Making their mark
a celebration of women in astronomy
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inside the issue

“I live and work with three basic assumptions: 1) There is no problem in science that can be solved by a man that cannot be solved by a woman. 2) Worldwide, half of all brains are in women. 3) We all need permission to do science, but, for reasons that are deeply ingrained in history, this permission is more often given to men than to women.”
— Astrophysicist Vera Rubin in Bright Galaxies, Dark Matter

In this special issue of Sky’s Up, we are celebrating the significant contributions and discoveries women have made in astronomy and related fields. The individual stories that unfold over the following pages are ones of achievement and challenge. They are the stories of women who have made their mark — like Cassini Project Scientist Linda Spilker or SETI co-founder Jill Tarter — and women who are just beginning their journey in astronomy — like Pluto researcher and outreach guru Caitlin Ahrens or Sepideh Hooshyar, an Iranian woman who is determined to study the stars no matter the obstacles.

In this issue, we highlight legendary discoverers like Carolyn Shoemaker and Jean Mueller; showcase the stunning images of women astrophotographers; touch on the invaluable work women are doing in nonprofits and outreach; and tackle the issue of inequality in astronomy through a Q&A with planetary scientist and inclusivity advocate Christina Richey.

Each of the women featured in this issue are inspiring, and we hope by giving our readers a glimpse of the versatile paths they have forged, we can encourage more women to find their passion, resist opposition and reach for the stars.
The sky has so much to offer

While every issue of Sky's Up concentrates on a different theme, the underlying goal of the magazine is to inspire our readers to enjoy the night sky. That is precisely the goal of the National Sharing the Sky Foundation. Since 2005, Sharing the Sky has been trying to motivate people to enjoy the sky. We conduct a monthly star party at a local school in our neighborhood and an annual retreat in the Adirondack mountains as part of what our foundation tries to do. Each monthly star party begins with an informational talk followed by guided observing through telescopes.

Perhaps more important is the thinking behind what our foundation does. We want to adopt a new way of thinking about the sky, an appreciation of its grandeur. The sky rises above our everyday concerns. The sky has so much to offer. For example, there was a news item recently about a member of the cabinet in the current United States administration using a government plane to travel to the path of totality of last month's total eclipse of the Sun. The cabinet secretary insisted, however, that he had absolutely no interest in viewing the eclipse. It was just that one statement that bothered me. I could not understand how anyone could travel to the path of a total eclipse, probably the most beautiful sight that anyone could see in nature, and express no interest in witnessing it!

The same might be said about many other aspects of the night sky. On a clear night, when the sun sets and the stars begin to appear, I always begin my observing session with a quick glance around and consider what might have happened in the sky since the last time I looked up.

There is a new comet in the northern sky that I have seen two or three times. It is called ASASSN after the group that discovered it. The name itself sparked some controversy because of its obvious pronunciation, but the International AstronomicalUnion allowed it to go forward because that is indeed the name of the group that found it. This comet is expected to become quite a bit brighter and easier to see. However, so far I have found it rather difficult to spot. Barely brighter than the brightness of the surrounding sky, it is a challenge. I rather doubt that any government airplanes will be flying about trying to spot this.

Should we legislate an interest in astronomy? Might there be a law stating that anyone planning to run for the legislature must have enjoyed several nights under the night sky? Or a substantial interest in the machinations of variable stars as a qualification for being a United States senator? And finally, to run for president, must one have discovered not one but two comets?

Much as it might be fun to think about, we will have to stand on our own. I have every confidence that the majority of the night sky is quite capable of producing plenty of magic on its own.

Over decades of observing, David Levy has discovered or co-discovered a total of 23 comets. His prolific record includes the joint discovery of Shoemaker-Levy 9, which quickly went on to dramatically crash into Jupiter in 1994, and the individual discoveries of two periodic comets – P/2000 O1 – through his backyard telescope. In 2010, Levy became the first person to have discovered comets in three ways - visually, photographically and electronically. Beyond his observation achievements, Levy has authored, edited or contributed to more than 30 books and has periodically provided articles for publications like Sky & Telescope and Parade Magazine.

what's up in the sky

January 3rd/4th – Quadrantid Meteor Shower Peaks

Although it can be as prolific as the legendary Perseids and Geminids, early January’s Quadrantid meteor shower garners a little less fanfare. The reason for the slight is because the shower’s peak period, which can generate a maximum hourly rate of 50-100 meteors, lasts mere hours so it is much more difficult for observers to find the right timing to truly enjoy maximum meteor levels. Another factor affecting the Quadrants’ status is the positioning of its radiant point, which is high in the northern sky near the Bootes constellation. This means the best, and possibly only, views are reserved for observers at mid to high northern latitudes. This year’s Quadrantid shower, which is predicted to peak by some sources around 21:00 UTC on January 3rd, will be particularly challenging due to the interference of the brilliant Full Moon. Observers will want to take extra care this year in choosing where to view because a dark sky will be vital.

January 7 – Conjunction of Mars and Jupiter

On January 7th, Mars and Jupiter will co-zap up in the predawn sky as they reach conjunction for the last time until 2020. Positioned visually within less than one degree of each other, the planets will be easily observable in the same binocular field. The reddish Mars will appear 0.25” below the brilliant Jupiter.

January 31 – Total Lunar Eclipse

Some North American viewers will be perfectly positioned to enjoy a total lunar eclipse that is set to occur in the predawn hours of January 31st. A total lunar eclipse occurs when a perfect alignment of the Sun, Earth and Moon causes the full moon to be shrouded by Earth’s shadow. During the event, the same phenomenon that gives our sunsets their beautiful, colorful glow will cast the Moon in some shade of burnt reddish-orange. How red the Moon will actually appear depends on Earth’s atmospheric conditions, such as dust levels and humidity, which affect the way sunlight is filtered and refracted to light the lunar surface. The total phase of the eclipse will last for one hour and 16 minutes beginning at 5:51 a.m. EST. The partial phase, which will last for a little more than two hours, begins at 4:48 a.m. EST.

February – Auriga Constellation

This month is an ideal time to catch the Auriga constellation riding across the northern hemisphere’s winter sky. Known as The Charioteer, Auriga is visible from 90° North to 40° South and plays host to the galactic anticenter, which is the point in the sky that is directly opposite the center of the Milky Way. One of its most prominent features is Capella, which is the sixth brightest star in the sky. Known as the Goat Star, Capella actually consists of two sets of binary pairs. The first is a set of large, bright yellow giants that are very close together and the second is a pair of small red dwarfs. A triangle-shaped asterism lies near the brilliant star system, and its trio of stars is often referred to as “The Kids.” Auriga also is home to Epsilon Aurigae, an eclipsing binary star system that dims for about two years every 27 years. The main component in the system is a supergiant but the nature of its companion has long been a subject of debate.

Beyond its star offerings, Auriga has many deep sky treasures including the Messier 36, Messier 37 and Messier 38 open star clusters and the Flame Nebula. This beautiful emission/reflection nebula is about five lightyears across and surrounds AE Aurigae - a brilliant blue star characterized as a “runaway star” due to the fact that it is moving at a higher velocity than its neighboring stars. It is believed that AE Aurigae was ejected when two binary systems collided.

Percid meteor, August 2016

Expected to become quite a bit brighter and easier to see. However, so far I have found it rather difficult to spot. Barely brighter than the brightness of the surrounding sky, it is a challenge. I rather doubt that any government airplanes will be flying about trying to spot this.

COURTESY OF David H. Levy

The sky has so much to offer
NASA remembers trio of tragedies

Near the end of January every year, NASA has a Day of Remembrance to mark the solemn anniversaries of three of its most stunning tragedies.

The first occurred on Jan. 27, 1967, during a pre-flight test for the Apollo 1 mission that had been slated to launch Feb. 21, 1967. Astronauts Virgil “ Gus” Grissom, Edward White and Roger Chaffee were inside the spacecraft as it sat on the launch pad at Cape Canaveral. Several hours and several problems into their launch rehearsal, a fire suddenly broke out in the spacecraft. Within seconds, the fire spread throughout the cabin and filled the space with a lethal mixture of carbon monoxide, smoke and fumes. Because the hatch door could only open inward, a feat made impossible by the high pressure inside the cabin, escape attempts were thwarted, and all three astronauts perished. The resulting investigation led to significant changes in the command module and launch pad procedures. Those included a new quick-operating hatch design that opened outward; the use of an oxygen-nitrogen mix rather than 100 percent oxygen in the launch pad cabin atmosphere; a major reduction in flammable materials inside the spacecraft; and the addition of protective insulation to plumbing and wiring. Manned Apollo flights resumed in October 1968.

Almost 20 years after the Apollo 1 fire, tragedy rocked NASA again when on Jan. 28, 1986, the Space Shuttle Challenger broke up after liftoff killing all seven crew members. On launch day, media hype was high and classrooms across the nation were tuned in to watch live as the first teacher-astronaut, Christa McAuliffe, journeyed into space on the inaugural mission in NASA’s new Teacher in Space program. Just 73 seconds after liftoff, spectators at the site and around the world watched in horror as the shuttle broke up in a plume of smoke and fire. In addition to McAuliffe, those killed were Francis “Dick” Scobee, Ron McNair, Michael Smith, Ellison Onizuka, Judy Resnik and Greg Jarvis. Subsequent investigations concluded that the disaster was caused when an O-ring seal on the right solid rocket booster failed in the unusually frigid temperatures on the morning of the launch. The shuttle program resumed in 1988.

The shuttle program once again faced disaster on Feb. 1, 2003, when the Space Shuttle Columbia was returning from a 16-day micro-gravity research mission. During re-entry, the shuttle disintegrated leaving its seven crew members deceased and a debris field spread across Texas and Louisiana. Those who perished in the devastating accident were U.S. astronauts Rick Husband, Willie McCool, Michael Anderson, Kalpana Chawla, David Brown and Laurel Clark; and Israeli astronaut Ilan Ramon. Husband, Willie McCool, Michael Anderson, Kalpana Chawla, and Israeli astronaut Ilan Ramon. On Jan. 31, 2003, Columbia set off on its 28th mission. During liftoff, a piece of insulating foam on the external fuel tank broke off and hit the shuttle’s left wing. Investigations following the accident determined that when the wayward foam struck the wing it caused a breach in the thermal protection that ultimately led to the spaceship’s destruction. Although these horrifying incidents occurred decades apart, they share a common legacy. Each was more than a grim reminder of the dangers of space exploration. Instead, they galvanized NASA to improve and drive the agency to persevere in its noble pursuit to discover the secrets of space.
In mythology, Cassiopeia was a vain creature undone by her arrogance. But the circumpolar constellation that bears her name certainly has some celestial beauties worth boasting about. Visible from 90° north to 20° south, Cassiopeia is known for the striking “W”-shaped asterism that is formed by its five brightest stars. The yellow-white giant Beta Cassiopeiae anchors one end of the “W.” Also known as Caph, this star is one of the brightest Delta Scuti type variables to grace the sky and has an average apparent magnitude of 2.27. The next point in the “W” is the orange giant Schedar (Alpha Cassiopeiae), which marks the heart of the doomed queen. The brilliant blue Gamma Cassiopeiae lies at the center of the famous asterism. Categorized as an eruptive variable, this star can outshine both Schedar and Caph when its intensity peaks. Nicknamed Navi by U.S. Astronaut Gus Grissom because of its usefulness as a navigational point in space, Gamma Cassiopeiae has a bulging equator due to rapid rotation and is also a spectroscopic binary.

The next point in the “W” is Delta Cassiopeiae, which is an eclipsing binary that is also identified as Ruchbah. Its apparent magnitude varies between 2.68 and 2.74. The last star that defines the asterism is Epsilon Cassiopeiae, which is also known as Segin. Located about 440 light years away, this blue-white giant shines from its post with an apparent magnitude of 3.38. The queen’s notable stellar offerings continue beyond the five that define her most recognizable feature. Best viewed with a telescope, Eta Cassiopeiae is a beautiful binary star system with a yellow dwarf primary component that is much like our own star and an orange dwarf companion. Cassiopeia is also home to two stars in the very rare yellow hypergiant class - Rho Cassiopeiae and V509 Cassiopeiae. Although they are each located thousands of light years from Earth, their extreme luminosity keeps them visible to the naked eye.

A quick tour of Cassiopeia’s deep sky offerings has to begin with the open cluster Messier 52. Although it can be enjoyed with binoculars, a moderate-sized telescope will reveal it as a fan of faint stars that includes a couple of bright yellow giants – one of which pops out from the cluster’s southwestern edge. A far more remote open cluster is Messier 103, which is best viewed through binoculars due to its loose structure. Located near Ruchbah, the cluster, which includes a red giant that truly shines in photographs, will manifest as a hazy V-shaped patch.

Another treat is the “The White Rose Cluster,” which is also known as “Caroline’s Rose Cluster” because it was discovered by famed astronomer Caroline Herschel. The cluster’s pattern of bright stars and dark paths is similar to the curves and valleys of a blooming rose.

The constellation also offers the Bubble Nebula, which is a diffuse nebula located southwest of Messier 52; the open star cluster NGC 457, which has around 100 stars and is sometimes called the Owl Cluster or ET Cluster due to an eye-like pairing of two bright stars; the irregular galaxy IC 10, which is the only starburst galaxy in our local group; and the Pacman Nebula, an emission nebula with an open cluster of brilliant blue supergiants at its core and several Bok globules.
Tabby’s star aims to misbehave

Is behavior as odd as Lady Gaga, and for the past two years, it’s been one of astronomy’s most celebrated puzzles. It’s a star whose shine varies erratically.

