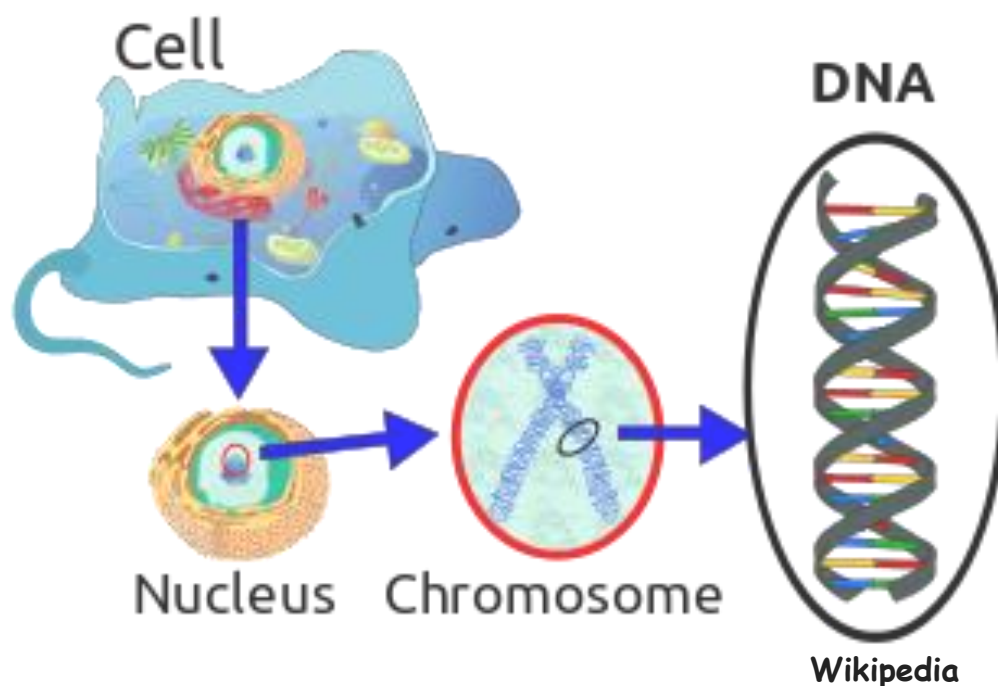
Resources

- <http://www.planet-science.com/categories/experiments/biology/2012/03/extract-your-own-dna.aspx> ---> Great Video!
- <http://studylib.net/doc/6903115/lab--dna-extraction-from-human-cheek-cells>



DNA

Deoxyribonucleic acid is a molecule that carries the genetic instructions used in the growth, development, functioning and reproduction of all known living organisms and many viruses.



- In this activity you see clumps/strings of DNA.
- DNA is too small to see with the naked eye.
- Rosalind Franklin, a Hidden Figure featured at this station, helped us to figure out that this tiny, yet important, molecule is in the structure of a double helix.



Alice Ball

Born in United States in 1892

Chemist



Alice Ball's fascination with chemistry began while spending time with her photographer grandfather in a darkroom. She later obtained a science degree from the University of Washington and became the first African American, and the first woman, to complete a master's degree at the University of Hawaii.

Her major contribution to science was a treatment for leprosy (Hansen's Disease). Leprosy is a skin disease that creates lesions resulting in deformities, as well as nerve and eye damage. Alice's work was focused in Hawaii, where those who got the disease were exiled to Kalaupapa.

During Alice's time, a Chinese medicine derived from the chaulmoogra tree was made into oil to treat skin diseases. This oil was ineffective when used as a lotion and was nauseating to swallow. The oil alone was not water soluble, which made it impossible to infuse into blood. Alice was able to isolate parts of the oil, making the treatment injectable. This put an end to the exile and allowed patients to return to their families.

Unfortunately, Alice died shortly afterward in 1916. The University of Hawaii's president (where she worked) continued to make the medication and took all the credit. It was not until the 1970s that it was accidentally uncovered that Alice had created this treatment.

References and Resources.

- Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.
- Swaby, R. (2015). *Headstrong: 52 women who changed science - and the world*. New York: Broadway Books.
- University of Hawai'i at Manoa. (n.d.). Ball, Alice Augusta. *Scholar Space*. Retrieved from: <https://scholarspace.manoa.hawaii.edu/handle/10125/1837>



Rosalind Franklin

Born in England in 1920
Chemist and X-Ray Crystallographer



Rosalind Franklin was born in London to a wealthy Jewish family. She received a PhD in physical chemistry from Cambridge University.

