#### Stories of Women in STEM

## SPACE



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#### Dedication

I would like to dedicate this book to Fredericka "Fredi" Stevenson. Fredi was a generous and humble volunteer of the Smithsonian Science Education Center National Advisory Board from 2014 – 2023. She served as the Board Chair and leader for three years. It was during this time that I came to appreciate not only her humility, but her tireless commitment to young people.

Fredi is dedicated to education and to advancing young women in achieving their goals. As a champion to middle school and high school students from low-income families, Fredi spent many years helping youth build confidence and hope through mentoring and summer programming. She believes deeply in the power of museums, committing her time and energy to helping both local and national museums spark students' interest in science, technology, engineering, and mathematics (STEM).

Like this eBook, Fredi knows the power of what it means to inspire young women in STEM and the important role that mentors play in our lives. I am eternally grateful to Fredi for all that she is doing to advance young girls and women in STEM. Fredi's passion for STEM education is unparalleled helping young girls reach their goals, from the moon and beyond.



Fredericka "Fredi" Stevenson - On behalf of all future girls in space science and STEM, this eBook is for you.

With deep appreciation,

Carol L. O Donnell

Carol

### Introduction

### **Dr. Carol O'Donnell**

Director Smithsonian Science Education Center

**Growing up in inner city Pittsburgh** in the 1960s and 70s, I was always tinkering—designing something new and putting my "inventions" in a little notebook. I also loved observing the world around me. In my small backyard, I was always experimenting—studying native plants during the day and observing the stars at night. I didn't know much about what it meant to study science, technology, engineering, or math (STEM) back then. I just knew that I loved making, testing, experimenting, inventing, and solving problems.

In high school, I got my first job at a library as a "Page." I would put books back on the shelf when people returned them, fix books that were broken, and help people find book titles that interested them. Books played such an important part in my life. And it was through books that I was first introduced to what it meant to be a "real scientist."



#### Dr. Carol O'Donnell

I don't recall having any women scientists in my life, though. At least not until I went off to college. That's when I got my first full-time job at the Gastroenterology Lab at the university hospital. Mary Mylo was the lab's Director, and I will never forget her. Other than my mother, Mary Mylo was my first "real science mentor."

I also had another job in college working in a museum—the Carnegie Museum of Natural History in Pittsburgh. (I worked a lot back then!) The Museum had just built the Benedum Hall of Geology and the Hillman Hall of Minerals and Gems. I fell in love with the history of our planet, and went on to get a Bachelor of Science Degree in Education and a Master of Science Degree in Geosciences with a focus on planetary geology.

I loved science, and I loved teaching about science even more. I started my professional career teaching science to elementary students in Virginia. I did that for almost a decade, before I had my own four children. I also taught Astronomy for the Physics Department at The George Washington University, where I got my doctorate. I helped students learn about our solar system, study our Sun and Moon, and discover new stars and galaxies in our universe. After I completed my doctorate, I helped the university transform the teaching and learning of astronomy and physics courses so that they were more hands-on, realworld, and experiential, rather than just lecture.

I am so glad that I had these experiences when I was young. They have shaped who I am today. Now, I direct the Smithsonian Science Education Center at the Smithsonian Institution. The books and the stories of women in STEM, the STEM mentors and role models I met along my journey, and hard work—they all helped me to achieve my goals.

As a young girl, it is so important to see yourself in the role models around you and in the stories you read. Some people call this the "See/Do" theory. If you can see yourself in others, then you will believe you can do it, too. That is the purpose of this book.

I hope when you read the stories of these amazing women in space, you can "see" your future self. Then, strive to be the best you can be.

Who knows? One day, you might be like Dr. Ellen Stofan, or Noor Haj-Tamim, or Diana Trujillo, or Ashley Kowalski and "do" STEM, too.

## THE PAST



For thousands of years people have looked at the sky. They have used the planets and stars to navigate. They have charted the seasons and made calendars. They have named the objects they saw in the sky. Planets like Venus and constellations such as Andromeda and Cassiopeia were named for women. But who were the women studying the stars?

Hypatia was an astronomer and philosopher. She is considered the earliest female mathematician. Hypatia was born between 350 and 370 CE in Alexandria, Egypt. At that time women did not study math or science. Women were banned from politics. Her father, Theon, was a mathematician and teacher. He was well respected. This respect for her father gave Hypatia more freedom. She was allowed to study. Theon did not raise Hypatia to perform the domestic work that was typical of most women in Alexandria at the time. Instead, he taught her to be a scholar.





Hypatia studied hard. She dedicated her career to continuing her father's work. She helped maintain Greek writings on geometry, arithmetic, and astronomical tables. One of the most famous writings Hypatia and Theon worked on is the Almagest. The Almagest was written by Claudius Ptolemy in the second century CE. It recorded the motions of the stars and the paths of the planets. It established the geocentric model of the universe. In this model, Earth is the center of the universe and everything revolves around it. We know now this is not true, but at the time this was a very important idea. The geocentric model of the universe became the accepted belief for more than 1,200 years.

Hypatia did not just preserve other people's work. She was a mathematician and astronomer in her own right. Hypatia wrote books and essays of her own. Her most famous book is called The Astronomical Canon. Hypatia was also a popular teacher. She taught astronomy and math. Students came from all over Alexandria to learn from her. She taught students in her home and gave public lectures to crowds.

Hypatia also did mathematical analysis. She charted the movements of the stars described by Ptolemy. She also made instruments such as astrolabes. An astrolabe is a device that shows the positions of the stars and planets. Letters still exist between Hypatia and one of her students, Synesius. In the letters they discuss astrolabes. They also discuss a device called a hydrometer. Hydrometers measure the density of liquids based on buoyancy, which is their ability to float.