The official moniker is KIC 8426852 – which reflects this object’s listing in the Kepler telescope index catalog. But who can pronounce that? Instead, most folks – including astronomers – refer to this stellar oddball as Tabby’s Star, or for the less genteel, the WTF star.

The Planet Hunters citizen science project was the first to note its freakish behavior, and in 2015 a team of researchers, led by Yale postdoc Tabetha Boyajian, published a paper charting the star’s unusual dips in brightness.

Of course, that’s exactly the type of behavior that the Kepler space telescope was looking for: stars that dim because orbiting planets occasionally block their light. But the brightness dips from Tabby’s star were not periodic, the signature of a planet. And the dimming was — at least in one instance — of outrageous proportions, reducing the star’s brightness by 22 percent. Even a planet as bulky as Jupiter would only cause a 1 percent dip.

So the big stumper is this: what’s causing Tabby’s star to vary? The light from stars is normally as constant as doggy love. Our Sun, despite being routinely blemished by spots and brightened by flares, doesn’t vary by more than 0.1 percent during its 11-year cycle. Multiple explanations have been proffered to account for the star’s erratic shine, including light blockage by comet dust, rock fragments, a large ring system, or even the disruptive burps caused by choking on a planet that wandered too close. But by far the most intriguing explanation, originally suggested by Jason Wright of Penn State University, is that Tabby’s star might be home to industrious aliens who have built an orbiting megastructure that now-and-again gets between us and the star. Perhaps they’ve deployed a multitude of energy-collecting satellites, known to science buffs as a Dyson swarm.

That last suggestion – which quickly became the headline for the whole Tabby’s star saga – prompted searches by SETI astronomers, including my colleagues. We used the Allen Telescope Array to look for signals that would give credence to the suggestion that this star shelters a technically adept society. No signals have been found, but then again Tabby’s star is not really next door: it’s roughly 1400 light-years distant (still visible in an amateur telescope), which means that if inhabitants are beaming their talk shows into space using an omnidirectional radio transmitter, those broadcasts would be detectable only if the power was at least a few hundred trillion watts, or several times the total energy consumption of all humanity. Then again, if they’ve constructed a Dyson swarm maybe they’ve got that kind of energy on tap! But we’ve heard nothing.

Tabby’s star resumed its odd comportment last summer, dimming by a few percent for a few days, and also displaying a slower overall decline in brightness. However, this time astronomers were able to catch it in the act, making observations with NASA’s Swift and Spitzer space telescopes, as well as at the Belgian IRIS observatory. These have provided new clues to the star’s gonzo behavior: the dimming was greatest at short wavelengths — ultraviolet. There was less dimming in the infrared.

So what does that mean? Just as dust in the air scatters short wavelengths, causing sunsets to be red, fine dust particles could account for the long-term dimming of Tabby’s star. An alien megastructure wouldn’t block more ultraviolet than infrared, so forget that.

It sounds as if the neighborhood of Tabby’s star is clogged with dust. Even so, it’s still hard to understand that 22 percent brightness drop. But hey, if there were no mysteries in the cosmos, why would anyone care about astronomy?

Dr. Seth Shostak is the senior astronomer and director of the Center for SETI Research at the SETI Institute.

Looking for ET

BY SETH SHOSTAK

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‘Science can be for everybody’
Pluto researcher takes outreach to a whole new level

By PATRICIA SMITH
Sky’s Up staff writer

Caitlin Ahrens has an overflowing plate. She’s a Ph.D. candidate, a dedicated researcher, manager of the Pluto simulation lab at the Arkansas Center for Space and Planetary Sciences, a NASA Solar System Ambassador and even the host of a weekly radio show on the local NPR affiliate.

Above all, though, she is a passionate advocate for science. “Science doesn’t have to be for the professionals, science doesn’t have to be for the students, science can be for everybody,” exclaimed Ahrens during a recent interview. Her wholehearted belief in this idea drives her to take every opportunity to cultivate curiosity in others about the workings of our world, our solar system and the universe beyond. Her approach to outreach is an eclectic mix of methods that combines traditional techniques like visits to astronomy clubs and schools with fresh tactics like her weekly radio show “Scratching the Surface.” Listeners can tune in to hear Ahrens give quick talks on intriguing subjects like sunquakes or the dark workings of our world, our solar system and the universe beyond.

Ahrens is engrossed in her own research, which currently centers on Pluto. Her first foray into planetary science was during an internship with a USGS astrogeology project in Flagstaff, Ariz. “From there, I worked on the Mars global surveyor that has since been decommissioned,” she said. “They specifically wanted someone to look at dunes on Mars. It may not sound exciting – they’re big piles of sand on Mars — but it’s quite entertaining because if you’re looking at a sand pile, it could move and then you have to start over. Sand moves everywhere on Mars. That was a very entertaining process, and we also discovered a dune on Mars, so I was on the team to name a dune on Mars.”

It was when she began her Ph.D. work at the University of Arkansas that her focus shifted to the ice geology of Pluto. “During that time that she was a grad student, the (male) advisor got the credit and even went on to win a Nobel Prize for it,” Ahrens said. “But she persevered. She still eventually had her name associated with pulsars.”

Ahrens speaks during an outreach event to a group of adults — a demographic she loves to reach. “The tricky part about Pluto is that all we sent was New Horizons,” she said. “New Horizons was our first, absolutely gorgeous look at Pluto, but we only have one side of Pluto, and only one time frame of Pluto. And it went by so quickly, that what if something active was going on on Pluto, we wouldn’t have been able to catch it. So there’s a sense of we need to go back for that purpose. Is anything actually moving on Pluto? Is anything active? We definitely see flow features on Pluto, but we can’t tell from one image how quickly it’s flowing, how young are certain features. Color variations on Pluto, do they change at all? That part’s tricky. You can only do so much with images and data of one flyby.”

With so little data to work with, Ahrens relies on the Pluto lab that she manages at the Arkansas Center for Space and Planetary Sciences. In addition to the Pluto lab, the center has a Venus lab, a Titan lab and two Mars labs in which researchers can essentially simulate temperatures and pressures of the different planetary bodies. “We specifically do planetary simulations, which I love to call mad science. It’s so cool, and hardly anybody knows about us,” Ahrens said. Ahrens makes it clear that she wants people to know about the research done at the center, just as she wants people to know about amazing scientific work being done throughout the world. She also wants to make sure that others realize how diverse the scientific community really is and give recognition to all of those who churn the wheels of discovery. When asked about her influences, she is quick to include two women who did not immediately get the recognition they deserved. One is Jocelyn Bell Burnell, an astrophysicist from Northern Ireland who discovered pulsars as a graduate student. “During that time that she was a grad student, the (male) advisor got the credit and even went on to win a Nobel Prize for it,” Ahrens said. “But she persevered. She still eventually had her name associated with pulsars.”

Ahrens feels has contributed to recognition they deserved. One is Katherine Johnson, the NASA mathematician who calculated flight paths during many of the agency’s most important missions — including Apollo 11. The book and subsequent film “Hidden Figures” recently shined a much deserved spotlight on Johnson’s contributions. Like Johnson, Ahrens is from West Virginia — a fact that Ahrens feels has contributed to disregard that some have aimed at her in the past. “If she can do it, if she can persevere through where she’s from, her background, then we could all achieve our goals,” said Ahrens. In this Rising Star Q&A feature, Ahrens discusses her research and her never-ending quest to spread the word about science.
When and why did you become interested in astronomy and space?

I have my father to thank for that. When I was 9, he got me my first telescope and membership into the Central Appalachian Astronomy Club based out of West Virginia. From there, it’s like a second family to me. They ask me to come back over the summer and give talks to their club and their star parties.

I formed such a relationship with the members of the club and through them I’ve met astronauts. I’ve gotten to talk with members of SETI. From the club, I’ve learned not only space is cool, but also, on a networking level, I’ve gotten to meet so many different kinds of people in astronomy.

What advice do you have for young people who are interested in the field of astronomy?

My advice: If you’re curious about something, go for it. There’s no limit to just discovering something. You don’t have to wait to go to college to get a textbook, or to talk to a professor. Go do it! Talk with those who are as curious about it as you are. In the end, it’s YOUR science to discover and learn!

What is the focus of your research?

The focus of my research involves simulating ice geology on Pluto, such as what kind of ice and how the ice is transformed to make different kinds of geology, in my experimental simulation laboratory at the Arkansas Center for Space and Planetary Sciences. Earth doesn’t get that cold, and there’s certain ices that we can’t find here on Earth, so I can simulate it in my lab to see how ice interacts with other ices – methane, carbon monoxide, nitrogen, ammonia. They all act differently, especially when you mix all of them together.

What kind of outreach activities do you do?

Anything from speaking at local schools and libraries, keynoting at star parties or adult group societies (Lifelong Learners, etc.) to having a mini radio show on local NPR about cool stuff in our solar system.

The most rewarding part in doing outreach is reaching out to all levels of society and seeing a sense of curiosity for science in the community!

What do people seem to find most exciting at outreach events?

The fun part about studying space geology is to study Earth geology. I think showing people how our own beautiful planet is giving us hints to what is going on on other planets is quite extraordinary. Bringing it (literally) down to Earth is fascinating!

What does the future hold for you as an astronomer?

Anything from speaking at local schools and libraries, keynoting at star parties or adult group societies (Lifelong Learners, etc.) to having a mini radio show on local NPR about cool stuff in our solar system.

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What does the future hold for you as an astronomer?

More outreach! More research! There is still so much we don’t know about our solar system. Planning more missions and getting researchers together to collaborate would be my goal!
Pursuing her dreams

Documentary chronicles young Iranian woman’s journey in astronomy

By PATRICIA SMITH
Sky’s Up staff writer

Like every teenage girl, Sepideh Hooshyar has big dreams. She wants to study the stars, she wants to go into space and she wants to fulfill the hopes her father had for her before he passed away.

But as a young woman in rural Iran, she knows her journey will not be an easy one. Even as logistical, financial, familial and cultural roadblocks impede her path to the stars, Sepideh presses on.

Hers is an inherently inspiring story told masterfully in the award-winning documentary “Sepideh: Reaching for the Stars” by Berit Madsen.

“Sepideh has a great message to send out to the world: Never give up on your dreams. And her life testifies to that,” Madsen said. “Even though you will meet a lot of resistance and have to overcome a lot to stay true to your dreams, it’s worth it. She is a special girl with her own special story – she is not just a dreamer but she fights.”

Madsen stumbled upon Sepideh while pursuing the story of Asghar Kabiri, a physics teacher in Saadat Shahr who was leading an astronomy club for young people and trying to build an observatory.

“I stayed many days in Mr. Kabiri’s house and one night Sepideh and a small group of friends came to his house on their way going stargazing. I followed them and observed how ambitious Sepideh seemed to be, carrying around her small telescope to get the right spots to observe the sky,” Madsen said.

“I was really curious to know how it was possible for her — at this point only 14 years old — to leave her house in these late hours to go out in the freezing night and what she was up to. Even though I knew Iran before coming to Saadat Shahr for the first time and know that it’s a much more complex country than it is most often portrayed in the global media, this is really not what you expect a young Iranian girl to do.”

The following day, Madsen visited Sepideh and her family at their home. Posters of Albert Einstein adorned the walls of Sepideh’s room, and she spoke of a promise she had made to her late father about becoming an astronomer.

“Upon getting these first insights into her dreams and background, I knew that I wanted to make a film about her,” she said. “I wanted to follow her to see how she would make these huge dreams come true; what would happen when her childhood dreams met reality.”

When viewers of Madsen’s film first meet Sepideh, we hear her sure footsteps crunching through the rocks as she trudges up a hillside grasping her precious telescope tightly to her heart. This image is a perfect introduction to the challenges that lie ahead and the determination she has to meet them.

Madsen herself faced uncertainties while making the film.

“Tonight I’m going star gazing, to observe the sky again. I feel I’m the only one in the world who is awake. In this instant, the world is mine ...”

— Sepideh Hooshyar

The documentary “Sepideh: Reaching for the Stars” tells the story of a young woman in rural Iran who is facing multiple obstacles as she pursues her dream of becoming an astronomer.

In a still from the documentary, Sepideh Hooshyar visits with Asghar Kabiri, a physics teacher who leads the local astronomy club.

Documentarian Berit Madsen poses with Sepideh Hooshyar at the Fajr Film Festival in 2014. The film had its Iranian premiere during the event.

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documentary film in Iran because you’re never sure if you’ll get permission to shoot. And upon getting permission, you never know if you can return for several shootings, which a film like ‘Sepideh’ depends on as it follows the main character through several years thereby also becoming a coming-of-age story,” Madsen said. “I was very lucky to work with a very skillful Iranian team and Iranian co-producer. But every time I went shooting, I was told that it might be the last time. So it was definitely a very stressful period, never knowing that I would manage to finish it. But as Sepideh is insisting, so was I.”

Throughout the film, Sepideh’s persistent spirit is tested but never broken. At one point, we watch as her uncle confronts her about how her observing outings with the astronomy club members — some of whom are male — could be misperceived and the harsh consequences that could follow.

With tear-rimmed eyes, the teenage Sepideh responds, “There’s nothing wrong with me looking at the stars. After me there will be 10 more doing what I have done. I’m not alone!”

Madsen echoes this statement that Sepideh is not alone when she speaks of how she sees the young woman’s story as a universal one.