During the Second World War, Rosalind researched and published about gas and water exchange from carbon. Charcoal was often used in gas masks.

However, her most notable work was on the structure of DNA at Kings College (London). Rosalind was an expert in using x-rays to capture images of materials. This experience resulted in high quality pictures of DNA.

Unfortunately, Rosalind's colleague was not fond of her and shared her work with scientists from another university without her permission. These other researchers were able to interpret the photo and determined that DNA was in a double helix shape. They published this information and received a Nobel Prize without acknowledging Rosalind.

Rosalind died at 37 years of age from cancer, which was likely caused by radiation from working with x-rays.

References and Resources.

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Maddox, B. (2003). *Rosalind Franklin: the dark lady of DNA*. New York: Perennial/HarperCollins.

Swaby, R. (2015). *Headstrong: 52 women who changed science - and the world*. New York: Broadway Books.

Nature Education. (n.d.). Rosalind Franklin: A crucial contribution. Retrieved from:
<https://www.nature.com/scitable/topicpage/rosalind-franklin-a-crucial-contribution-6538012>



Environmental Engineering Learning Centre

Activity Overview

Participants will construct a wetland to support its filtration function from cotton balls, rocks, and sand in a pre-cut juice container. They will have information available related to wetlands and wetland construction in real-life applications. The aim of this activity is to understand that careers in STEAM have real -life applications, while fostering kinesthetic learning and promoting environmental conservation. An interesting discussion with the learners would be to talk about the benefits and downfalls of constructing man-made habitats verses protecting natural environments. These activities have been adapted from a project by the NGWA, The Ground Water Association, which can be found at:
<http://www.ngwa.org/Fundamentals/teachers/Pages/Building-a-wetland-filter.aspx> .

Hidden Figure Connection

- Edith Clarke: the first electrical engineer with General Motors.
- Mary Wells: a material engineer that has advocated for women representation within her field.

Materials

- Wetland supplies
 - 2L juice containers, cotton balls, sand, rocks, pollution (e.g. confetti, soil, food colouring, etc.)
- Printed materials
 - Wetland Factsheet:
https://www.novascotia.ca/nse/wetland/docs/Wetlands_in_Nova_Scotia.pdf
 - Nova Scotia Wetland Policy:
<https://novascotia.ca/nse/wetland/conservation.policy.asp>
 - Canadian Wetland Classification Guide:
<http://www.wetlandpolicy.ca/canadian-wetland-classification-system/>
 - Wetland Heroes: <http://www.ducks.ca/initiatives/wetland-heroes/>
 - Wetland Construction:
<https://nepis.epa.gov/Exe/ZyPDF.cgi/30005UPS.PDF?Dockkey=30005UPS.PDF>
- Career Profiles
 - [Environmental Engineer](#)
 - [Electrical Engineer](#)
- Activity instructions
- *Hidden Figures* handouts



Wetland Construction

What is a wetland?

Wetlands are land that is saturated with water long enough to promote wetland or aquatic processes, as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment (National Wetlands Working Group 1988).

OR

Land that contains vegetation and soil adapted to wet conditions.

Did you know wetlands provide hydrological functions to us? Can you think of any?

Unfortunately, wetlands are disappearing at an alarming rate. Many jurisdictions are putting policies in place to protect them. In some cases, constructed wetlands are being built to compensate for wetland lost.

Activity

Here is your chance to construct a wetland!

With the supplies provided, construct a wetland. When finished, take some debris from the pollution bowls and see how well it filters the water.

What do you think the cotton balls, sand, and rocks represent?



Edith Clarke

Born in United States in 1883

Electrical Engineer



Edith Clarke's upbringing was challenging; she had a reading and writing learning disability and her parents died before she was 12. She used her inheritance to pay for college to study math and astronomy at Vassar College. She also became the first woman to complete a master's degree at Massachusetts Institute of Technology (MIT).

When she graduated, the only work she could find was crunching numbers. General Electric hired her to calculate numbers and train other women. During this job, she created a new graphical calculator which made equations with hyperbolic functions easier to solve. The company still did not recognize her as an engineer, so she travelled the world and taught in Turkey. Then, General Electric re-hired her as their first female engineer. Her contributions helped to alleviate electric power line transmission problems.