When you consider that she worked in the fourth century CE, Hypatia's work is well documented. She is one of the earliest female scientists to be written about. She was written about by people who lived at the same time as her and people who lived later.

Her work is recorded in letters from her student, Christian historians, philosophers, and Islamic scholars in the Suda. The Suda is a 10th century Byzantine encyclopedia of the ancient Mediterranean world.

In her lifetime Hypatia was the world's leading mathematician and astronomer. She died in 415 CE. She was killed by a mob that disapproved of her pagan philosophy and the fact that she lectured in public. About 10 years after her death a church historian named Philostorgius wrote that Hypatia "was so well educated in mathematics by her father that she far surpassed her teacher, and especially in astronomy, and taught many others the mathematical sciences." Hypatia had a lasting impact on research in astronomy and mathematics, and she paved the way for other female scientists and educators.





For a long time, people with disabilities have had a hard time being accepted into public life. The Americans with Disabilities Act was passed on July 26, 1990. Before it passed, people with disabilities could be barred from many things. They could be denied jobs. They could be blocked from using public transportation. And they could also be denied entry into schools.

There were many people who fought against this mistreatment. One of those people was Alverna Williams. She was the first American with a disability to get a pilot's license. It was a long fight. But she was able to reach many heights in her career and inspire others to do the same.

Alverna was born on September 3, 1918. She was raised in the small town of Farrell, Pennsylvania. When she was thirteen months old, Alverna and her aunt got into a car accident. This accident caused Alverna to lose both her legs. She was given her first pair of artificial legs when she was two years old. But she felt more comfortable using her hands to move around. From then on, she got rid of her artificial legs and used her hands.





This new reality did not stop her from doing the activities she loved to do. Alverna was an active child. She played baseball. She was a swimmer. And she got involved in tap dancing. As Alverna got older, her mother supported her interest in the entertainment business. Alverna started performing at local carnivals as a teenager. Then she got the opportunity to tour with the Ringling Brothers Circus across the United States. She started as an acrobatic dancer and trapeze artist.

While there, Alverna met her soon-to-be husband, Louis "Speedy" Babbs. He raced motorcycles and did aerial tricks. She soon became interested in doing those acts. They got married in 1936. Then they went on tour together. Alverna would perform tricks like riding on the handlebars of a motorcycle on treadmill rollers.

To assist with her needs, Speedy rebuilt a car so she could drive it. With the success of their act, Alverna wanted to aspire to something even higher. She wanted to fly. Alverna took a class on aeronautics in 1942 at Youngstown College. For their anniversary, she and Speedy bought a plane they nicknamed "Seventh Heaven." Alverna was able to learn all aspects of how to operate a plane. She came one step closer to her dream of becoming a pilot. But problems would soon arise.

Alverna got her radio license. She learned proper techniques and hand controls of the plane. She got many letters of recommendation. She completed more than 45 hours of dual time. That means she flew the plane along with a flying instructor. And she passed her physical exam. But the Civil Aeronautics Administration (CAA) would not give her the waiver she needed to get a student permit. She was not able to do a solo flight.

She was determined not to give up. In 1944, she wrote to Roscoe Turner. Roscoe was a famous pilot. He was also president of the National Aviation Trades Association. After she explained her issue with the CAA, he agreed to help her. Alverna then wrote to the CAA asking why they denied her permit. They told her she did not put in the work required to fly the plane. The CAA said it was the plane's special mechanics that was flying the plane, not Alverna.



In July 1944, Roscoe wrote to the CAA and told them he was unhappy with their decision. He also told them that he or his associates would be at a hearing about this issue. In September, the CAA added new rules that helped Alverna and others like her who want to pursue aviation. With Roscoe's help, she was able to get her permit and do her solo flight.

Alverna completed her first solo flight on October 30, 1944. In 1945, she flew round trip from Jacksonville, Florida, to Pomona, California. Alverna got her pilot's license in 1946 and got a waiver to be able to take the commercial pilot exams.

For 30 years, she took a break from flying. In the 1970s, Alverna decided to come back to the activity she enjoyed most. She joined the Ninety-Nines in 1973. The Ninety-Nines is an organization that was founded in 1929 by women pilots. It was created to highlight women pilots and encourage more women to fly.



In 1977, she participated in the 30th Anniversary Powder Puff Derby Commemorative Flight. She had a hard time getting sponsors. They did not like her disability or appearance. But this did not stop her drive. Alverna was able to raise money with the help of family, friends, and other pilots. She was unable to do the flight solo because of plane issues. So she completed the flight with Suzanne "Sue" Parrish. Sue was a fellow pilot, and they became lifelong friends.

After the flight, Alverna got much praise and honors. She soon met Geraldyn "Jerrie" Cobb. Jerrie was a pilot and did humanitarian work in South America. Alverna went with Jerrie on one of her flights to South America. They went to provide medicine and supplies to areas in the Amazon. Alverna continued to be awarded for her work. She was honored by the Wheelchair Association. She was named Lady Ercouper of the Year. An ercoupe is a type of small plane. And she was mentioned in the Congressional Record in December 1977. Alverna was a member of many pilot organizations, including Silver Wings, Ercoupe Owners Club, and Aircraft Owners and Pilots Association.

Alverna passed away on March 7, 2007. She did not view her disability as a setback. She continued to follow her dreams. She believed that if she could do something, anyone can do it. This is a good message for women and girls in the past, present, and future.