“To me, ‘Sepideh’ is a film about hope,” she said. “It’s telling us that, if we’re willing to fight for our dreams, then we might reach further than we ourselves believed. If we dare to seek out all opportunities and put effort into it.”

The film follows Sepideh’s journey for several years, but her story is still unfolding. Now in her early 20s, she has married, begun studying physics at a university and had a daughter with whom she makes a point to share the sky. She is also actively pursuing research opportunities.

“I’m collecting information and studying for work on supernovae,” Sepideh writes during a recent interview. “I am in the final semester in the field of undergraduate physics. It’s a bit hard because I study in absentia, but I enjoy it so much even with all the hardships.”

One of the largest obstacles to Sepideh’s current astronomy pursuits is the cost of equipment such as telescopes and cameras. She has no capital to put toward her scientific work, but she does have a piece of agricultural land that she hopes will one day produce enough profits to fund some research.

“She live like all other women in the world. All women are inspirational,” Sepideh writes. “I know that after every night, the sun will rise, and I hope that someone really looks at the sky because of my movie.”

“Sepideh: Reaching for the Stars” is available on iTunes.
1. What made you enter the field of astronomy when you were 51?

I entered the field of astronomy at age 51 for several reasons. My children were grown and had left home to do their own thing. They no longer needed my attention. I felt that I needed something of consequence to do and was somewhat familiar with my husband's work in searching for near Earth asteroids. I could try my hand at some of it and feel my way along.

2. What type of astronomy work do you do, and how have those tasks evolved over the decades?

My work in astronomy studies involved studying both glass plates and films taken at the telescope searching for asteroids. When I found something of interest, I measured its position in the sky and reported that to the Minor Planet Center in Cambridge, Mass. Over many decades, the use of film and glass plates has been discontinued. Today's observing uses computers and technology to replace much that astronomers once did.

3. What is your favorite part of being an astronomer?

My favorite part of being an astronomer was being gazing into space, either by telescope or in a dome open to the sky, and wondering about the enormity of the universe I saw there. We have a fabulous sky!

4. How did it feel when you discovered your first comet? Did the excitement of discovering a comet fade as you found more?

When I discovered my first comet I was terribly excited, and that feeling has never left me. I thought that I would never really be able to discover a comet, and that was because I had seen the comets on the films that other people had discovered, and it looked so difficult that I wasn't sure I'd ever see anything like that. But I did. When I did I was so terribly excited, I knew that that was what I wanted to concentrate on especially.

Carolyn Shoemaker stands next to the 18-inch Schmidt telescope at Palomar Observatory.
5 What has been your favorite discovery so far?

My favorite discovery has been Comet Shoemaker-Levy 9!

6 What was it like to experience a comet that you co-discovered crash into Jupiter?

I had mixed feelings when I learned that this comet would hit Jupiter. First was a feeling of dismay because I realized that I would never see that comet again — I was going to lose a comet. But then came the excitement of seeing an impact, knowing that I had discovered the impactor!

One of the things that pleased both Gene and me was the fact that our telescope on Palomar was the 18-inch but the big 200-inch telescope observed our comet impacting Jupiter.

Sometimes in astronomy, bigger is more impressive, so we thought that was pretty neat. We appreciated the help that everyone gave each other in getting ready for the impact and then when the impact occurred, we couldn't have been more excited.

7 What challenges have you faced personally in the field because of your gender?

I did not face challenges in my field due to gender, probably being married to Gene Shoemaker saved me from that.

8 Was there ever a point when you wanted to quit?

I was never frustrated or wanted to quit. I was having too much fun with my work, and those years of working with Gene on something that excited us both were some of my happiest.

9 How do you make sure you are heard in a huge community of astronomers?

Being interested in the work of other astronomers seems to encourage a like-minded response.

10 Who do you think is the most influential female astronomer/astrophysicist?

Vera Rubin* was the most influential astronomer/astrophysicist of my time. She was in the field before I was and made many discoveries of different sorts. I just had so much admiration for her. I think most people did. She was just remarkable.

* For more information on Vera Rubin, please see the sidebar on page 44.
Night sky a lifelong inspiration for astrophotographer Terry Mann

By PATRICIA SMITH
Sky's Up staff writer

Driven by her lifelong fascination with the night sky, award-winning astrophotographer Terry Mann has become a master of capturing stunning skyscapes.

“My mom once told me, when I was still small enough to sit on her lap that I would ask about the stars every time I was outside,” Mann writes. “I don’t know how, but that curiosity has stayed with me.”

Now, through her camera lens, Mann fosters that same curiosity about the stars in others. This need to share the sky began in the latter half of her elementary school years, when her parents bought her a 60mm refractor.

“I took it to school to show everyone the Sun. It had one of those screw-in-the-eyepiece solar filters,” she writes. “I can’t believe my class all looked through that telescope that day, and I kept looking at the Sun with that filter. I still cringe when I think about it.”

Her first foray into astrophotography came shortly after.

“I decided I wanted a picture of the Moon. My dad had a camera that I wasn’t allowed to touch. One night when he was reading the newspaper I took the camera and went outside to take a picture of the Moon,” she writes. “When the flash went off my dad came out to see what happened. I was caught red handed! I’ll never forget, he didn’t punish me for taking the camera, instead he explained why I didn’t need a flash to take that picture. My parents were the best!”

With just a quick look at her work or host of accolades, it is clear that Mann has honed both her outreach and her imaging skills in the decades since she first peeked through that 60mm refractor.

Her images have been shown in galleries and have appeared in magazines, on television and on popular websites like space.com. She has served as both vice president and president of the Astronomical League — one of the largest amateur astronomical organizations in the world — and has been a NASA Solar System Ambassador since 2002. Her honors have included the R.G. Wright Award from the Astronomical League, the Kepler Award from the Miami Valley Astronomical Society and an award from the Ohio House of Representatives.

Even with all of these credentials, the road to these successes has had its share of bumps.

“I remember one of the first times I won a category in an astrophoto competition, since my name is Terry, they assumed I was a male. When they called my name and I went up front, they made me go back and get my driver’s license to prove I was who I said I was,” she reflects. “That was a few years back. I am glad to say that I have never had to deal with being treated like that since.”

Over the years, Mann has seen some shifts in the astronomy community.

“I know the astronomy classes used to be more men than women. Now the balance seems to be changing,” she writes. “Women are out there and involved in many areas of astronomy. As far as being treated equally, I’m sure you can find good and bad.”

Mann strongly believes that if what you are doing is something that you really want to do, you will find a way. When asked about the women in astronomy who have influenced her, Mann produces a long list of women who have done just that.

“Annie Jump Cannon, Henrietta Swan Leavitt, Vera Rubin, Jocelyn Bell Burnell, Sandra Faber, Carolyn Shoemaker — my list could go on and on,” she writes. “There are so many women that have done amazing things. So many times they were in the background doing incredible things without any recognition. They are all an inspiration to me.”

Above, the Milky Way arches over City of Rocks State Park in New Mexico. “I spent two nights camping at this amazing park. I could have easily spent a week there investigating the rocks. I was there during monsoon season. It rained during the day and luckily, it cleared at night.” Left, the Milky Way glows through openings of the Double Arch in Arches National Park. “This was the first time I hiked up a wall to catch the view! There were some outcropped rocks but it was the first night I had to master setting up a tripod and changing lenses while wedging myself against the wall of Double Arch. We did some light painting to help show the beauty of the rock walls.”
Coronal aurora in Fairbanks, Alaska — “I love Alaska, I have been there in the summer and winter. Winter can be very cold but I prefer it to summer. It is a great place to view the aurora and watch it dance from horizon to horizon. When the aurora goes coronal, overhead, it moves so fast that there are times it is hard to turn your camera to get the shot. By that time, your jaw is on the ground in disbelief of what you just experienced. It was around -25° on this night. At these temperatures all I had to do was turn around with my cable release in my hand, and see my wire to my camera snap into two pieces. The cold really can mess with the cameras so go prepared.”

Arched Milky Way in Bryce Canyon National Park — “This is one of my favorite images. I call it ‘Cosmic Rainbow.’ I hiked into the canyon, down a narrow path and took this image while inside the canyon looking up. There was barely enough room for my tripod legs. I remember thinking how the headline might read the next morning: ‘Amateur astronomer hikes down canyon in the dark, pressed shutter button as she fell into the canyon, see farewell picture below!!’ Getting to truly dark skies makes such a difference in what you see and image.”

Winter Silence in Alaska — “I call this image ‘Winter Silence.’ It was taken north of Fairbanks, Alaska. This tree caught my eye as I waited for the aurora to appear. That night the stars looked like diamonds and the familiar constellations seemed to get lost in all the stars. A CBS news crew stayed with our group hoping to catch the aurora, they were not disappointed.”

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The Only One Awake in Fairbanks, Alaska — “I call this image, ‘The Only One Awake.’ It reminds me of this quote: ‘We of the night will know many things of which sleepers will never dream.’ - Bessie Hyde

Cabin aurora and Big Dipper in Fairbanks, Alaska — “I call this image ‘Mile 48.’ Here, I’m on the Dalton Highway (the Haul road). I was on a driving tour to the Arctic Circle with a guide and six others. A snow storm blew in on the way back to Fairbanks. We were dealing with blizzard conditions. We were driving beside and above the Yukon River when suddenly, sky opened up. We all jumped out of the van and took image after image as the aurora blazed across the sky. The ice road trucker’s headlights lit the trees as they drove by. Forty-five minutes later the clouds closed in and we were on our way again. We spent fifteen hours on the road but it was worth it. If there is a most amazing night to be had on a bucket list, this was it.”

Milky Way and the Rams at Borrego Springs, Calif. — “This was something I had wanted to see for a long time, the Galleta Meadows Metal Sculptures in Borrego Springs. The sculptures are incredible, day or night. If you are there during the New Moon and are not familiar with the locations of all the sculptures, they can be hard to find in the dark.”
— Photography by Terry Mann —

Left, Delicate Arch at Arches National Park — “A small group of us hiked up to Delicate Arch in the late afternoon to watch the sunset then we stayed until about 2 a.m. Watching the Milky Way glide behind the arch was incredible. We were there a few hours and most of us had laid down on the rocks. I had my tripod by my feet doing a time-lapse when a kangaroo rat ran across my shoulders. I can still feel those little feet. I sat up screaming and almost kicked my tripod over. Over the next hour, one after the other, that rat ventured down the line. By the end of the night everyone had screamed at least once. I must really love doing this stuff!”

Right, Delicate Arch at Arches National Park — “My sister wanted to go on a trip out west and see how I image at night. This was the first and last time my sister went out shooting with me. She decided this was not for her. But she will tell you she will never forget this sight. I’ll never forget both of us looking at each other yelling, ‘Did you see that?’”

Below, the Very Large Array in Socorro, New Mexico — “I stop here whenever I am close by. The temperature had dropped into the low 30s when I took this image. It was cold and quiet. Something you come to expect when you are a night imager. On this night I was listening to the dishes move in the dark. That metal screeching sound echoed in the night. Sometimes I felt like we really were talking to the Milky Way and we were waiting for the response.”

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Left, Perseid meteor at Devils Tower — “My sister wanted to go on a trip out west and see how I image at night. This was the first and last time my sister went out shooting with me. She decided this was not for her. But she will tell you she will never forget this sight. I’ll never forget both of us looking at each other yelling, ‘Did you see that?’”

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Above, Aurora and Big Dipper from Minnesota Boundary Waters — "I have been back to this area many times since my first trip here, when I imaged Superior Rock. Every time I go a little deeper into the woods. There are so many lakes and so much wildlife here. I understand what draws people from all over to this area. I took this image at the end of October 2017. That night, there were gale warnings on Lake Superior and most places were cloud covered. I was there for a week and on this night, I had 3 1/2 hours of partially clear skies. On this night, I ended up on a gravel road by this lake, deep into the woods. I had to use a flashlight to walk to the edge of the water. There I waited for my eyes to adapt to the darkness. The forest was so thick but you could see some of the sky through the trees. After about a half hour, I took my first shot. I couldn't see it but the aurora showed up in the image. Within a few minutes, I noticed the aurora was low on the horizon. Soon, large pillars were brightening in the Big Dipper. I imaged for about 2 1/2 hours. Then the wind blew the clouds in and that was the end of the imaging. I looked up at the swaying trees and hoped I could get through this gravel road without a tree falling.....The gales of November came early." Right, Fisheye Aurora at North Pole, Alaska — "I stood on the frozen Chena River to take this shot. Standing on a frozen river or lake is not what I like to do. There is something about that cracking sound that makes me nervous. The aurora was going horizon to horizon and I couldn't resist. Standing on the frozen river was the clearest view I could have. Slowly, I walked out until I could see most of the sky. I love Alaska but I like solid ground best."
Ring master

Drive to discover fuels Cassini Project Scientist Linda Spilker

By PATRICIA SMITH
Sky's Up staff writer

It’s easy for Linda Spilker to recall the moment she became infatuated with planets.

As a third-grader, she got her first telescope, tilted it toward Jupiter and watched in awe as the eyepiece revealed several tiny moons marching by the giant planet.

In that instant, she was hooked on the study of our planetary brethren for the past four decades at NASA’s Jet Propulsion Laboratory. Her impressive career path has taken her from an assistant experiment representative on Voyager to her current position as project scientist at the helm of one of the most extensive exploratory missions in the agency’s history — Cassini.

Her time at JPL has been filled with groundbreaking research, astounding discoveries and history-making moments. But if she had listened to one of her high school advisers, she might have missed it all.