References and Resources.

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Riddle, L. (2016). Edith Clarke. Retrieved from: <https://www.agnesscott.edu/lriddle/women/clarke.htm>

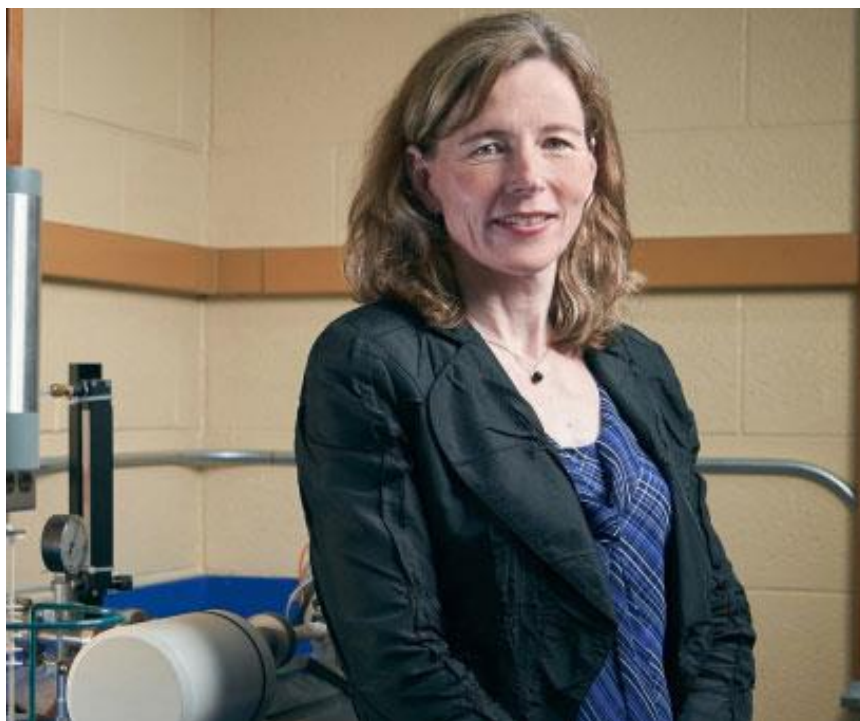
Barr, J. (2015). First female engineer inducted into inventors hall of fame. Retrieved from: <https://slice.mit.edu/2015/04/08/first-female-engineer-inducted-into-inventors-hall-of-fame/>

Engineer Girl. (n.d.). Edith Clarke. Retrieved from: <https://www.engineergirl.org/42005/Historical-Edith-Clarke>



Mary Wells

Mechanical Engineer and Professor



Dr. Mary Wells has spent most of her life in the world of science. Her main field of study is metals and materials engineering, which is the study of metallic materials and their composition. This study includes creating mathematical models of how metallic products are made. Along with her colleagues, Mary is putting a large focus on using lightweight materials for transportation.

Dr. Wells is currently a professor of Mechanical and Mechatronics Engineering at the University of Waterloo in Ontario, as well as the Associate Dean of Outreach in the Engineering Department. Mary has spoken out multiple times over the last 10 years about her concerns on the lack of female representation in engineering. It is her hope that we will see the amount of women in engineering rise over the next few years, especially in Canada.

References and Resources.

University of Waterloo. (n.d.). Mary Wells. Retrieved from: <https://uwaterloo.ca/mechanical-mechatronics-engineering/profile/mawells>

Pause, A. (2015, August 25). Women in engineering: a look at the personal and the professional. *Waterloo Stories*. Retrieved from: <https://uwaterloo.ca/stories/women-tech-look-personal-and-professional>



Aeronautical Science Learning Centre

Activity Overview

Participants will use origami to create a space shield for NASA. This was a 2017 public challenge lead by NASA. Details can be found here:

<https://www.nasa.gov/feature/develop-an-origamifolding-concept-for-radiation-shield-packingdeploying> .

Hidden Figure Connection

- Julie Payette: a former Canadian astronaut who is now the Governor General of Canada.
- Valentina Tereshkova: the first woman in space.