Patti Grace Smith was born in Tuskegee, Alabama, on November 10, 1947. Tuskegee was famous for the Tuskegee Airmen. They were the first African American military aviators in the United States. They flew during World War II. After World War II there were still hardships and prejudices in Alabama and throughout the country. Patti grew up in Alabama during segregation. There were laws know as Jim Crow laws. These laws forbid Black people and white people from visiting the same public places. Places such as parks, libraries, restaurants, and schools were white only or Black only. This was difficult for a young Black woman like Patti.





Patti's parents were first-generation college students. They told her not to let anything hold her back. They encouraged her to pursue whatever she wanted. So, with the support of her family, Patti fought against racism to better her education. In 1963, Patti and her sister joined 10 other students to sue the Macon County Board of Education. At the time, only white students were allowed to attend Tuskegee High School. Patti and the other students wanted to force integration. This would allow Black and white students to attend Tuskegee High School together.

The Alabama governor fought hard against Patti and the students. But he was unsuccessful. Patti and the students won. In 1967 the federal district court ruled that schools must be desegregated. Patti's case not only integrated Tuskegee High School but all of Alabama's primary and secondary schools, two-year postsecondary schools, and public universities. This ruling was later upheld by the Supreme Court of the United States. Later in life Patti said that this case was when she learned to overcome limits imposed by others. Patti was a great student. She graduated from high school a year early. Afterward she went to college at Tuskegee Institute, which is now called Tuskegee University. While in college, Patti continued her fight against injustice. She was part of the Student Non-Violent Coordinating Committee (SNCC). SNCC was a human rights organization founded in 1960. It was made up of students in the civil rights movement. Patti participated in many of SNCC's voter registration campaigns in Alabama. Patti graduated with honors in English in 1969. It was the same year Apollo 11 landed on the moon.

After graduating, Patti pursued a career in broadcast journalism. That brought her to the East Coast. Patti worked for a radio station and a TV station. She then took a job with the National Association of Broadcasters. Working in Washington, D.C., would change the course of Patti's life and career. It was here that she transitioned to working in the federal government. Patti worked for the US Senate Commerce Committee, the US Department of Defense, and the Federal Communications Commission (FCC). She took on more responsibility with each role.



Working at the FCC and the Defense Communications Agency introduced Patti to the field of aerospace. Her interest in aerospace grew. She began to focus on communications satellites. Communications satellites are used for television, telephone, radio, Internet, and military applications.

After a while Patti moved to the US Department of Transportation and joined the Office of Commercial Space Transportation. She rose to the position of chief of staff. As chief of staff, Patti reported to the director. She solved problems behind the scenes before bringing them to the director. In 1995 the Office of Commercial Space Transportation was moved to the US Federal Aviation Administration (FAA). The FAA regulates civilian aviation. It oversees air traffic control, certifying people and aircraft, setting standards for airports, and protecting US assets during the launch or reentry of commercial space vehicles. Patti was named the head of the Office of Commercial Space Transportation. She also became an associate administrator of the FAA.

Patti worked at the FAA for 11 years. While there she oversaw licensing and regulating the commercial space industry. Under Patti's leadership Mojave Air & Space Port in California became the first licensed inland spaceport. That meant for the first time a commercial company could launch people into orbit. Patti oversaw the first private human spaceflight and the launch of the first privately developed rocket, SpaceX's Falcon 1.

Patti did not only work on regulations for the commercial space industry. She helped make human spaceflight safer for private companies and the government. She helped develop rules for human spaceflight. These rules are now followed by countries around the world. Patti also helped make launches safer. She and her office worked with the US Air Force on common launch safety standards.

Patti retired from the government in 2008. She did not stop working though. She became a consultant for aerospace companies. She also worked with nonprofits and charities, served on boards, and was an advisor. In



2012 President Barak Obama appointed Patti to the Board of the National Air and Space Museum. He and NASA Administrator Charlie Bolden also appointed Patti to serve as chair of the Commercial Space Committee of the NASA Advisory Council (NAC). At the time, Patti was one of only two people of color and only three women on the NAC.

Patti died June 5, 2016, but her legacy lives on. People remember her passion for aerospace, the value of education, and her fight to support people of color. She has been honored with awards and had awards named in her honor. In 2020 the Patti Grace Smith Fellowship was created. The fellowship provides paid internships and executive mentoring for Black undergraduates in aerospace. In four years, the fellowship has helped 141 young people take a step closer to fulfilling their dreams of careers in aerospace.



### Dr. Ellen Ochoa

#### **Dr. Ellen Ochoa**

It was small step for a young girl, but the beginning of a big leap for Latina women in the space industry.

Born and raised in Southern California in 1958, Ellen Lauri Ochoa was one of five children and the granddaughter of Mexican immigrants. When she was in the fifth grade, a simple classroom activity shaping pipe cleaners into the double helix of DNA sparked a lifelong interest in science and math. But it wasn't until Ellen took calculus in high school that a path to becoming an astronaut began to open. Her teacher made the subject fun and exciting, but most importantly, he believed in her and helped give her the confidence to keep exploring math in college.

Neither one of Ellen's parents had a college degree, but they saw their daughter's talent and encouraged her take her passion for math to San Diego State University. Although many subjects and interesting careers involved math, there were very few women and Latinos in those fields at the time, and some professors struggled to understand why she was even interested in



#### Dr. Ellen Ochoa

such a "difficult" field. But one professor was happy to support her, and that was all she needed. He told her math is the language of physics, so why not study that?

After graduating with a degree in physics, Ellen began a doctoral program at Stanford University. Then everything changed when Sally Ride became the first American woman to fly into space. Ellen applied to be an astronaut at NASA the moment she finished her PhD. She was not accepted, but that only motivated her to keep exploring space and science on Earth as an engineer for the Department of Energy, Sandia National Labs, and the NASA Ames Research Center. At NASA she worked inventing new tools for space shuttles and rovers, but Ellen was also learning how to fly a plane and earned her pilot's license.