“One of the first places that I really came up against a feeling of gender difference was actually in high school. There was an adviser I was talking to as I was getting closer to graduating. I said ‘I’m thinking that I maybe want to major in math, maybe in science,’” she recalled. “He just sort of looked at me and said, ‘Well, you know those are not careers that women usually head toward. You should think more about becoming a nurse or a teacher.’ He was very serious, he really, really meant that.”

This advice ran contrary to what Spilker had been raised to believe. “My mom was very supportive. I was the oldest of four girls, and she had loved math, too, and had run into this problem where she was the only girl in her algebra class,” she said. “She felt the peer pressure to stop taking math after algebra, but she loved it and was really good at, so, as a consequence, we heard all along ‘women are good at math, women can do science, you can do anything you want to do.’”

After high school, Spilker headed to Cal State Fullerton where she was one of only a handful of women majoring in physics. The department’s sole female professor — Dorothy Woolum — quickly took Spilker and the others under her wing. Working with Woolum for a couple of summers on a meteorite study funded by a National Science Foundation grant kickstarted Spilker’s interest in becoming a researcher.

“She really encouraged us and supported us and was an excellent role model for us,” Spilker said.

After graduating with a bachelor’s degree in physics in 1977, Spilker started at JPL where she was presented a choice between working on an extended Viking mission on Mars or a new project called Voyager.

“I asked where’s Voyager going, and they said Jupiter and Saturn and if

Don’t miss our March issue of Sky’s Up.

Women in astronomy

Born on December 11, 1863, Annie Jump Cannon earned her place in the annals of astronomy by developing a system for classifying stars by their spectra.

In the late 1800s, Cannon joined a group of women hired by Harvard College Observatory Director Edward Pickering to pour through astronomical data and catalog the stars as part of an effort that led to the Henry Draper Catalogue. While working on the project, Cannon refined the classification systems of her predecessors to create what became known as the Harvard Classification Scheme, which is still in use today.

Throughout her life, Cannon cataloged around 350,000 stars and discovered hundreds of variable stars. A graduate of Wellesley College, Cannon was the first female recipient of an honorary doctorate from Oxford University, the first woman elected as an officer of the American Astronomical Society and a recipient of the illustrious Henry Draper Medal from the National Academy of Sciences.
I like this project. I love Saturn and the rings. When I started I didn’t think I’d necessarily see it through to the end, but it’s very gratifying. I’m so proud to have said I started on Cassini in the very beginning, and I’ve managed to go all the way to the end.

Like many women both inside and outside astronomy-related fields, Spilker puts balancing a family with a very active career near the top of the list when asked about challenges she has faced. She grew up on a street where there were no working moms and that was still the prevailing paradigm in the late 1970s as she was beginning her career.

At one point in those early years at JPL, Spilker and one of her female colleagues were asked by a high-level manager, who was male, why they felt like they had to work.

“He said ‘My wife is perfectly happy to stay at home, and take care of the house, and take care of the kids. Help me understand why women feel like they need to have a job outside of the home.’ We looked at him and we said, ‘Well, you know it’s very fulfilling to work on a mission like Voyager. We have kids, and we have a family and we have all of these other things. We really want to be in the work force, too,’” she recalls. “I thought that was interesting. It was a very serious question from someone who was sort of looking for an answer back in the late 70s of why women felt like that had to work especially in technical jobs. Of course you’d never get asked that question today, but I sensed it was a general curiosity — that he was curious and probably we weren’t the only people he had asked this question of.”

One factor that helped Spilker find that crucial balance was the timing of the Voyager mission. She had her daughters during a five-year window between the Saturn flybys in the 1980s and the Uranus flyby in 1986.

“I had my daughters just at the very beginning of that, and I tell them, ‘your births are based on the alignment of the planets. And I really mean that, I had five years to have you and have you grow up and be ready to go to preschool and kindergarten by the time all of these things got started,’” she said.

Spilker’s career has always been driven by the science. During her Voyager years, she was fascinated by the work of Project Scientist Ed Stone.

“I really liked what he was doing because he got to look at all of the science, not just one piece of the science. I remember saying to a friend of mine, ‘you know, the job I’d really like in the future is a job like his,’” she said. That desire stuck with her, so when the opportunity to be deputy project scientist on Cassini came up in 1997, she jumped at the chance.

In 2010, Spilker had to say a bittersweet goodbye to the spacecraft that for 20 years had been her long-long-distance colleague in her pursuit of knowledge about the Saturn system. Right up until its dramatic demise plunging into the atmosphere of Saturn, Cassini continued to add to the mountain of more than 600 gigabytes of data it collected.

“There’s a year left for the scientists, myself included, to analyze the data, to calibrate it, make sure it’s in good shape to save that data for future generations,” she said. As Cassini is wrapping up, spinoffs are already in the planning stages. Five of the 12 proposed missions currently being considered for NASA’s New Frontiers program involve the Saturn system.

Spilker is thrilled to note that the principal investigators on two of those five are women.

“I think that really says a lot about how times have changed and how women can have the major lead roles on missions for NASA,” she said.

The data is not the only legacy of Cassini. The mission’s high visibility put a spotlight on the key roles women are playing in major scientific undertakings. This has meant more girls and young women are looking to Spilker as a role model.

“I’m getting lots of little notes or sometimes people send me an email and just say, ‘you’re really great as a role model. I have a couple of questions’... I will always try and respond to those questions and those people because you just never know,” she said. “I never would have imagined myself in that particular role, I’m really proud and really humbled to be a role model to people in the same way that other woman or other people were a role model to me.”

As a woman in astronomy, I am very aware of the image I project and the culture I create. In college I was frequently the only girl or one of a few girls in my classes, and I didn’t have many female role models who I could actually relate to. So now that I’m a professor I try to make sure I’m relatable to students.

“Whenever possible, I try to shed light on the contributions of women scientists, and I try to bolster up my female colleagues by celebrating their accomplishments. I feel like as women, we need to be advocates for each other.

In the decade I’ve been in this career path, I’m encouraged by the progress I’ve seen. There are more women astronomers, and the younger women who are just entering the field as students have so much going for them. I look forward to helping to shape our field to be more equitable for all.”

One of the final images of Saturn’s moon Titan that was taken by the Cassini spacecraft on Sept. 15, 2017, Cassini program manager at JPL, Earl Maize, left, and spacecraft operations team manager for the Cassini mission at Saturn, Julie Webster, right, also participated in the press conference. 

COURTESY OF NASA/Joe Rokowsky
“...it always seemed obvious that those stars up there were going to be somebody else’s suns. It always just seemed natural that the kind of things that happened here might well have happened somewhere else.”
— Jill Tarter

**SETI: a lifelong calling for Jill Tarter**

**By PATRICIA SMITH**
Sky’s Up staff writer

At 8 years old, Jill Tarter decided she wanted to be an engineer. When she started at Cornell University in the 1960s, she didn’t let the fact that she was the only woman in a class of 300 engineering students deter her from achieving her long-held dream. In the 1970s, she became intrigued by the search for extraterrestrial life even though the fringe field of study was more often than not met with eye rolls. She ignored the naysayers, dove into the hunt without hesitation and, eventually, co-founded the SETI Institute.

As a woman and an astronomer, Tarter knows what it’s like to be on the periphery, but she thrives on the edge. For more than four decades, Tarter has been a pioneer in SETI research.

The idea that forms of life might exist elsewhere in the universe was a concept Tarter had reconciled with as a child watching the adventures of Flash Gordon on Saturday morning television, so believing in the purpose of the search was never a hurdle that she had to jump. “I think that just set my world view so that later on it always seemed obvious that those stars up there were going to be somebody else’s suns,” she reflected during a recent interview. “It always just seemed natural that the kind of things that happened here might well have happened somewhere else, and there might be all kinds of different tool-using and technological civilizations out there.”

Even though she had the mindset for the search at a young age, devoting her career to SETI was actually quite unexpected. “I was in the right place, at the right time with a good set of skills that I could do this. It seemed to me it was the most important question you could possibly work on, and I had the privilege to do that,” she said.

The path that eventually brought Tarter to SETI actually began in the early 1960s when she started at Cornell to pursue her childhood goal. As the only woman in the engineering program, she faced a unique set of challenges.

The university had a policy in place that women had to be in their dormitories by 10 p.m. and had to remain locked inside until the doors reopened at 6 a.m. The women’s dorms also were located more than a mile away in the engineering quad. These factors made it difficult for Tarter to participate in the type of group study sessions that her male counterparts took for granted.

“I had to do all of the problem sets myself while the guys were over in their area, and I got a really good education, but I never learned how to be part of a team, and that was a big lack,” she said. “I never experienced a team until I had to lead one, and that’s no good. Being part of a team in a scientific environment is a really important skill to have.”

Tarter finished the five-year engineering degree program a year early. By this point, she was married and her husband was still wrapping up his Ph.D., so Tarter continued taking classes in other disciplines. “I stayed around Cornell, just taking courses of all different kinds knowing that if engineers were as boring as my professors, I was just going to find more interesting problems and people to work with. So I ended up taking a course in star formation from Ed Salpeter, and I just got hooked on that,” she said.

Tarter eventually headed to the University of California, Berkeley, where she began working on a Ph.D. in astronomy. As she was wrapping up her graduate studies, she was approached by fellow astronomer Stuart Bowyer, who was working on a plan to search for extraterrestrial signals using the 85-foot telescope at Hat Creek Radio Observatory.

“He had a great idea about how to piggyback and do SETI observing while the radio astronomers were doing their observations,” Tarter said. “Basically the way a radio telescope works, you can in fact make multiple copies of the voltage time series being recorded at the antennae without introducing very much extra noise. That means that the SETI group could go and take these data and analyze them in a different way looking for engineered signals, and the radio astronomers would be doing what they were doing. They would be deciding what frequency to tune to and where to look. We would be going along for the ride to do SETI. It was a very clever idea.”

Bowyer wanted to bring Tarter on board, so he gave her a copy of the Cyclops Report, which was produced by a NASA-sanctioned committee. It laid out in intense detail the particulars...
for the technology it would take to detect potential extraterrestrial signals.

She devoured the “dense engineering tome” from cover to cover, and emerged fully committed to seeking the long-awaited answer to the question of are we alone.

“I was just so excited because I realized that for millennia we had been asking the priests and the philosophers what we should believe about life beyond Earth. But here, now, in the middle of the 20th century, there were some tools — the radio telescopes that had come out of the second world war and computing — that would allow scientists and engineers to actually go and look and see what’s out there and see if we could answer the question.”

Tarter and her colleagues approached SETI research just like any other scientific investigation. They sat down, wrote a strategic plan, established objectives and procedures, figured out their instrumentation needs and started the laborious process of securing funding. This last task was especially daunting because their field was not one that most people took seriously at that time. To advance their efforts, they needed to move SETI from its unwarranted place on the fringe.

“From the very first decadal review, we made sure that SETI got in there so it kind of got the Good Housekeeping stamp of approval. We always made sure that somewhere in there, SETI was recommended as being a high risk but potentially extremely important reward opportunity,” Tarter said. “We got the people that needed to say good things about us to put that in writing and then we could point to that, and we did frequently. You have to take yourself seriously and not too humorously. There’s this fine line about yes, you can appreciate a joke or two, but if that’s your attitude towards your field, you won’t be taken seriously.”

Over the course of her career, Tarter has definitely seen the mainstream image of SETI evolve.

“We’re now gotten beyond the giggle factor. I think that over the decades, SETI has become legitimate. It is a scientific exploration. There aren’t too many people who roll their eyes when I walk in a room anymore,” she said.

Even with the wider acceptance of SETI observing, Tarter still encounters people that ask why those in her field haven’t given up after decades of looking for but not finding an extraterrestrial signal. In Tarter’s opinion, this take stems from a general lack of understanding of just how vast the search area is and just how little has been actually explored.

“When SETI turned 50, as part of a paper I tried to do a calculation of what fraction of this nine dimensional search space we’ve actually looked at. I ended up with an analogy that if you set that nine dimensional volume equal to the volume of all the Earth’s oceans, what we’ve looked at so far is one 12-ounce glass,” she said. “Fifty years might be long for a human endeavor but it is a short time on cosmic time scales and it is not surprising that we haven’t found anything yet because we’ve hardly begun to look. As hard as we’ve worked at it, there’s still a lot to do.”

Just because SETI researchers have not found THE signal, doesn’t mean that there have not been any “aha!” moments.

“The people that are in the field don’t wake up every morning thinking I’m going to get a signal today because odds are you’re going to go to bed disappointed. But you can get up and say I’m going to figure out how to do it better today than I did yesterday,” she said. “Right now we’re looking at raising funds to rebuild the back end of the Allen Telescope Array to make it more flexible and capable of looking for many different signal types. We’re trying to figure out how we can use machine learning and how we can get that incorporated into our near real time data analysis stream. We couldn’t have thought of any of that 10 years ago, but that’s where we are now. And we always reserve the right to get smarter. That’s where you get your satisfaction.”

In addition to technological advances, two new disciplines in astrobiology have emerged over the course of her career that have big implications for SETI researchers.

These game changers are exoplanets and extremophiles. The confirmation of the existence of exoplanets, which are planets outside of our solar system, has broadened the range of real estate suitable for life. The same basic parameters of supporting life. At the same time, the parameters of what technologies to support life are being refined by the study of extremophiles, which are organisms that thrive in environments once thought to be incapable of sustaining life due to factors like extreme temperatures, pressures and more.