Materials

- Origami paper
- Career Profiles
 - [Astronaut](#)
 - [Aeronautical Engineer](#)
- Canadian Astronaut [job requirements](#)
- Activity Instructions
- *Hidden Figures* Handouts

Resources

- <https://harvardmagazine.com/2017/01/williamina-fleming>
- NASA resources for educators:
<https://www.nasa.gov/audience/foreducators/index.html>
- NASA resources for students:
<https://www.nasa.gov/audience/forstudents/index.html>



NASA Wants You!

NASA is trying to find an origami expert that can come up with a design for a radiation shield that will protect future spacecraft from cosmic rays. Cosmic rays have always been a large obstacle for NASA in their dream of exploring space for long periods of time. The radiation from these rays can cause a large amount of damage to not only the astronauts, but the spacecraft itself.

Your task is to make a 3D object from origami paper that could be used as a shield on these spacecrafts. NASA is looking for an object that is compact, but can also be deployed upon landing to give the astronauts ample protection from radiation. So go ahead, get started!

If you'd like more information on this challenge, you can visit the link below. This is a real challenge from NASA, and there's even a \$500 award if you create something they like!

For more details, visit: https://www.freelancer.com/contest/NASA-Contest-Develop-an-OrigamiFolding-Concept-for-Radiation-Shield-PackingDeploying-1059534.html?ft_prog=FLC&ft_prog_id=100005040



Julie Payette

Born in Quebec in 1963

Astronaut, Engineer and Governor General of Canada



Born and raised in Quebec, Julie Payette is a very successful Canadian woman involved in business, astronomy, engineering and politics. Ms. Payette has attained an engineering degree and a computer engineering degree. In 1992, shortly after earning her master's degree, she worked on a project in Montreal involving telephone to computer speech recognition.

Julie served as the chief astronaut for the Canadian Space Agency from 2000 – 2007, and has travelled to space on two separate occasions. During these two missions, her main focus was in robotics, with her first mission focusing on operating a Canadian robotic arm. She was the lead robotic operator on her second space mission as well as the flight engineer.

Ms. Payette has now entered into the world of politics. On July 13th, 2017, it was announced that she would become Canada's 29th Governor General. She is the fourth woman to ever hold this role. In this position, she will be the representative of Canada's monarch, Queen Elizabeth II.

References and Resources

Canadian Space Agency. (2017). Biography of Julie Payette. Retrieved from: <http://www.asc-csa.gc.ca/eng/astronauts/canadian/former/bio-julie-payette.asp>

Forester, M. Biographies Julie Payette (1963 -). Retrieved from: <http://www.heroines.ca/people/payette.html>

Raymond, A. (2008). Julie Payette. *The Canadian Encyclopedia*. Retrieved from: <http://www.thecanadianencyclopedia.ca/en/article/julie-payette/>

The Governor General of Canada (2017). Governor General Julie Payette. Retrieved from: <https://www.gg.ca/document.aspx?id=16943>



Valentina Tereshkova

Born in Russia in 1937
Cosmonaut, Engineer, and Politician



At the age of 26, Valentina Tereshkova was the first woman in space. In 1963, she was chosen from more than 400 applicants to pilot a Russian spacecraft. On this mission, she orbited the Earth 48 times in her 3 days in space. This was a large accomplishment for women, because at this time in history, women were seen as too delicate for this type of work and it was still believed that women should be homemakers and mothers before anything else.

Valentina formally attended school until the age of 8, after which she completed courses via correspondence. Before her recruitment as a cosmonaut, she was a factory worker and an amateur skydiver. Valentina made her first jump as a skydiver at the age of 22, and it was largely because of her expertise in this field that she was chosen as a cosmonaut.

Ms. Tereshkova also held a long-time membership in the Communist Party of the Soviet Union. Having a woman belong to a high party was also unusual at the time, but because of her work as a cosmonaut and her lavish accomplishments, she attained a seat in the party. She was a member of multiple parties within Russia, as well as a member of the World Peace Council.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

Sharp, T. (2018, January 22). Valentina Tereshkova: First Women in Science. *Space*. Retrieved from: <https://www.space.com/21571-valentina-tereshkova.html>

Valentina Tereshkova Biography. (2016, March 1). A&E Television Network. Retrieved from: <https://www.biography.com/people/valentina-tereshkova-022516>



Cryptography Learning Centre

Activity Overview

Participants will read about the “Caesar Cypher” and solve a code written using the provided cypher. They will then research or make up their own code and write a phrase using their code.