In 1990, NASA chose Ellen for their astronaut program, and in 1992, she became the first Latina woman to go into space. Looking down at Earth from the space shuttle Discovery, Ellen was struck by the connectedness of everything, from the atmosphere, land, and ocean to the



power of people working together to accomplish great feats like reaching the stars. She returned to space many times, working on the International Space Station and logging more than 1,000 hours in space.

When Ellen was new to NASA, her coworkers did not always consider her for promotions. It was not common for a woman to lead engineering projects. But by 2012, and after leading many successful missions, Ellen was chosen to lead the NASA Johnson Space Center, becoming the first Latina and second female director in its history.

Today, Ellen is retired and devotes her time to encouraging young people across America to explore science and math. And her name won't just live on in history books. Seven schools are named after her and her books for kids about space are in classrooms around the world.

## THE PRESENT



Dava Newman grew up during the height of the Apollo program in the 1960s. She remembers watching the broadcast of Apollo 11 from her home in Helena, Montana. Apollo 11 was the first mission to land people on the moon. Even at five years old she found it inspirational to see the moon landing. It opened Dava's mind to human space travel.

Dava had examples of scientists in her family. Both her mom and dad were trained as teachers, and she credits her parents with her desire to be a teacher herself. Her dad was also a private pilot, which influenced her future aerospace engineering career and passion for exploration.

Growing up, Dava loved school. She liked all the subjects, and didn't decide that she would end up pursuing science and engineering until after high school. When applying to colleges, Dava wanted a technical education but in a liberal arts environment. So she looked for a school that had both, and found Notre Dame. Dava attended Notre Dame, where she graduated with a degree in aerospace engineering in 1986.



After graduation Dava continued her studies at Massachusetts Institute of Technology (MIT). Dava attended MIT to pursue a master's degree in aeronautics and astronautics. She was also an athlete and loved all sports. She had played Division 1 basketball at Notre Dame and was so good at ski racing that she competed in the Junior Olympics. Her athletics began influencing her academics while in graduate school. There she found people with similar interests. They were studying astronaut performance in extreme environments. Dava focused the main part of her master's degree work on astronauts' short-term memory and some of their anthropometrics. Anthropometry studies the physical measures of a person's size, form, and physical capabilities. She also developed an interest in public policy. During one of her classes, she was introduced to the Technology and Policy Program. So, from her second semester at MIT Dava was a dual master's student. She pursued both an aerospace engineering and a policy degree.

During the summers Dava worked for Boeing. She loved spacecraft and aircraft but didn't know if she was going to



spend her career in spacecraft design. When she started her doctoral work, Dava shifted her focus of study. She moved to more interdisciplinary study with a degree in aerospace biomedical engineering. Dava studied human performance, applying her engineering expertise to physiological musculoskeletal problems. She took some Harvard-MIT health, science, and technology courses. This enabled her to learn more about physiology, muscles, and bones. She completed her doctorate in 1992.

Dava's career has been as interdisciplinary as her education. Today, Dava is the director of the MIT Media Lab, Apollo Program Professor of Astronautics, and MacVicar Faculty Fellow in the Department of Aeronautics and Astronautics at MIT, and a faculty member in the Harvard-MIT Program in Health, Sciences, and Technology. She is a researcher, innovator, teacher, and mentor.

Dava has served as principal investigator on four space missions. She developed experiments that measured the dynamics of astronaut activity on the space shuttle, the Mir space station, and the International Space Station. Dava's overarching goal in her research has been assessing human performance across the spectrum of gravity. She studies astronauts in zero gravity as well as people in Earth's gravity. She works on biomedical devices and applications for human movements such as walking. Dava also studies climate and Earth systems from space. Her latest research includes Earth Speaks. Earth Speaks is an open-source platform of curated space data. It applies artificial intelligence (AI) to help regenerate Earth's oceans, land, and climate.

Dava has made many engineering innovations. She has developed four space suits for intravehicular and extravehicular activity in space and has broken new ground in studying astronaut motion. Dava's most famous innovation is BioSuit. It is a "second skin" space suit that allows astronauts greater flexibility while providing the pressure needed to function well in a lowgravity environment. It is meant for future moon and Mars exploration, but also has other possible uses.



The BioSuit could be used as an assistive device for people with long-term challenges. It was recognized as a 2007 TIME Best Invention and was exhibited at the Metropolitan Museum of Art's Superheroes show from May to September 2008.

Dava has also continued pursuing her interest in policy. From 2015 to 2017 she served as NASA deputy administrator. Along with the NASA administrator, she was responsible for the agency's vision, leadership, and policy direction. She was the first female engineer to serve in this role and was awarded the NASA Distinguished Service Medal. This representation is important to Dava.

When Dava joined the faculty at the Aeronautics and Astronautics Department at MIT, it was made up of 35 men and her. Dava's faculty mentors were critical in her development, especially at the doctoral level. They were one of the main reasons that she became a university faculty member. After benefiting from mentorship, she wants to help students find their own voice. As an MIT faculty member, the students can challenge Dava, and she challenges them, and they come up with ideas and solutions that may be better than anyone would have developed on their own.

Dava was never taught by a female engineer. She did not see this as a deficit and has learned a lot from male mentors. But not having a female professor fueled her passion to be a role model and to make sure girls know that aerospace engineering is a career for girls and boys alike. She thinks science and engineering are not the domain of any one gender and that putting together men and women and diverse people of all types really helps us come up with different engineering solutions.