“When I was a student, I was told there were very tight limits on where life could exist — between the boiling and freezing points of water, very neutral PH, reasonable pressures and not very high radiation. Of course, you had to have sunlight because Sun was the engine that drove life. Now, we have found organisms — and they are not all microbial — that live in environments that we couldn’t tolerate,” Tarter said. Examples she points to include tube worms that thrive around hydrothermal vents on the ocean floor under intense pressures; radiodurans living in the cooling waters of nuclear reactors; and tardigrades that can carry on even after being put into the vacuum of space.

“In all the decades that I’ve been doing this, I would summarize by saying that what we have learned has made the universe appear to be more bio-friendly. Maybe more than we thought when I started as a student,” she said. “Now, that doesn’t mean that it is in fact habitable or inhabited anywhere else, but it seems like it might be, so we need to go looking for it.”

In addition to expanding possibilities for finding life outside of our planet, the growing fields of exoplanets and extremophiles are areas of study being well populated by women scientists, according to Tarter’s experience.

Unlike more established research paths, these fields are open territory, and women are finding there is more room at the table because the table hasn’t even really been set yet.

“I’m really ecstatic about that. I thought that should have happened with computer science as well because there’s a new field that isn’t already too heavy with older white male professors, you can jump in with everybody else, there should be more of a meritocracy. That didn’t happen with women in astronomy.
women in astronomy

When Space Shuttle Endeavour launched on Sept. 12, 1992, Mae Jemison became the first African American woman to travel into space. Jemison was the science mission specialist on the eight-day mission, which was a cooperative venture between the United States and Japan. During her time in space, Jemison, who is a medical doctor, served as a co-investigator on a bone cell research experiment flown on the mission. When Endeavour returned on Sept. 20, she had logged a total of 190 hours, 30 minutes, 23 seconds in space. Jemison, who grew up in Chicago, received a bachelor’s degree in chemical engineering from Stanford University and a doctorate in medicine from Cornell University. Before joining NASA’s astronaut program, she worked as a general practitioner in Chicago, received a bachelor’s degree in chemical engineering from Stanford University and a doctorate in medicine from Cornell University. Before joining NASA’s astronaut program, she worked as a general practitioner and a medical officer in the Peace Corps. Upon retiring from NASA in 1993, she founded her own company — the Jemison Group — as well as the Dorothy Jemison Foundation for Excellence. The foundation’s signature program is The Earth We Share, which is an international science camp for students 12-16 years of age.

Tarter knows very well what’s like to work in an uncharted field of science. She knows about challenges like dragging equipment around the globe to access the stars through some of the world’s largest radio telescopes even though only a small fraction of observing time would be available. She knows about rewards like seeing years of planning and fundraising at SETI pay off with the construction of an observatory of their own — the Allen Telescope Array. She knows the opportunities that arise from getting in on the ground floor, and she has been one of only a handful of people who have defined what SETI is today. Her experience is an iconic one that even led Carl Sagan to use her as an inspiration for Ellie Arroway, the tenacious lead character in his book Contact, who was later brought to the big screen by Jodie Foster in the film adaptation. “I know that with Cosmos, Carl Sagan used to get approached by younger people all the time, who said, ‘It was Cosmos that inspired me to go into science.’ It was so great. Contact is now old enough so that it’s hard to decide that we don’t know and the fulfillment that comes from puzzling out a solution. “I think that the thing we need to emphasize to young people today is that what they need to do is find something that they love and get very, very, very good at doing it and then be willing to use those skills not in just doing the same thing over and over again, but in doing something new,” Tarter said. “The jobs of tomorrow many of them don’t even exist today. We couldn’t imagine them, we couldn’t write down a job description or a set of criteria for the jobs of the future, but if you have good skills you can transition and you can in fact prepare yourself now for doing something that you can’t conceive of.”

Advocate for women in astronomy tackles inclusivity, works to foster lasting change

When it comes to her career as a planetary scientist, Dr. Christina Richey has a full plate. She is a Senior Scientist at ASRC Federal, working for the Science Mission Directorate (SMD) at NASA Headquarters; the Deputy Science Advisor for SMD; the Division Scientist for the Emerging Worlds Program, the Cross-Divisional Exoplanet Research Program, and the Planetary Data, Archiving, Restoration, and Tools Program. Her obvious and unwavering dedication to science is outpaced only by her passion for creating a more inclusive, safe and equal workplace for astronomers and planetary scientists. Richey, who is currently serving as past chair of the American Astronomical Society (AAS) Committee on the Status of Women in Astronomy, is a contributor for the Women in Astronomy, is a contributor for the Women in Astronomy Working Group on Implicit Bias. As an active member of the Women in Planetary Science Group. From 2011 to 2015, she was the co-chair of the Division for Planetary Sciences (DPS) Professional Culture and Climate Subcommittees and is currently a member of the NASA Headquarters Working Group on Implicit Bias. Over the last several years, Richey has earned a number of accolades, including the 2014 Special Service Award at NASA for her work within the planetary science community. In 2015, she was the recipient of the AAS DPS Harold Masursky Meritorious Service Award in recognition of her efforts to promote equality, diversity and inclusion in the field of planetary science. Richey recently co-authored an eye-opening study that revealed disheartening statistics on the hostile workplace experiences of women in astronomy and planetary science. In the following Q&A, she reflects on the findings of the study and what can be done to facilitate a climate of equality in these disciplines.

Can you give a brief summary of the findings of the study you co-authored? Do you have plans for a follow-up study?

We wanted to understand the underlying issue of harassment and workplace climate in planetary science and astronomy and analyze which groups were dealing with these issues the most. As published in The Journal of Geophysical Research Planets (click here), we conducted an internet-based survey of the workplace experiences of 474 astronomers and planetary scientists between 2011 and 2015. In this sample, in nearly every significant finding, women of color experienced the highest rates of negative workplace experiences, including harassment and assault. Further, women of color reported feeling unsafe in the workplace either due to their race or gender. Our results suggest that certain community members may be at additional risk of hostile workplace experiences due to their gender, race, or both. This was the first in a series of papers we’re publishing from the data...
Above all, I’m inspired by those who have dealt with some difficulties and spoke out to try to change the world. We need more allies, we need more advocates, and we desperately need more diverse faces to inspire the next generation.

set we obtained. Additionally, we did follow-on interviews with several of the respondents and intend to use that information to drive our suggestions for improvement within the field.

When women face discrimination or harassment, the whole community suffers. How does gender inequality in astronomy affect research and stifle scientific discovery?

Our results highlight that women of color (18%) and white women (12%) skipped professional events due to feeling unsafe within their work environment. It’s hard to become a great scientist when you’re not in the room for that lecture, when you’re skipping out on observing runs, due to fears for your own safety. Now add implicit bias into the equation, and add to that the stress that accumulates over time from dealing with harassment (read section 4.3 of our paper for a few of the many references available), and it’s no longer a question of whether we have a ‘pipeline issue.’ The key question is how do we keep people in fields where there may be a hostile environment? (Note that this goes well beyond astronomy and planetary science, as we’ve seen in the film industry, media and politics in recent weeks.)

Discrimination and harassment force people to choose between their passion and their safety. There’s a constant internal struggle, which becomes a major distraction from study and work. To succeed, one needs to publish (shown to have implicit bias issues) and receive funding (also found to have a degree of implicit bias). The addition of harassment and threats for reporting harassment turns it into a triple whammy. For many aspiring scientists, it’s easier to quit than fight.

Were you surprised by the study’s findings?

I don’t want to say surprised so much as disappointed. I’ve been working to help those in my field who are dealing with harassment issue for many years now; I knew the issue was there. But to see the extent to which people felt unsafe as a result, and to realize the double jeopardy that women of color were dealing with… I won’t pretend that I didn’t sob the first time I saw those results. I’m still upset about it. I’ve been channeling my rage into useful endeavors for those who are being hurt, from working with this fantastic survey team, to helping with policy changes and trying to force our leadership to more accountable to what is occurring.

A couple of years ago I was asked at a town hall on sexual harassment if we (the astronomy community) had reached ‘rock bottom,’ and my response was no, we’d be there if we were still having this same conversation in 5-10 years. Here we are, 2 years later, and while we have made some progress, we still have known harassers in our community, cases of bullying hitting the media, and now a much larger cultural conversation being developed around that. And while there are some who will say we’ve improved, our survey findings were only for experiences from the year 2011-2015, so obviously we have a great deal of progress to make. I only hope we, as one of the most intelligent and capable communities around, can really step up to this challenge.

Do you think the astronomy community can successfully tackle the problem of gender inequality when it is so pervasive in society as a whole?

Yes, I do believe the astronomy and planetary science communities can tackle the issue of inequalities in general and improve their work place climates to have a welcoming environment focused on fantastic science. We’ve made real progress with regard to equality of white women, so I’m encouraged. However, the community still has much work to do with regards to persons of color, LGBTIQ&A+ issues, and in other areas of equality. We brag about being the brightest and most gifted folks around, so if not us, then who? And if not now, when?

What steps need to be taken to further gender equality in astronomy?

We actually had a list of recommendations within our survey paper that came from literature within the field in terms of providing a safe and welcoming environment for all, which is a direct route to furthering gender equality (we can talk all day long about increasing the pipeline, but if it’s a hostile environment, that pipeline is going to useless):

1. A code of conduct or other education on appropriate work behavior should be required of all trainees and employees at all levels.
2. Diversity and cultural awareness training is necessary to raise awareness and understanding of the problems faced by women of color and other underrepresented groups.
3. Leaders in the discipline and in individual programs need to model appropriate behavior and define an inclusive, equitable culture for their workplaces, disciplines, and professional societies.
4. When abuses are reported, “instigators should be swiftly, justly, and consistently sanctioned,” as this is the only way to signal consequences to the target and the broader community. Many of the professional societies have increased their awareness and willingness to openly discuss harassment, including having large-scale town halls and workshops. In addition, the American Astronomical Society has used large signage at conferences and hotline phone numbers, and has updated its Ethics Code for membership to ensure a safe and welcoming environment within its professional society for all.

Federal agencies have also been discussing the issue, and how to deal with principal investigators who are violating Titles IX, VI, et c., and many

Women in astronomy

Dr. Julia Kennefick is an associate professor in the physics department at the University of Arkansas. In this Q&A, she reflects on gender equality in astronomy:

• What challenges have you experienced as a woman working in astronomy?

I’ve been pretty lucky and haven’t experienced a lot of direct sexism, although there have been times when working with certain people was uncomfortable. I was the only female in my class at the University of Arkansas in physics back in the late 80s, but the guys I went through the program with were respectful and we had a lot of fun. Caltech, where I got my Ph.D., had its issues, but I never felt that my research advisor limited me because of my gender. There have been times when I suspected things didn’t go my way because of my gender, mainly due to older men being conservative, but in the end, things worked out to my satisfaction. I did take a break in my career due to having a family, and that was almost a career killer. It’s very hard to take a break in research and get back. But I got a good NSF ADVANCE fellowship in 2004 that got me going again and allowed me to secure a tenure track position.

• What can be done to draw more women into astronomy?

Well, luckily, women have always played a large role in astronomy, so attracting females to the field is not an issue. Keeping them there is, and this is a problem across the board in the STEM fields. I’d say the main issue is climate and promotion. There has to be institutional change in the work environment, both in terms of attitudes and policies. Younger women need more senior women with a variety of life experiences and career paths around so that they can imagine themselves being successful and happy. It’s just that simple.
women in astronomy

In the 1960s, astronomer Vera Rubin secured her well-deserved spot in the annals of astronomy when she and her collaborator Kent Ford began an in-depth study of how stars orbit their galactic centers. Through this research, they stunned the astronomy community by discovering observable evidence for the potential existence of dark matter—a controversial concept first proposed in the 20th century. Rubin began forging her career path when she graduated as the lone astronomy major in Vassar College’s class of 1948. When Princeton rebuffed her interest in their astrophysics graduate program because the program did not admit women, she headed to Cornell University for her master’s and then on to Georgetown University where she earned her Ph.D. in 1954. It was not only her inspiring science that made Rubin an icon in astronomy; she also was a fierce advocate for women in science.

In 1965, Rubin, who had just begun her decades-long career with the Carnegie Institute, applied for telescope time at Palomar Observatory and faced opposition. When she was given the ‘privilege’ to be a part of this amazing community that is working to understand how all this works and came about (this being the whole Universe, or just one planet, or just one species, or whatever thing in STEM motivates you). That privilege would have nothing to do with your race, gender, ability status, partners, whether you do or don’t want children… the only thing that should matter is your science. Know that there are people like me trying to use our privilege and power in this community to make that so for you.

My grandfather said it best: “It’s going to be fun watching you prove them wrong.”

Within my fields, I highly recommend the Women in Astronomy blog, the Astronomers in Color blog, the Access: Astronomers blog, and the Women in Planetary Science blog. I also love the Vanguard Women in STEM series and all the amazing STEM folks on social media.

How did you become interested in astronomy? Who are some of your female role models (contemporary or historic) in the field?

I am a proud Appalachian from a small town where folks don’t necessarily wake up saying ‘today I’m going to become an astrophysicist.’ And I wasn’t the ‘smart one’ in my family; that designation was given to my older sister (who is now an amazing environmental scientist). But I had this huge support system around me that pushed me as much as possible, particularly my mom, who was insistent on her kids becoming first-generation college grads. I fondly remember my grandfather got a telescope when I was kid and showed me Saturn for the first time and I was just amazed. I’d walk around being like ‘I’m going to work for NASA one day… I’ll be an astronaut.’

Sally Ride and Mae Jamison were huge influences on me and so many young girls from my generation. And who doesn’t love Vera Rubin, who ushered in a new era of cosmology (and yet didn’t win the Nobel Prize)???