Hidden Figure Connection

- Mavis Batey: a codebreaker during World War II and garden historian.
- Rozanne Colchester: a codebreaker that decoded messages between enemy fighter pilots.

Materials

- Info on Caesar Cypher
- Multiple phrases written using Caesar Cypher
 - A. Wkh qdph ri wklv zrunvkrs lv "Klgghq lljxukv".
 - B. Gu Frqqrq lv d fubswrjudskhu, vkh whdfjhv dw Dfdgid.
 - C. D orw ri fubswrjudskhuv gr wrv vhfuhw jryhuqphqw zrun.
 - D. Wkhuh duh 77 gdbv xqwlo kdoorzhq!
- Info on other cyphers/tech that they can research their own
- Career profile:
 - [Cryptographer](#)
- Activity Instructions
- *Hidden Figures* Handouts

Resources

- <https://www.khanacademy.org/computing/computer-science/cryptography/crypt/v/intro-to-cryptography> (Video)
- <https://www.khanacademy.org/computing/computer-science/cryptography>
- <https://learncryptography.com/classical-encryption/caesar-cipher>
- <http://crypto.interactive-maths.com/atbash-cipher.html>
- <https://www.braingle.com/brainteasers/codes/polybius.php>
- <http://www.dailymail.co.uk/femail/article-2533366/The-REAL-Bletchley-Circle-Fascinating-work-female-codebreakers-World-War-II-revealed.html>



What is Cryptography?

Cryptography is the art of writing and solving codes. These codes protect secret messages that are meant to be hidden. Cryptography is used by militaries, governments, officials and so on, to protect secrets, since before 1900 BCE! There are many different kinds of "ciphers," or codes. Each cipher has a rule; sometimes letters are rearranged randomly, sometimes there is a specific way that the letters are shifted. Sometimes, the letters can even turn into numbers! The ways a message can be coded are endless.

Your Tasks:

1. First, you get to have fun trying to solve a secret message. On the bristol board to the right, there are four different secret messages (all using the same cipher). Try to figure out what at least one of the secret messages says. If you get stuck, flip over the green cue card and it will give you the rule of the cipher to help you out.
2. After you have solved at least one message, you get to code your own message! Find your own cipher online, or you can use one that is already explained on the yellow cue cards. Grab a piece of white paper, and write down your secret message. Maybe some of the other groups will try to solve it!



Caesar Cipher

The Caesar Cipher, named after Julius Caesar, is a "shift" cipher. This means that the letter of the alphabet is simply shifted a certain amount to find the hidden message. In this case, in the coded message, each letter is shifted 3 places backward to find the true message. (E becomes B)

Atbash Cipher

This is formed by mapping the alphabet backwards. This means the first letter becomes the last letter, the second letter becomes the second to last letter, and so on.

ROT13 Cipher

Rot13 means "rotate by 13 places". In this cipher, each letter is replaced by the 13th letter after it in the alphabet.

	A	B	C	D	E	F	G	H	I	J	K	L	M
ROT13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

	H	E	L	L	O
ROT13	↓	↓	↓	↓	↓
	U	R	Y	Y	B

Polybius Square

This is a table that allows someone to translate letters into numbers. In order to fit in all 26 letters, I and J are combined, which means that this is not a perfect cipher. However, it is usually easy to tell if the letter in question should be an I or a J.

	1	2	3	4	5
1	A	B	C	D	E
2	F	G	H	I/J	K
3	L	M	N	O	P
4	Q	R	S	T	U
5	V	W	X	Y	Z



Mavis Batey

Born in London, England in 1921
Code Breaker and Garden Historian



When World War Two broke out, Mavis was studying German at University College in London. In 1940, Mavis was employed by the London Section. Her job was to check the personal columns of *The Times* for coded messages throughout the war.

Shortly after this, she was recruited to work as a codebreaker at Bletchley Park, which was the top-secret home for codebreakers during World War II. She was one of the few women that worked at Bletchley Park during the war, as this was typically a job for males.

In 1941, Mavis broke a message between Belgrade and Berlin that allowed the rest of the team at Bletchley Park to work out the wiring of the Enigma Machine, a coding machine created by the Germans. This machine was previously thought to be unbreakable. This break in coding was one of the reasons that D-Day was so successful.