Her BioSuit research is one example of that. For the first time in space suit technology there's a female suit and a male suit. She has found young girls are so excited about this spacesuit because there is a spacesuit for females now. It makes a great connection with them. Dave is very dedicated to outreach efforts and trying to inspire future astronauts, engineers, and scientists. She hopes her work inspires and lets kids dream.



"I used to clean houses. Today, I'm trying to find out if there's life on another planet," says Diana Trujillo. People might not see how cleaning houses as a young person in college can one day lead to trying to find life on another planet. But Colombia native Diana Trujillo proved to the world that all work is important and valuable and opens doors to new places—including space.

Diana was born in 1980 in Cali, Colombia, a place that was sometimes unsafe due to crime. Looking at the stars, she wondered if there was somewhere in the universe where life was different. Her mother, who studied medicine but left to take care of Diana after she was born, kept Diana safe and supported her daughter's bright mind from the beginning. She enrolled her in a bilingual school and encouraged Diana to ask why girls couldn't be as interested in science as boys.





Diana wanted to play with engineering toys and study the field just like they did. But she needed to be in a place with more opportunities for young women like her, where she felt safer. So when she was a teenager, she came to the United States with only \$300 and a desire to earn a science degree and study English more, while working as a housekeeper to support herself. Eventually she was accepted to the University of Florida.

While studying at Florida, Diana became interested in aerospace. She decided to apply to a leadership program and soon made a groundbreaking achievement, not just for her, but for many women like her. She became the first Latina immigrant woman accepted to the NASA Academy, a leadership program at the agency for college students. Later, she was one of only two people from that competitive program who were offered a job at NASA Goddard Space Center and the Jet Propulsion Laboratory. She continued her studies at the University of Maryland, working as a research assistant and earning her degree in aerospace engineering.

Something as seemingly small as dust on a rover's tools could ruin an entire mission in space. Diana's team at NASA was determined to find a solution that would allow robots to gather samples on distant planets safely. In 2009, Diana saw her team's work pay off when their Dust Removal Tool was applied to the Curiosity rover on Mars, ensuring we could study the landscape of the red planet. Soon, she would be responsible for communications between the rover and Earth. She would become a flight ground engineer and eventually a flight director at NASA, engineering missions to explore space through rovers and satellites. Her

The journey to become the first Latina woman in so many parts of the space industry was not easy for Diana, but she is determined to make it easier for the women and Latinos who follow in her footsteps. She became a founding mentor of an organization that provides internships and experience to women and genderminority students studying aerospace. Her legacy at NASA will also be bilingual. She rallied NASA and fellow Latino collogues at the agency to make many important NASA missions, resources, and programs available in Spanish, like the live broadcast of the historic landing of the Perseverance rover on Mars. From kids across Latin America to her own grandmother in Colombia, now millions of people can understand and explore the wonders of space too.





When Ellen Stofan was a young girl, she loved rocks. Her family had a summer cottage on a lake in Michigan. She loved nothing more than to wander the shores picking up pieces of fossilized coral. These coral pieces are called Petoskey stones. They tell the story that millions of years ago that area of Michigan was a saltwater sea. Then the corals were broken up by glaciers and left on the shore of the lake. Ellen loved that the rocks told stories. When she was around 12, she learned what a geologist was. She thought that is the career for her.

Ellen's parents and teachers were very supportive of her desire to be a scientist. She could look up to her parents in this way. Her father was an engineer at NASA and her mother was a science teacher. Ellen had a grade school science teacher who saw how interested she was in science. She gave Ellen harder work to challenge her. This helped nurture Ellen's interest.

Ellen also liked reading. She read everything she could about science and scientists. But she found it very frustrating that there were so few stories about women scientists.



She turned to the pages of National Geographic. There she read stories about women like Jane Goodall and Mary Leakey. They showed Ellen that women could be excellent scientists and do important work around the world.

After high school Ellen went to the College of William and Mary in Virginia to study geology. Even with a supportive family, teacher, and undergraduate professors there were still difficulties. She was teased and called a nerd, and some people called her "rocks" as a nickname. Ellen was able to shrug it off. She did love science and she thought "rocks" was funny. The teasing did not deter her. She continued her studies and earned her master's and doctorate degrees from Brown University. Ellen's thesis was on the geology of Venus.

After completing graduate school Ellen went to work. It wasn't until this first job that Ellen really felt she was being treated differently because she was a woman. She was frequently the only woman in a room. She saw work colleagues clearly question whether she belonged. She was talked over by men in meetings, and sometimes saw her good ideas ignored until the same thing was suggested by a man. Ellen credits her early supportive environment for



her ability to persevere. She knew she belonged and that she could contribute. But she felt she had to work three times harder than the men to be taken half as seriously.

Ellen persevered. She went to the NASA Jet Propulsion Laboratory in California to work on the Magellan mission to Venus. Magellan was the first mission to take images of the entire surface of Venus. She was one of the first people to look at the surface of this other planet. She found this very exciting. After Magellan ended, Ellen worked on a radar instrument that flew on the space shuttle twice. She also worked on the New Millennium Program, which introduced new technology into NASA science missions.

Ellen then moved to London for her husband's job. While there she worked at University College London. That gave her the opportunity to continue her research on volcanic features on Venus, Earth, and Mars. She also joined the NASA Cassini mission to Saturn.

The Cassini mission became Ellen's favorite mission. She worked on a radar instrument that studied Titan, Saturn's largest moon. Titan is the only moon in the solar system that has a significant atmosphere. Titan is so far out in the solar system that it has frigid temperatures. Yet it is the only place in the solar system where there are open bodies of liquid, with waves and river deltas. Ellen loved the team she worked with on the Cassini mission. She found the scientists on the radar team were very fun. They loved working together, debating ideas to come up with better interpretations of what they were seeing from the instrument. Ellen also thought it was fun to be an armchair explorer. Every pass of Cassini would reveal some new geology on the surface of Titan. The team used radar to discover lakes and seas at the north pole of Titan. They discovered that the seas are made of liquid methane and ethane—basically gasoline!