In terms of the folks influencing me today, Meg Urry has been one of the best people around me that I could call mentor. She was President of the American Astronomical Society while I was the Chair of the Committee of the Status of Women in Astronomy, and she taught me how to use my voice to rise above the chaos and make change. Jedidiah Isler is another woman who inspires me on a daily basis with the work she is doing to connect Women in Color in STEM, and everyone should be obsessed with the Vanguard series. I actually kept going on this list, and quickly realized I could list hundreds of women, and men and non-binary folks, who truly inspire me on a daily basis. One of the greatest parts of my job is being an advocate for my community, and I’m extremely grateful and humbled that they’ve allowed me to stand up and represent them and advocate for them.

Above all, I’m inspired by those who have dealt with some difficulties and spoke out to try to change the world. We need more allies, we need more advocates, and we desperately need more diverse faces to inspire the next generation.

Sky surveyor extraordinaire

Jean Mueller’s long list of discoveries is sure to impress

By PATRICIA SMITH

Sky’s Up staff writer

With the discoveries of 107 supernovae, 15 comets, and 13 numbered minor planets to her credit, Jean Mueller is undoubtedly prolific when it comes to finding and identifying astronomical objects. This number is even more impressive when you consider that searching for undiscovered celestial wonders was just a side venture to her main passion—the Palomar Observatory Sky Survey II (POSS II).

For years, Mueller spent a majority of her nights operating the historic Samuel Oschin 48-inch Schmidt telescope at Caltech’s legendary observatory in southern California, which was a crucial component of the team that conducted the extensive POSS II during the 1980s and 90s. “‘You don’t have to be an astronomer to work in astronomy and really make a difference,’” Mueller said during a recent interview. “‘Good telescope operators are very important to people getting their data and their science done. In astronomy and science, there are a lot of support jobs that are really important, and they’re fun!’

Although she was intrigued by the night sky as a child, Mueller’s astronomical adventures didn’t begin until several years after she graduated from college and was working in the Gerontology Library at the University of Southern California. One Monday night in 1980, Mueller convinced a coworker to go with her to Griffith Observatory for a series of astronomy lessons for laypeople.

“I learned how to look at the sky, and I loved it so much!” she said. “I bought a planisphere there, and I taught myself stars and constellations. In the fall of 1980, I took my first astronomy class at Rio Hondo College. I sat in the back row the first session. After that, I was in the front row every single class.”

Mueller would go on to take several more astronomy courses. Then in October 1981, she took a tour of Mount Wilson Observatory, and a new vision for her future began to emerge. In January 1983, she left the librarian position at USC to take a position as a telescope operator and observer at Mount Wilson. Later that year, she became the first woman to operate the observatory’s 100-inch Hooker telescope.

“The hardest part of being a telescope operator, in my opinion, is making the decision to close an astronomer down...
Astronomer Jean Mueller stands in front of the historic Samuel Oschin 48-inch Schmidt telescope at Caltech’s legendary Palomar Observatory in southern California in the 1990s.

COURTESY OF Jean Mueller

**You don’t have to be an astronomer to work in astronomy and really make a difference. Good telescope operators are very important to people getting their data and their science done.**

In astronomy and science, there are a lot of support jobs that are really important, and they’re fun! Due to weather conditions or other environmental issues like ash from a nearby forest fire, she said. “Probably even harder than that is when to open back up. What’s that fine line between keeping your instruments safe and getting the sky available to the astronomer again so they can do their research.”

In 1985, Mueller left Mount Wilson for a post at Palomar Observatory just as the institution’s second sky survey was getting under way. This extensive wide-field scan of the entire northern sky was a reincarnation of the first Palomar Sky Survey, which was an almost decade-long venture that began in 1949.

“An almost decade-long venture that began in 1949. The second survey tackled the same celestial real estate with more advanced equipment and technologies. “Now the importance of the second one would never rival the fundamental contribution that the first one had, but I knew it was still a reference work extraordinaire,” Mueller said. “It was an honor to get to work on this project.”

Over the course of almost 15 years, Mueller worked on the survey — taking around 6,500 photographic plates. Shortly before POSS II wrapped up, Mueller did an eight-month stint taking observations on the Palomar Testbed Interferometer before moving on to operating the observatory’s 200-inch telescope. However, on the final night of the sky survey she had the honor to set the 48-inch telescope for its final exposure and remove the last plate.

Mueller’s dedication to completing the mission of the second sky survey was unwavering, and, like everyone on the team, she always put the needs of the survey first. That didn’t prevent her though from eventually tackling a new challenge — discovery!

“The day I went to the interview for the sky survey job, I had no idea that I might be able to discover something. That had never even crossed my mind,” she said. “Once I started working at the 48-inch, there were two people there who encouraged me to look at the plates. They said you can make discoveries, and they gave me the tools and the knowledge to do it.”

Although she was excited at the idea of making discoveries, Mueller couldn’t really dive into analyzing the plates for the first couple of years because the 48-inch telescope had no autoguider. This meant that Mueller had to hand guide all of the plates as well as process them and inspect them for quality.

“It wasn’t until the summer of ’87 that I started looking at the plates carefully — looking for comets and asteroids,” she said.

On October 18, 1987, she discovered her first comet — 120P/ Mueller.

“For comets — there is an adrenaline rush that I can’t describe. It feels so good to find a comet. I have to admit I miss that,” she said.

In 1988, Mueller expanded her search criteria and became quite adept at finding supernovae.

“The hard part is learning what to look for. The supernovae search took a long time. There’s no way to tell a star from a supernova until you compared that object on that plate with a plate or print that had been taken years before,” she said. “Sometimes it would take an hour per plate to scan for supernovae. Whereas the comet/asteroid search I could do that in about 15 to 20 minutes per plate.”

Through her work as a telescope operator and discoverer, Mueller developed a special appreciation for the plates that she and so many others had labored to produce. In 2002, thousands of plates stored in a large vault in the basement of the Caltech astronomy building faced an uncertain future when more space was needed for an optics lab. Mueller heard about the issue while operating the 200-inch one night, and presented a proposal for securing the plates, which were spread out between an inner and an outer vault.

She ended up putting together a group of a dozen volunteers who spent about eight months helping her organize, inventory and pack away the plates.

“Every weekend off, I spent three days at Caltech in that plate vault analyzing the plates for the first couple of years because the 48-inch telescope had no autoguider. This also gave me the tools and the knowledge to do it.”

The plates vaults were very messy. There were unopened boxes. There were plates that were never put in sleeves. Things were out of order. They didn’t know what was in there. The only section that was in fairly good order was the inner vault, which held the two sky surveys, POSS I and POSS II. That’s the good news.”

In the end, Mueller and her team of volunteers packed up 558 boxes of plates that were moved to Palomar.

Although she retired from her post as a telescope operator years ago, Mueller is still an active presence at Palomar due in large part to her ongoing efforts to preserve its history through an artifact archive. This effort involves collecting items from around the observatory that have significance then photographing and cataloging them.

“The items will then be stored in an archive room in the 200.”

“This is what I’m doing now — making sure that nothing gets thrown out that shouldn’t be thrown out,” she said. “I’m trying to keep stuff that tells the story of Palomar. We call it the Palomar historical collection.”

Outreach is another important part of Mueller’s life, which is obvious from her longstanding commitment to the RTMC Astronomy Expo, a major amateur astronomy event that will celebrate its 50th year in 2018.

Mueller, who has served on the RTMC board for years and has missed an expo since 1990, believes this type of outreach is vital. “Everything that we do adds up,” she said. “All the meetings, all the star parties around the country, if you can inspire a few kids every year, you’ve done good.”

On August 1, 1786, Caroline Herschel became the first woman to discover a comet. As a young woman, she was stifled by a musician and conductor. This move set her on the path to a revered place in the annals of astronomy.

Once she was in England, Caroline cared for William’s household, and he taught her mathematics. At the same time, he delved deeper into his burgeoning passion for astronomy, and, soon, recruited Caroline to serve as his astronomy assistant. In this position, she helped him grind and polish mirrors for telescopes he built, and, most importantly, she recorded his nightly observations and did the intense calculations that were necessary to pinpoint exact locations of the objects he had seen. After he discovered the planet Uranus, William appointed the planet Uranus, and he and Caroline embraced the skies full time. Eventually, Caroline started making her own observations and began to discover nebulae. On August 1st, 1786, she found her first comet and got on the king’s radar.

The king quickly employed her as William’s paid assistant — making her the first female astronomer compensated for her scientific services. Caroline would go on to discover more nebulae and seven other comets. She also catalogued every item she and her brother had found and continued to rack up honors. These included being the first women to receive the Royal Astronomical Society’s Gold Medal, gaining honorary membership in the same organization and receiving the King of Prussia’s Gold Medal of Science Award.
Scientist sees education as best weapon against light pollution

By KEITH ASHLEY

Guest Contributor from International Dark-Sky Association

“From Shakespeare’s sonnets and Van Gogh’s starry nights, since the beginnings of humanity, we have shared this enormous source of inspiration,” explains Dr. Connie Walker, a scientist at the National Optical Astronomy Observatory (NOAO) Office of Education and Public Outreach. “And to think that it might not be there for future generations….”

Walker is referring to the natural night sky, and lamenting its destruction through needless light pollution. Walker has devoted much of her career to tackling this issue by creating opportunities for younger generations to learn about the “dark skies” mission, the dangers of light pollution and how we could collectively solve this problem, soon.

Through her work at the National Optical Astronomy Observatory, Walker has developed and managed several astronomy-focused educational programs for K-12 students and teachers, universities and the general public. Her work was recognized by the International Dark-Sky Association (IDA) in 2011 with the prestigious Hoag-Robinson Award. Walker is now serving her sixth and final year on the IDA Board of Directors, and has brought her focus on the next generation to her leadership, spurring IDA members to take part in the Globe at Night project, and the creation of an Education Committee committed to the goal of teaching youth about light pollution.

Globe at Night is an international citizen-science project that enables participants to log night sky brightness data for their communities. It contributes to our global knowledge of light pollution, while helping connect students and families to the wonders of the night sky. After participating in Globe at Night, high school students and local amateur astronomers in Norman, Okla., took the data they gathered to their city council and within two years the city created stricter lighting ordinance. Also among Walker’s many accomplishments is the Quality Lighting Teaching Kit, a problem-based learning model that engages students in real-world scenarios solving light pollution problems affecting wildlife, human vision, energy waste, safety, light trespass, and the night sky. The Kits are being used by 92 different organizations in 32 countries. “We know that kids really get it when they have the chance to do it,” says Walker. “The feedback we’re getting is that after they learn about the situation, and explore solutions, students want to make changes. We’ve seen these kinds of education campaigns work in the past—think of littering and the revolution in recycling.”

Globe at Night and the Quality Lighting Teaching Kit are just two among many learning projects Dr. Walker has brought to life during her 17 years with NOAO and her two terms on the IDA Board of Directors. During that time she has also guided her own two children from cuddle toys to college. As toddlers Connie’s daughter and son could often be heard in the halls of Steward Observatory, where she and her husband both worked. Later the children participated in many star parties and astronomical events with their mom and dad.

Workshop in the Canary Islands on the Quality Lighting Teaching Kit at the SpaceLight, Beyond Light Pollution Conference May 2016 attended by astrophotographers, local teachers, astronomers and staff from the La Palma Office of Tourism.

IDA relies on strong female leadership

The International Dark-Sky Association’s success is built on a foundation of women’s leadership that lives on today. Dr. Connie Walker is one of seven women who currently contribute to the success of the International Dark-Sky Association through their leadership on the Board of Directors. Three of her IDA colleagues also work in fields directly related to science and conservation:

- Diana Umpierre (AICP, GISP), IDA President, is a dedicated dark sky advocate. With more than 25 years of experience in urban planning, geography and geoscience, Umpierre currently works as a grassroots organizer for Sierra Club. Her passion for grassroots/public advocacy began with efforts to protect the last remaining natural night skies over Florida’s Everglades. In 2013 she was named IDA’s Volunteer of the Year, and in 2016 she helped kickoff IDA’s Grassroots Empowerment Advisory Committee.
- Kim Patten, IDA Vice President, has an M.S. in environmental planning from the University of Arizona and more than 10 years of experience managing projects and programs in conservation, renewable energy, and distributed data systems both nationally and internationally. Her experience includes managing and conducting research on a more than $30 million portfolio, including co-principal investigator on a $3.6 million National Science Foundation cooperative agreement and project manager of a $22 million U.S. Department of Energy funded project.
- Kellie Pendoley, IDA Director, has worked for more than 30 years with the oil and gas, mining and ports industries and local councils to minimize and manage their light pollution and to protect nearby marine turtle rookeries from negative impacts of artificial light at night. Kellie is actively involved in the development of biologically meaningful light measuring equipment, as well as research to improve understanding of the impacts of light on seabirds and marine turtles.
Although they followed different career paths (law and computer science) there is little doubt where they got their love of learning and drive to succeed. Dr. Walker’s accomplishments are inspiring ... and inspiration, itself, is part of her motivation. “From the days of Star Trek and the first man on the moon, I have seen starry skies opening our minds to endless possibilities,” explains Walker. While Walker is motivated by the humanistic aspect of protecting night sky heritage, she is equally in tune with the significance of preserving dark skies for astronomy and research. Walker was herself a radio-astronomer who helped to build instrumentation for the Heinrich Hertz Sub-millimeter Telescope for Mt. Graham in southeast Arizona. With an undergraduate degree in astronomy-physics, a masters in electrical engineering, and a Ph.D. in astronomy, Walker is one of those rare individuals who values night skies from both the humanities and the scientific perspectives with equal depth. Walker easily identifies the heroes who inspired her, many of them notable women in the field of astronomy. Waltraut Seitter, director of the Astronomy Department at Muenster Universitaet in Germany was “a powerhouse” who invited Walker as a student to work with her at the observatory in Germany. Dorrit Hoffleit of Yale was the director of the Maria Mitchell Observatory on Nantucket Island and gave Walker her first summer job. And Maria Mitchell was herself the first female astronomer in the U.S., a comet-finder in the 1840s who was not recognized as a scientist in her home country, though the Queen of Denmark honored her. When Walker describes the education projects she and her team have created, it’s impossible not to hear in her voice a sense of maternal pride, love, and concern. Equally clear is a scientist’s insight—and a dark-sky advocate’s hope for the future of night on Earth.
Changing our mindset on outreach

By THERESA SUMMER
Guest Contributor from Astronomical Society of the Pacific

You may remember a night in your childhood looking at the stars or your first view looking through a telescope. Can you recall that initial experience that sparked your passion for astronomy?