After the war, Mavis went on to become a garden historian, campaigning to save many historic parks and gardens, as well as an author who published more than twelve pieces of work.

References and Resources

Spartacus Educational. (n.d.). Mavis Batey. Retrieved by: http://spartacus-educational.com/Mavis_Batey.htm



Rozanne Colchester

Born in England in 1923

Code Breaker and Secret Intelligence Service Worker



During World War Two, Rozanne worked as a codebreaker for the British, decoding messages between enemy fighter pilots. She found her work extremely exciting because the job was so top-secret. She was always found telling outsiders that “if you talked about it, you could be shot.” Rozanne would travel more than three miles to work everyday by bicycle, and most people recall seeing her with a smile on her face, excited to go to work.

Rozanne’s father worked for British Intelligence, and he himself recruited Rozanne. Because of this, she was sometimes badgered by her coworkers, as the other women working for British Intelligence were recruited on their own accord.

After the war, Rozanne went on to work for the Secret Intelligence Service serving in Cairo and Istanbul investigating double agents.

It wasn’t until the 1970s that the work of the decoders was first talked about by British Intelligence. Even then, although three quarters of the codebreakers were women, the heroes were seen as men. Even in recent depictions such as *The Imitation Game* (2014), a movie based on World War II codebreakers, the main characters were all men. Rozanne Colchester is one of the 15 women written about in Tessa Dunlop’s new book *The Bletchley Girls*. Dunlop stated that the women of the war have been “airbrushed from history for too long.”

References and Resources

Rainey, S. (2015, Jan 4). The extraordinary female codebreakers of Bletchy Park. *The Guardian*. Retrieved from: <https://www.telegraph.co.uk/history/world-war-two/11308744/The-extraordinary-female-codebreakers-of-Bletchley-Park.html>



Paleontology Learning Centre

Activity Overview

Participants will be provided with pictures of fossils. If real fossils are available, it is recommended that they be used instead.* Participants will create a story about how the fossils came to be in the area where they were found.

**Acadia Earth and Environmental Science department is a good place to inquire regarding fossils.*

Hidden Figure Connection

- Mary Anning: a palaeontologist that helped scientists learn about evolution.
- Lou Henry Hoover: a First Lady of the United States that was also a geologist.

Materials

- Pictures
 - Such as: <http://www.fossilmuseum.net/EdResources/FossilImages.htm> , <http://www.fossils-facts-and-finds.com/fossil-gallery.html>
- If using real fossils:
 - hand lens, magnify glass, ruler, geological time scale
- Books
 - Kulling, M. (2017). *Mary Annings Curiosity*. Toronto: Groundwood Books Ltd.
 - Domm, J. (2012). *Formac Pocketguide to Fossils, Rocks, and Minerals in Nova Scotia, New Brunswick, and Prince Edward Island*. Halifax: Formax.
 - Sandra, B., and Hild, M.H. (2015). *Geology of Nova Scotia: Field Guide: Touring through time at 48 scenic sites*. Portugal Cove- St. Philip's: Boulder publications.
- Career Profiles
 - [Paleontologist](#)
 - [Geologist](#)
- Activity Instructions
- *Hidden Figures* Handouts



You're a Palaeontologist Today!

Some of your colleagues have found multiple specimens in an area where they have been digging. Take a look at the pictures they have sent you of these specimens.

Your task is to come up with a story as to how these specimens may have ended up in this area, based on the pictures your colleagues have sent you. Use the looseleaf on this table to record your story.

There are two different sets of pictures. Try to come up with a creative story for one, or both if you wish!



Lou Henry Hoover

Born in Iowa, US in 1874

Geologist, Teacher and First Lady of the United States



In 1893, Lou Henry Hoover graduated with a teaching credential from what is now San Jose State University. She went on to obtain a bachelor degree at Stanford University, and was the only female geology major at the time. While she was at university she met her husband, Herbert Hoover, who would go on to become the President of the United States.

At the time, it was very unlikely for a woman to land a geology job, so Lou went off to China with her new husband. While there, she learned the language and remains the only First Lady to speak an Asian language. She spent her time collecting rock and mineral samples and studying languages through her travels. She was

fluent in multiple languages including Chinese and Latin. It is because of this that she managed to publish an award winning Latin to English translation of a guide to mining and metallurgy from 1565.