Ellen's career path has not been a straight line. She was chief scientist at NASA from 2013 to 2016. In this position



she served as the principal advisor to former Administrator Charles Bolden on NASA's strategic planning and programs. For her work as NASA chief scientist, Ellen received the NASA Distinguished Service Medal. She counts this time as something she is most proud of. She got to work with a personal hero, Charlie Bolden, on fun and challenging projects. They studied how to get humans to Mars and supporting NASA's mission to study climate change.

As a planetary geologist Ellen believes the goal of planetary geology is to understand Earth. By comparing the geology of other planets to Earth, we can better understand how geologic processes shape Earth. We can study volcanoes on Venus, buried glaciers on Mars, the atmosphere and seas of Titan, and compare how the physics of these processes differ on other planets. Having multiple planets to study enables us to test and push our ideas.



In April 2018 Ellen joined the Smithsonian as the John and Adrienne Mars Director of the National Air and Space Museum. She was the first female director of the museum. In March 2021, she became the undersecretary for science and research at the Smithsonian. She oversees its science research centers and the National Air and Space Museum, National Museum of Natural History, and the National Zoo and Conservation Biology Institute. The Smithsonian Libraries and Archives, Smithsonian Scholarly Press, and Scientific Diving Program also report to Ellen. Her focus is on the Smithsonian's Our Shared Future: Life on a Sustainable Planet initiative and collective research, especially in areas of biodiversity, climate change, global health, sustainable communities, and environmental justice.

Outside of work Ellen enjoys spending time doing needlepoint, gardening, and downhill skiing. She also loves playing with her black lab Juniper! Ellen believes in wellrounded scientists. She thinks the arts are incredibly important to making a good scientist. To be a scientist, you need to be a good writer, a good communicator, and able to think creatively. These are all skills you get from a liberal arts education. Of course, you still need lots of science courses. Ellen had a minor in art history in college. She knows scientists who are musicians and even one who is a ballerina.

As the undersecretary for science and research at the Smithsonian, Ellen promotes the Smithsonian mission to increase and diffuse knowledge. This includes setting an example for girls to see themselves as scientists. Ellen identifies with Marion Wright Edelman's quote: "If you can't see it, you can't be it." She felt that early in her life when she had to search hard for stories of women scientists. Now she wants every girl to see that she can accomplish anything she sets her mind to. Having women run major museums, lead NASA missions, pilot aircraft, and run companies shows girls the sky is not the limit.



Since she was a child, Lama Al Oraiman had an interest in seeing what exists beyond our world. This interest led her to becoming a mechanical engineer. Now, Lama has reached so many heights at a young age. At 24 years old, she is the founder and CEO of two companies. Both her companies, Ignition Kuwait LLC and BLUDOT, focus on space technology. While she is living out her dream, it was not an easy journey.

Lama grew up in Kuwait. As a child, she had a curious mind. She would look up at the sky and wonder what it was like in the rest of the universe. Lama comes from an artistic family. Through her interest in art, she loved to design things. She wanted to combine her creativity and her love of science, technology, engineering, and math (STEM) into a career. But this was a challenge. She was the only person in her family who was interested in STEM. Lama had a hard time convincing her father that girls can study to be mechanical engineers. "It's hard to break through and give them the mindset or change their mindset," Lama said. "It was difficult to do that in the first place. But because I did it well, I was able to change their minds about it."



But there was another hurdle she had to face. It was changing the mindset of her society. Kuwait does not have a space agency or space programs. Growing up, Lama says there were no space or astronomy classes in school. This made it hard for her to learn more about those subjects. And she was often discouraged from pursuing them. "When I got into school, I was a little bit disappointed," Lama explained. "I was told that's not realistic. I shouldn't be focusing on that, since they're not teaching me that in the first place. And there's no future for such a thing."

As a teenager, she realized she had to look for her own opportunities. She went to American University of the Middle East. Lama studied mechanical engineering. In her program, she learned how her field of study closely ties in to the space sector. She also learned that there are more mechanical engineers in space agencies than there are people with a space background. This gave Lama more of



the push she needed to reach her goal of working in the space industry.

She searched online for international opportunities to learn more about the space sector. Lama soon ran across the Space Generation Advisory Council (SGAC). The council is a nonprofit organization based in Austria. Their goal is to help people around the world learn about space and get them working in the space sector. Lama was selected to be Kuwait's national point of contact on the council. Joining the SGAC opened a new world for Lama. She was able to explore her love of space even more.

"It was fun. I did not have any expertise at this time. I was learning as I go," Lama said. "I tried to pick up on it to become a fast learner. I jumped on so many opportunities after that helped me reach an international level."

Lama was able to travel to many places, including Germany and the United States. She was put on the United Nations Committee of SGAC at 19 years old. She gave a speech at the United Nations. Her speech was translated into seven languages. Lama talked about how important it is to have a space industry in growing space countries. She also talked about how the space industry is needed in places where it has not yet been created. This will give those countries the chance to create a space program if they choose. "The day that I gave that speech, so many people came up to me. They gave me so many opportunities. I'm just so grateful for that," Lama said.

She met many people while she was a part of the council. One of the people she met was astronaut Sandy Magnus. Lama met Sandy at a space conference in Germany. Since then, they developed a close friendship. Lama says Sandy's guidance and down-to-earth nature have been helpful in the growth of her career.