Imagine if, when you were full of the joy of this newfound wonder, you were actively and/or passively discouraged from pursuing it. This experience has happened to many girls and women. Many astronomers are aware of this problem and are deeply saddened by it. They wonder what they can do to increase opportunities for girls. Please, read on!

The Astronomical Society of the Pacific (ASP) is working to even the playing field by participating in a new STEM project organized by the SETI Institute

“Reaching for the Stars: NASA Science for Girl Scouts” was selected by NASA’s Science Mission Directive release from SETI. Other partners in the project, which is led by the SETI Institute’s Edna DeVore and Pamela Harman, include NASA STEM professionals, the Girl Scouts of Northern California, the Girl Scouts of the United States of America (GSUSA), the University of Arizona, and Aries Scientific at Goddard Space Flight Center.

One focus of ASP’s work is to help create content for new space science badges for all stages of Girl Scouts, from the youngest “Daisies” (kindergarten age to graders) up to high school — the Senior and Ambassador levels. We are also assisting with the Volunteer Tool Kit — an online resource guide for the adults

who work with Girl Scouts. ASP is also holding workshops with astronomers to prepare them for working with Girl Scouts.

Creating these workshops has given me a wonderful opportunity to investigate this problem of how astronomy can be more welcoming to girls. I want to share one finding that has great potential.

One key idea that has emerged in education and psychology is something called “growth mindset” based on work by Carol Dweck, a psychology professor at Stanford University. In a 2012 interview with onedublin.org, Dweck described both fixed and growth mindsets: “In a fixed mindset students believe their basic abilities, their intelligence, their talents, are just fixed traits. They have a certain amount and that’s that, and then their goal becomes to look smart all the time and never look dumb. In a growth mindset students understand that their talents and abilities can be developed through effort, good teaching and persistence. They don’t necessarily think everyone’s the same or anyone can be Einstein, but they believe everyone can get smarter if they work at it.”

With a fixed mindset, we accept much of the status quo and do not challenge it. When an authority figure tells us we believe them. It can become part of the mindset of our budding astronomer. If success in science is a pre-determined trait that only belongs to boys, then there is no pathway for girls to even try.

Growth mindset, on the other hand, encourages not only girls, but also other groups that sometimes get left out of science — people of color or low-income folks, for example. It also can be very freeing — we no longer have to prove we are smart at every encounter. We can truly listen to what others have to say. We know our knowledge comes from our efforts, persistence in the face of failure and our experiences.

Growth mindset is also the way science works! We call the scientific method “trial and error.” We make mistakes, we fail, and we try other strategies. We see how learning happens through practice and effort, and is not a set quantity determined at birth by your gender. With a growth mindset, a girl has the ability to fight that authority figure and say, “Yes, I can. I may not have mastered this yet, but I can.”

With this in mind, what we can do is to create welcoming astronomy experiences for girls to counteract the negative messages they have received.

So our first step in creating a welcoming environment is to have a growth mindset ourselves. For every astronomer reaching out to children, you must believe that each one of them can achieve their goals with effort, persistence and the ability to try different strategies when they get stuck. Sometimes it can be tricky to re-imagine activities we have done many, many times over! Let’s take an example of a traditional star party.

Often, amateur astronomers will set up telescopes, show the sky and sometimes give lectures on the objects to see in the sky. A way to make the evening more welcoming to girls would be to ask questions about the girls’ prior knowledge of astronomy. If some have extensive experience, speak to them at their level. If they are newcomers, tell a story of when you were a beginner. Bring some inexpensive equipment, such as binoculars or a second telescope, that girls can use to spy on their own celestial targets. Share some star charts, or even make some with the girls in lieu of a lecture. When they have a question, encourage girls to talk to each other and think about it, before providing an answer.

The practice of thinking and reasoning will stay longer with a future scientist than providing a quick response, and gives an experience that shows that they, too, can do science.

A last thought:

While we won’t be able to reverse all of the sexism built up over our society’s history, we can give all children the tools to fight its effects. We can help girls to thrive, by creating interactions where they can practice on their reasoning skills and build their own science confidence.

Theresa Sommer is an astronomy educator for the Astronomical Society of the Pacific. She has worked in science education since 1998, mainly in planetariums and museums, but also in high school classrooms, teacher trainings and tutoring. She has two bachelor’s degrees: one in Astronomy and Physics from San Francisco State University and one in Theater, Education and Empowerment from Eugene Lang College, the New School for Social Research. Her secret mission in life is to help people to understand that science is not just for crazed geniuses in lab coats, but is for everyone, and is an important part of being an active citizen in today’s world.
Two magic minutes worth the trip

By DAVID H. LEVY
Sky's Up Editor in Chief

What happened on August 21, late in the summer of 2017, was breathtaking, incredible, and incomprehensible. An eclipse of the sun is actually very simple — a cosmic coincidence during which the Moon passes in front of the Sun. Because Wendee and I were in the path of totality, we saw a total eclipse, which is a lot more than science, and which is not so simple.

We left Tucson on August 19th, traveling by airplane to Los Angeles and thence to Redmond in Oregon. We arrived in Madras a few hours later, and over the course of the next day joined with several of our friends who had agreed to make a similar trip. The eclipse began promptly at 09:07 a.m. on the 21st. As the Moon took its first tentative bite out of the Sun, the eclipse appeared to be as simple as described; as more and more of the sun was covered by the moon the temperature began to drop, slowly at first, and then more precipitously. And with less sunlight, shadows of buildings, trees, and people became sharper. But still the eclipse was a simple event — until totality came.

As the shadow of the Moon approached us, the solar crescent became a thin line of light. As the light began to thin even further, it broke into a multitude of points. Bailey’s Beads! First described by Francis Baily at the annular eclipse of May 15, 1836, these tiny beads of sunlight peering through valleys at the edge of the Moon, precede and follow totality. Within a second or two those beads vanished, all but one. At that one moment, the Diamond Ring, the simplicity of the eclipse utterly transformed itself into a complex symphony of magic, beauty, romance, emotion and wonder. This effect, which takes place in the seconds just before and after totality, is very difficult to see. Sadly, she told me that she had failed to see them. “I did see a faint rolling effect of light and darkness that lasted for a few seconds.”

“I can’t!” I answered her. “You saw the shadow bands, that’s what they often look like!” The play of light and shadow is very subtle indeed. At only one other eclipse did Wendee and I see better shadow bands. Instead of a small white sheet to cross over, the eclipse did Wendee and I see better shadow bands.

The corona, the Sun’s atmosphere, stretched several solar diameters out into space; actually it reaches Earth. Two minutes later the shadow left us and continued on the road with Doveed. We had been witness to one of the most spectacular events nature can provide — a total eclipse of the Sun.

A partnership written in the stars

By WENDEE WALLACH-LEVY

No matter what I chose to do in life I was always the organizer. As a physical education teacher and coach, I organized all the in class tournaments, the intramural activities in my schools as well as the after school activities. My days were long, and my weekends non-existent as they were filled with school sporting events. On the occasional weekend when no school events were planned, I did volunteer work for our local American Red Cross Chapter. There, I organized the annual Learn to Swim programs in the city of Las Cruces, N.M. Before I retired from teaching I was the chair of the local Health and Safety Services Committee. As if I didn’t have enough to do I moonlighted for New Mexico State University at the Weekend College on Sunday afternoons. Without going into great detail about each area I organized I viewed the rare free weekend as a vacation. I used to wonder, after all the organizing I did during my 26 year teaching career, what would it be like to organize a famous person. (This was way before I had met David).

Needless to say, when David and I eventually did get together I was ready to keep his life organized but totally unprepared for what I thought would be a fairly simple transition. When it became obvious that I was going to formally retire from teaching and move out to Tucson and co-habitate with David, this is how I broke down our tasks. I began by confessing to David that I knew comparatively little about astronomy, but did know enough to see through a situation/problem and intuitively know what needed to be done. Then I objectively looked at our strengths and naively said these words: You are a wonderful astronomer, lecturer and writer, I will take care of everything else. (What was I thinking?) At first David disagreed. He knew how hard I worked in Las Cruces and he wanted to take care of me and let me just relax and enjoy the ride. That didn’t last long. By the end of our first week, I took over the billing and the shopping, and 21 years later I am back to doing what I originally suggested. For those of you familiar with the Rocky movies, especially Rocky 1, this needs no explanation. One of the strengths of our marriage is that our strengths are so different, there is no competition between us in every aspect of our life together. We are like the Opposite extremes of the Opposition tract theory. One of the best descriptions of our partnership was best described by John Thompson, a regular attendee at our Adelante Astronomers Retreat. He simply said: David is the talent and Wendee is administration. As much as I didn’t like the sound of my half of the description, I had to admit, he pegged our roles exactly. In other words, I’m now doing for David what I originally suggested he do. I live my life by the calendar and the moon phases so I can make sure to keep David’s schedule the most productive for him. When he is invited to lecture, the first thing I do is make sure the calendar is free at that time and the next is to check the moon phase. I make sure he knows if he will be missing an optimum observing time or if the upcoming lecture trip will allow him the opportunity to observe there as well. When asked if I will be accompanying him on a particular trip, usually my response is “No. I cannot do his job and mine at the same time.” In the beginning I tried traveling with him. After a few years it became easier for me to get David ready to go and I’d stay home and handle emergencies from here. Among the things David has me do for him, that I had never done before is copy edit his writings. If any of David’s book publishers are reading this article, you need to thank me. I generally read and edit his books two times. The first time is when I see his first draft. That is any eye opener. David cannot type. (The best thing I learned in school was touch typing). David’s first drafts in some places are incomprehensible. My initial corrections are as simple as a spelling correction to a possible re-wording of what I think he meant to say. If he didn’t tell me his stories and fascinating research for each book I would be lost. There are the occasional corrections that look simply like this: “.” In other words the publisher and the professional copy editors then have a comprehensible book to work with. When we get the galley proofs I read the book again for the tiny errors we all missed and to do his index.

The point of all of this is that the way David teaches me about astronomy is through his books that I edit and by listening to his lectures. David and I each have our ways of doing things and they are never alike. But, in the ways we need to be alike we are truly in sync with each other. It starts with the simple fact that we not only love, but we like each other and enjoy being together 24/7. Our brains seem to work at the same speed, we have the same beliefs and ideals that when added to the enormous respect we have for each other allows us to work so well together.
“The Moon is a wonderful friend and companion to the Earth and its residents. Hardly a day goes by that someone does not hear me say, ‘Oh! Look at the Moon.’ It is like Earth’s little brother, and a rocky soul mate to all who dwell here.”

— Howard Eskildsen

It’s a steady presence in all of our lives, but few people take the time to truly get to know Earth’s closest neighbor.

In this recurring feature, accomplished astronomer and astrophotographer Dr. Howard Eskildsen will take readers on a quadrant by quadrant journey across the luminous face of the Full Moon.

Through his images and words, Eskildsen will explore the legions of geological formations that give the Moon its distinct personality. His in-depth information will give context to the features that pop to life when one views our oft romanticized satellite through a telescope or other optical aid. Over the next few pages, the impacts of volcanoes, meteors and other forces will be revealed in detail.

From its contribution to our tides to the artistic inspiration it provides, the Moon’s influence on Earth is profound, and it deserves a deeper look.
Rubble surrounds smooth basins

This quadrant stretches from Mare Vaporum (Sea of Vapors) to Sinus Medii (Middle Bay) with the ghosts of ruined craters overlain by ejecta from the great Imbrium impact beyond the upper left of the image. The devastation caused by that impact was later modified by subsequent periods of volcanism, cracking of the crust, and later, smaller crater-forming impacts.

The rugged lands of the upper left and lower right of the image are tailings of material ejected from Mare Imbrium after some ancient craters had been formed. Presumably, the basins in which Sinus Medii and Mare Vaporum lie were once craters or small impact basins that were inundated by the ejecta, leaving only depressions as a reminder of their prior existence. Craters such as Pallus, Murchison, Rhæticus and Dembowski fared slightly better, only being partially obliterated by the raging rocky torrent from so long ago.