Although Lou Henry Hoover is well known for being the First Lady, she is known in the science world as the “Lady of Firsts.” She was very independent; she continued to explore the world of science despite all odds being against her, and she did not pin her successes as a woman on her husband. She was President of the Girl Scouts of the United States, an avid athlete, and explorer.

References and Resources

Caroli, B.B. (1998, July 28). Lou Hoover: American First Lady. *Britannica*. Retrieved from: <https://www.britannica.com/biography/Lou-Hoover>



Mary Anning

Born in England in 1799
Fossil Collector and Paleontologist



As a child, Mary helped her father with his fossil business. When she turned 11, her father died and she took over the business. It was dangerous job as the cliffs were prone to erosion and waves.

During this era, many people did not understand species extinction. Her work helped change people's minds when she discovered an ichthyosaur skeleton (reptile fish). She also discovered the skeleton of a plesiosaur, another type of marine fish. Her work and research has been important in understanding the evolution of species.

Unfortunately, at the time women were not allowed to publish their work. As such, scientists took her work as their own.

References and Resources

Ignatofsky, R. (2017). *Women in science: 50 fearless pioneers who changed the world*. London: Wren & Rook.

BBC. (n.d.). Mary Anning. Retrieved from:
http://www.bbc.co.uk/schools/primaryhistory/famouspeople/mary_anning



Neuroscience Learning Centre

Activity Overview

Participants will learn about neuropsychologist Marian Diamond's fascination with the brain and complete memory activities.

Hidden Figure Connection

- Marian Diamond - a neuropsychologist who carried a brain in a hat box and made a breakthrough discovery: neuroplasticity.

Materials

- Computer and headphones
- Memory items
- Career profile
 - [Neuropsychologist](#)
 - [Psychiatrist](#)
- Activity Instructions
- *Hidden Figures* Handout



Neuroscience Learning Centre

Your Tasks:

1. Watch the interesting video on Dr. Marian Diamond called "My Love Affair with the Brain." (<http://lunaproductions.com/marian-diamond/>)
Feel free to search for more videos of Dr. Diamond if you wish; she is a very interesting woman!
2. Test your memory! Neuroscience is the study of the brain, so what better way to explore your own neuro-function than by testing your own memory? There are multiple options for you to do this:
 - a) Download the app "Retap!" or "Memory Classic" and play these games to test your memory. "Retap!" is a game where you have to tap out the colors that were just played for you (there are sounds too). "Memory Classic" is like the game of pairs, where you must try to remember where the pairs are laid out on the screen and match them.
 - b) Follow this link: <https://faculty.washington.edu/chudler/puzmatch.html> and it will take you to a picture memory game. Many pictures will stay on the screen for a limited amount of time. You will try to memorize as many as you can in the time given!
 - c) Hands on! On this table is a tray filled with many different objects. Have your partner put some items on the tray. You can look at these items for 20 seconds. Then, have your partner take away a few of the items without you watching. Your task is to remember which items your partner took away.



Marian Diamond

Born in California in 1926
Neuroanatomist and Professor



Dr. Marian Diamond was a remarkable woman who studied the anatomy of the brain as well as its functions and development. She won 12 awards throughout her lifetime, and taught university classes well into her eighties. Dr. Diamond had a documentary made about her in 2016. She passed away on July 25th, 2017.

Marian was the first female graduate student of the anatomy department at Berkeley. Marian's studies have forever changed the way people look at the human brain. She was the first person to provide evidence of neuroplasticity (how the brain changes).

Before her studies, it was believed that brains have a period of changing and developing during childhood, and then remain unchanging for the rest of a person's life. Using rats, Marian proved that the brain can be changed at any age. It is because of these findings that we now know children learn better when they are well cared for and loved. This was a huge discovery not only for neuroscience but for humanity as well.

References and Resources

Sanders, R. (2017, July 28). Marian Diamond, known for studies of Einstein's brain, dies at 90. Berkeley News. Retrieved from: <http://news.berkeley.edu/2017/07/28/marian-diamond-known-for-studies-of-einsteins-brain-dies-at-90/>

Luna Productions. (n.d.). My love affair with the brain: The Life and Science of Marian Diamond (clip). Retrieved from: <http://news.berkeley.edu/2017/07/28/marian-diamond-known-for-studies-of-einsteins-brain-dies-at-90/>