Lama now plays a big role in the space sector as a mechanical engineer. "Mechanical engineers basically make things move," Lama said. "We work on many parts. The field I'm focusing on is designing." She is most interested in building rocket engines. This is where good design comes in. The materials for the rocket need to endure different—sometimes extreme—environments. Factors like orbits, motion, and atmosphere conditions go into this. This is a big part of what mechanical engineers study.

Lama wants this and other aspects of space taught in schools in Kuwait. While there is an interest in STEM, space technology is not a priority. Lama says there are more women graduating with STEM degrees than men. She believes this would be a good opportunity to expand on the growing interest in STEM. Through her work and high profile, Lama has met with the Prince of Kuwait. He praised her for her success and expressed interest in her goals. She hopes this inspires the country to have its own space agency.

"Young people are studying space now," Lama said. "I was one of the people that changed the curriculum to involve space and the latest space technology. I can see that drastic change, the way that people are being receptive." She is using this growing interest to connect the youth to learn more about space.

Lama always dreamed of having her own space agency. But she decided to start her own business instead. She founded Ignition Kuwait LLC in 2020. It's a nonprofit aimed at creating Kuwait's first space program. Lama wants other young people to have their own startups. These startups would be a good way to push for space technology. She also believes this would be a good way to push the government into creating a space agency.

But Lama believes a big barrier to this is getting to know the right people. This became more real when she tried to create her own cube satellite to send into space. "I realized I have to travel to so many countries and waste so many hours just to get one deal or two deals done," Lama said. "It's hard to get access to such companies because you always need connections."

Lama created BluDot to fix this issue. BluDot is an app that helps you build your space mission. It connects you with people and services in the space sector. There is also an educational part to the app. It gives aspiring astronauts a space where they can unlock missions and work on experiments. BluDot is in the testing phase. Lama says she has received good feedback so far.

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Her goal is to see a future where everyone will be able to send anything to space.

In her free time, Lama enjoys swimming. She has been swimming since she was a child. It is her favorite sport, and she does it every day. Lama is also a photographer. She uses her telescope to take pictures. She volunteers at schools and invites students to use the telescope as well.

Lama has had many successes so far, and she continues to strive for more. The main advice she gives to women and girls interested in STEM is to just go for it. She also encourages them to be around people who support you. "When I started it was difficult. But today I have so many people loving me and appreciating me," Lama said. "I always say that when you find an opportunity, seize it. I think this does not only apply to space. It applies to so many things in life."

## THE FUTURE



One Halloween, Katya Echazarreta's phone lit up with notifications. Only a few months before, she had become the first Mexican-born woman to travel to space, and now Latino parents were tagging her in photos of their young daughters dressed up as astronauts. As she admired the photos, something caught her eye. The little girls had patches on their space suits with a name on it, but it wasn't their name. It was hers: KATYA ECHAZARRETA.

Katya's path to space and becoming a role model for millions was not easy. She was born in Guadalajara, Mexico, in 1995, and moved to the United States when she was only eight years old. She didn't speak English, and sometimes kids teased her about it. But she studied hard and learned the language quickly, and soon she could tell people hundreds of facts about her favorite planet, Mars, in perfect English.





Even though she knew building blocks and toy racetracks are not usually made with girls in mind, she wanted to learn how to put things together. Toward the end of elementary school, she got her first computer. But it was in parts, so he had to put the pieces, like cables and circuits, together with the help of her parents. They saw that she loved learning about how things worked.

High school was challenging for Katya. Her family went through tough times. She had to work multiple jobs to help them pay for everyday things. At the same time, she began her first physics and calculus classes. Mastering these subjects did come easily to her, and sometimes her teachers noticed that the stress at home made it even more difficult. She did not get good grades right away. But to her, it was so beautiful to finally find something so interesting, even if it was challenging. She knew she wanted to explore the world of science and math for the rest of her life. People like her physics teacher and her mother supported her every step of the way. To save money and help her family, after high school Katya attended a local community college. She did so well that she received a full scholarship to her dream school, the University of California in Los Angeles, to study electrical engineering. This led to a summer internship at the NASA Jet Propulsion Laboratory, where she learned that having people from different backgrounds helps us look at problems in new ways and find creative solutions.

Her experiences at NASA motivated her to keep dreaming big, and there was no dream bigger than exploring space. She applied to join a mission called the Overview Effect that would analyze how experiencing space and our place in it affects the way we see things. In June 2022, she was selected for the mission out of 7,000 applications.

Fewer than 800 people have been to space. Looking down at Earth, Katya was amazed. She joked after that she wished she had beautiful thoughts and bits of wisdom, but the view from blue orbit made her feel more human, with many emotions, and even a little sweaty! After she landed, she thought about how we should love one another more because we are all neighbors in this one very special place in the universe.

Today, Katya frequently talks about her mission to inspire young people, and is getting a doctoral degree in aerospace engineering from John Hopkins University. And she is technically still in space, because she beams down to Earth from communications satellites every week as the star and cohost of many science TV shows.





Ashley Kowalski's story is a great example of how your future can be determined by your curiosity and determination today. Ashley grew up in a family with no specific connections to the STEM community. Her parents, immigrants striving for a better life, enrolled her in an all-girls high school. This school offered a great education, but there wasn't really an emphasis on STEM. Even so, she had several exceptional math teachers who noticed her talent and pushed her to pursue additional studies in math and engineering after high school.



Ashley followed those words of encouragement to explore math, engineering, and science in college, which led her to eventually pursue a mechanical engineering degree. One of her favorite experiences was a freshman year project—disassembling and reassembling various tools such as electric screwdrivers. This work ignited her passion for hands-on engineering. There was something mesmerizing about knowing how things worked and how to fix them, and this marked the beginning of her career in engineering.

In addition to her focus on engineering, Ashley explored a diverse set of non-traditional STEM experiences, from participating in math competitions to exploring drama and sports.





These activities, supported wholeheartedly by her parents, fostered a well-rounded skill set—from teamwork and strategic thinking to effective communication and confidence—that would later prove invaluable in her career. Ashley's path was not without obstacles; she often felt an academic step behind her peers, requiring extra effort to keep pace.

As Ashley advanced in her career, she navigated through various STEM interests, from fluid dynamics simulations to aerospace engineering, before finding her niche in international space partnerships. Her work making sure the technical expertise is being properly understood during international collaborations underscores the importance of a diversity of experiences in STEM fields.

One of Ashley's most significant achievements was her participation in a NASA analog simulation in Moscow,

simulating long-duration spaceflight. Her team of five spent months in isolation, grappling with problems such as confined living quarters and simulated emergencies that were all designed to prepare humans for future longduration space travel. This challenge not only tested her technical skills but also her psychological endurance and knowledge of how best to navigate team dynamics. Ashley noted that it was a profound testament to her capabilities and a step forward in her aspirations toward space exploration.

Ashley's journey is a symbol for those who may feel out of place in the world of STEM due to their background or interests. Her successes and challenges illustrate that passion, curiosity, and resilience can pave the way to groundbreaking achievements and open new avenues for future scientists and engineers who are ready to explore the universe.

Noor Haj-Tamim's journey from a young Palestinian girl staring up at the stars, translating for her non-Englishspeaking parents, to becoming the executive director of Jordan Student Space Outreach and Academic Relations (JSSOAR) and a private science astronaut candidate is nothing short of remarkable.

Born into a family that believed in the power of education, Noor's early experiences in the United States set the stage for her future ambitions. Her parents, immigrants themselves, instilled in her the importance of education and determination, overcoming language barriers and financial challenges to achieve their own educational goals.





Her mother is a perfect example of this, as she went to school to learn English and then eventually became a teacher herself. These role models of resilience and determination were pivotal in shaping Noor.

Noor's passion for science and the stars started at a very young age. From seeing her first meteor shower and thinking of the potential for life on other planets, to painting the sky and stars in her free time, she's always been captivated by space. As a young woman interested in science, life wasn't always easy. There were times when she was excluded from conducting experiments, participating in a robotics club, or even stepping into a lab. This didn't deter Noor. She kept asking, she kept pushing, and kept working hard. Her passion translated into a focus on science in college, where she graduated early from Arizona State University with a degree in mechanical engineering. Afterward, she pursued a master's degree in mathematics while simultaneously working toward an airline transportation pilot license. These accomplishments prepared her for her work with the International Institute for Astronautical Sciences. Her focus on flight test engineering enabled her to further align her career goals with her passion for space science and exploration. Now, instead of being excluded from the laboratories, she's running them.

JSSOAR is a nonprofit that is now being led by Noor. JSSOAR serves Jordanian students and is dedicated to promoting space and STEM education. Through Noor's

leadership, JSSOAR is paving the way for underserved communities to participate in real-world space and Earth-related experiments. This initiative taps into Noor's own experiences as a young female scientist, but also fosters scientific curiosity among students, with the goal of launching Jordanian students' experiments into space.

The L'SPACE Program, another element of Noor's work, offers students unparalleled exposure to NASA mission procedures and hands-on project experience,



further confirming JSSOAR's commitment to cultivating future leaders in the aerospace industry by making the science approachable and accessible.

Noor's story is an example of overcoming adversity, a relentless passion for science and space, and the power education has to change a life. As the first and only Palestinian with the International Institute for Astronautical Sciences and a symbol of hope for aspiring space enthusiasts in Jordan, she embodies the spirit of perseverance and the relentless pursuit of one's dreams. Noor is not just reaching for the stars she's paving the way for the next generation of explorers.



### Your Identity Map

In this eBook you have learned about scientists who study and work in space. Each of the scientists has a unique path in their career and a unique identity. Our different experiences, backgrounds, and ideas give each of us a unique identity. Your identity is what makes you, you.

Our different identities often lead to different perspectives. Perspectives are the ways we think about the world around us. Understanding your own identity and perspectives can help you understand other perspectives. This activity will help you think about your own identity. Could you be part of the future of a space field?

### **Your Identity Map**



- Take out a piece of paper and title it "Identity Map."
- 2. On the paper, write your **name** in the center of the page or draw a **small picture of yourself**.
- 3. Draw a circle around your name or picture.
- 4. Answer the question, "Who am I?" or, "What describes me?" The list below can give you some ideas to consider, but you choose what you want to include. You can also include things that are not on the list. Record anything you can think of that is important to who you are.
  - Age
  - School or class
  - Race and/or ethnicity
  - Gender
  - Country or place where you live

- Groups you belong to
- Country or place that is important to you or your family
- Ideas or beliefs that are important to you
- Topics or subjects that interest you
- Hobbies or things you like to do for fun
- Physical traits (such as tall, black hair, blue eyes, wears glasses)
- Personality traits (such as loud, funny, sad, kind)
- Roles you have in your household (such as big sister, helper, cousin)
- 5. Write each answer on the page around your name. Draw a line between your name and each answer.
- 6. **Share your Identity Map** with family and friends to find out what you have in common.

Explore cosmic images up close and welcome them into your living room via Instagram augmented reality experiences. Snap a selfie with the Helix Nebula or share a video of the Vela Pulsar in your backyard with friends! Scan the QR code to learn more or visit the Smithsonian or Chandra Instagram accounts on your mobile device and tap the three stars icon to find the effects!



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