Note the plateau on the lower right of the image near the letter C. This is a collection of rubble that fortuitously assembled in the plateau form and is sometimes referred to as the Godin C Plateau, just above its namesake crater to the left of the letter C. A smooth patch of mare basalt winds its way from the lower portion of the image all the way to the top of the image. After the Imbrium devastation, lava rose through cracks to fill depressions of Sinus Medii and Mare Vaporum and low areas between. The angled Hyginus rille is bisected by the rimless crater six miles in diameter named Hyginus. This has the looks of Earthly collapse pits of extinct volcanoes. Also notice the tiny string of craters to the upper left of Hyginus. These also are likely collapse pits representing the last gasps of volcanism from that area.

A dark mantling coats the right side of Mare Vaporum as well as on the left side of the image. These pyroclastics represent the final volcanic activity in the region. Orbital spectral analysis shows them to be glassy material like that spewed from fire fountain eruptions as seen in Hawaii. The region known as the Bode Pyroclastics is part of the largest known pyroclastic deposit on the moon.

The crater Bode impacted into rubbly terrain and has a curious radial ridge, perhaps due to asymmetrical collapse during the crater formation. Next to it lies a sinuous rille just visible on this image. Other preserved craters are notably smaller than the ruined craters and suggest a decrease in size and frequency of impacts that have occurred with time.

Triesnecker, 16 miles in diameter, is the most notable crater on the image with terraced walls, distinct rim and ray remnants brightening the surrounding surface. It rests near a complex series of rills, or cracks in the outer surface of the moon. Something, perhaps rising magma, caused swelling of that area and cracked the surface. The crater came after the rilles since the branch of the rill disappears under the Triesnecker ejecta. Still later, smaller, tiny craters such as Bruce and Blagg pocked the lunar surface, but other than a rare impact little has changed in this area for perhaps three billion years.
Ruined craters, impressive rilles

The top of the image speaks of devastation as if a slurry of mud had been smeared from the top right to the central part of the image. Of course, it was fluidized ejecta from Imbrium, not mud, that did the dirty deed, but the effect is the same. Ruined craters Julius Caesar and Boscovich fared better than the craters above them that are now discernible only as wretched rectangles or as the depressions at the top of the image that are now filled with lava. Some of the basalt-flooded depressions include Lacus Lenitatis, Lacus Hiemalis, and Sinus Honoris. Boscovich and Julius Caesar also have lava-coated floors that are mostly smooth except for the rill seen crossing Boscovich.

A large crack known as Ariadaeus Rille can be seen angling across the center of the image. Its steeply sloping walls and flat floor show it to be a type of fault common on Earth that is known as a graben. Forces from below split the outer surface apart to form parallel cracks that spread apart while the central part sank downward. The rille is about 220 km long, 4-5 km wide and about 0.8 km deep. Based on the geometry of the parallel faults, they are believed to meet at a depth of 2-3 km where there is likely a more coherent layer of rock beneath the heavily fractured outer layer of ejecta known as the megaregolith (regolith is the term for the lunar surface soil).

Note how the ridge just north of Silberschlag also drops downward across the rill and hence predates the formation of the rille. Also, a branch on the western end intersects with The Hyginus rille. The opposite end of the rille disappears near the crater Ariadaeus, which abuts a smaller crater known as Ariadneus A. They are separated by a straight thin wall indicating that they formed from two objects that impacted simultaneously, suggesting that either they had been traveling as a gravitationally bound pair prior to impact, or had been split by tidal forces just prior to impact. On the lower right of the image the craters Ritter and Sabine may have formed in a comparable manner, although not to the extent of the upper part of the image. Dembowski, Temple and D’Arrest suffered severely from the Imbrium impact though more than 650 kilometers away from the Apennine rim. Agrippa and Godin arrived after the disaster, however, and so were spared.

Finally, the diminutive crater Cayley deserves mention as the namesake for the Cayley Formation. The flat areas of the formation extend southward and includes an area near Descartes, a very forgettable crater had it not been for the landing of Apollo 16 near there. What they were seeking was not found, and their unexpected discoveries rewrote our knowledge of the lunar geology.
Taking astronomy to the people

Life of an outreach educator is a hectic one

Never in a million years would I have expected to find myself in a place where I would ever be considered a pioneer or trend-setter of any sort. Amazingly it is all astronomical – in the literal sense of the word.

More than a decade ago I looked at the Full Moon through a 4” Orion telescope at the Lowell Observatory and knew I would never be the same. My husband and I left the observatory with that same telescope, which he had reluctantly purchased for me and said, “We are never going to do anything with that.” Now, thirteen years later, our back room is filled with telescopes numbering in the double digits.

As a right-brain thinker, artist and tactile learner, I quickly realized astronomy is a great science that accommodates a full spectrum of individuals — from the most linear thinker to the most artistic-creative individuals. However, it is dominated by left-brainers, and throughout the years that has been extremely alienating and lonely for a right-brainer like me.

In 2009, I took on the position of International Year of Astronomy Coordinator for a large astronomy club. I found that watching the public’s reaction to looking through my eyepiece brought back the same feelings as when I looked through the telescope at that Full Moon at the Lowell Observatory. My excitement continued the more involved I got, but I was taken aback that I was not being encouraged by club members. My enthusiasm and passion about this new found hobby seemed to create a disturbance in the force, and rattled the cage of a few of the veteran members. One woman told me, “You are too loud for astronomy. Astronomy is quiet.” I retorted, “I have an Einstein quote app and he never said that it is not true.” I was surprised that a woman would have tried to stifle another woman since there are so few women in this hobby. Another was surprised that a woman would have tried to stifle another woman by little, I found my way into STEM Nights at elementary school not only in Broken Arrow but into neighboring school systems as well. Teachers freely passed my name around to their fellow teachers and our calendar quickly filled up! A few teachers also had us come to their Girl Scout events where I garnered a new name — Solar Sister.

Word spread, and in no time, we attended 15 to 20 STEM functions a year in three school systems. Several of these schools had their first STEM event so I would send them many ideas and activities in addition to our telescopes, which were always greeted with great enthusiasm and gratitude from the school staff. In fact, we got to see our first STEM elementary school receive the International Excellence in STEM Award in 2013. Unfortunately, the next year, the Oklahoma legislature started defunding STEM and education by 30 percent for the next few years.

Still, classroom visits grew and a few after school astronomy clubs were birthed at community schools in the Union School District. These schools had a more economically challenged and culturally diverse student population. My activities usually are generated with middle schoolers in mind, which allows me to water the material down if necessary. When I showed up to these schools to teach 4th and 5th graders, along with a 3rd grader or two, I announced that we were going to do a middle school-level class on the Hertzsprung-Russell Diagram, which is a tool used to classify stars. I added that I could make it for their grade levels if they wanted. They emphatically said, “No,” and insisted I use what I had prepared. So that day, 15 students learned the Oh Be A Fine Girl Kiss Me mnemonic associated with stellar spectral classification while they used colored pencils to fill in the H/R chart. One week they used a slingshot to make craters, another week they made a sun spot, and then, a plastic coin drop to show gravitational waves and black holes. My favorite, though, was the Hubble Classification of Galaxies. I would give them a back-to-back sheet with general information on my topic and a space to fill in. One week they used the double digits to make craters during a STEM function run by Walker. Survey and asked them to tell me which dots were stars and which ones were galaxies. The stars were easy. I told them not to worry because at the end they would be able to tell me which ones were galaxies AND what kind they are. Little did they know I came packing an edible surprise. When they finished their classification fork diagram, and they successfully named the galaxies in the book, I asked them if they would like to eat a galaxy. Their eyes got big as I pulled out a box of large cinnamon rolls. I cut them in fourths, and they joyously ate their spiral galaxy.

One of these schools became my favorite place to be on...
Wednesday afternoons, two weeks before the end of my eighth week commitment, the school embarked on its first ever STEM Night. I got a crazy scheme to set up scopes on the rooftop. After getting clearance from the manager, we set up before sunset and encountered a newly married couple from Tulsa. The manager came up then continued to send up her staff, maintenance crew and some guests throughout the night. It was fun hosting our very first “roof top” astronomy. As a staff member of Astronomers Without Borders, I met Amelia Gil from Valencia Planetarium, where she ran the “Sky in Your Hands” planetarium session for the blind. I was co-chair with her for the People With Disabilities for Global Astronomy Month and worked with others like noted astronomer Noreen Grice on doing outreach for those with accessibility issues. Amelia’s program consists of a 3D printed, 18-inch half-sphere with a few constellations on it and an integrated show with visuals and music with narration. Working with her got me thinking: Is there some way for blindlegally blind people to feel what I see when I look at Hubble images? What would be more interesting and exciting than smooth resin with a few gradations or raised spots? What dynamic materials can I use that would be more engaging than ridges and lines in a Braille image book? This group was so inspiring, it is these six to eight people from all over the world that shared their successes and failures that I storyboarded another paradigm shift. As I embarked on this new journey, I started to print out some popular Hubble images and let me imagine go! As a creative artists and lover of fabric and sewing, I have lots of friends in the cloth business that I take my projects to and ask for advice. The Ring Nebula was suitable for satin, colored foam, some beads and red tulle for the nebulosity around the edge. The Orion Nebula looked like a prom dress to me with a wonderful star-studded belt at the waist. It screamed for chiffon, organza, netting, tulle and pearls just like a real prom dress. Of course, I could not forget about a foam witch-head piece in the bottom of the pond that would allow for the sense of cold gases and twisted dark nebula. The Crab Nebula reminded me of a cool clear pond with lots of vegetation that would wrap around your feet once you entered the pond. So, I thought it was fitting that a turquoise synthetic fabric that is cool to touch for the water, and then moss for the vegetation in the pond. A larger pearl bead would be for the pulse in the center of the nebula. The Seven Sisters had turquoise netting with white batting for the nebulous gases and large pearl beads for the girls. The Hercules Cluster does not have stars in all the exact and proper location like on the image, however, it does have six different sizes and colors of beads for those who are legally blind or have some vision to show the younger age of this object. This panel has yellow, gold and several white pearl beads in a few sizes and then to delineate the number of young blue stars, I used faceted dark blue and light blue beads. This will give a good indication of how many young stars are in this cluster. Coral Hale-Jopp had a foam core with some glitter to add variety, then a ruffling of light green tulle, cording and a huge bead.

My friend who works with the Night Sky Network happened to talk about my crafty endeavor with a lady from a club in Talequah, Okla. I was told to be on the lookout for a lady at the Okie Tex Star Party wanting to meet up with me. She commented her club had several members with low vision and needed to figure out how to help them stay connected to astronomy. The NSN gave her my name and I was asked to bring some samples and hunt my fellow Oklahoman down. The last day we spotted each other, and I showed her the attempts.
I continued to add several other items like a wooden moon phase resource from a NASA poster and wooden phase pieces that could fit on top of the face mask to a large wooden panel of the planets that featured the scaled sizes of the planets. I made lunar craters out of Styrofoam rings, sand, gesso and clay. The Hertzbrunsgen Russell Diagram was on a wooden panel with foam core models of the moon and sun. I covered the sun with a large Styrofoam ball for a Sun globe where I glued yellow, orange, and red beads on and made holes for the sunspots with pipe cleaner connection currents. I used a wooden panel to make a replication of the atmosphere of the planets using the different cotton cotting and smaller orange cotting for the bands and zones. I embarked on making a curriculum for the blind using the sun, moon and planets complete with a binder of information on the constellations on the panel that could host at least 4 classroom sessions. I spoke at Oklahoma School for the Blind and brought my wares for my talk to teachers from the national schools for the blind. Sadly, I found out that these teachers did not have time to use such learning enrichments in their classrooms. They continued to tell me that they have to teach the students how to get answers to the year-end test instead of teaching them actual information in order to maintain funding. No different from the public school system. However, I did have a great conversation with a teacher from the Oklahoma School for the Blind about left brain and right brain learners. She had told me that she knew which students were which because the left brainers would read the narrative or chapter and go straight to the work while the right brain students needed more help from her to describe the concepts they were to manipulate with her.

As my tactile resources grew, I beta tested them with the Tulsa Council for the Blind at a monthly meeting. But for some reason I could not get them or any other group to come to an event where I would feature my creations. I had booked a large booth at the Maker Faire hosted by Tulsa's Fab Lab that featured all 40 of my hand made tactile resources. I emailed and called all other kinds of groups for the blind and visually impaired. Not one of them showed up. With a huge booth and all sighted visitors, I was very disappointed and let down. It took me a while to snap out of it.

A few years ago, Mid States Regional Astronomical League 2015 sent out emails to gather speakers. I decided to throw my name into the hat but thought that my topic would not be of much interest to amateur observers since it was not about outreach. I made that comment in the email, but was surprised by the speaker coordinator’s response that he for one planned on listening to me. I submitted my title, “Astrology for Blind and Visually Impaired.” I was so to hear that it was accepted but Rick said, “You are talking about hands-on and you aren’t bringing anything?” So I packed up almost everything for a 30-minute talk. I had so many tactile resources, I decided to bring all of the ones he said he could not get his group involved. I was considering them because of their good size and very active high school group. So that gave me a focus—on the next generation. I tried to talk to the Tulsa Stem Alliance and the Tulsa Botanical Gardens and the Tulsa Museum of Science and History, but they gave me the brush off… IGH! Little did I know that this might be a springboard event, even though at the time it did not feel like that.

Well… as the paradigm shifts…. Carroll asked if I would fill in for Jim Smith the MSRAL Regional Chair at AL's business meeting the day before Alcon started since he was staying in Missouri for the eclipse. So, I showed up to take notes with my concept of going after the youth still fresh in my mind. At one point during the meeting, I made a comment about the constant articles about the graying of the clubs and where are the youth? I asked, “What is AL doing about it?” I continued to say that I thought the ALCons need to be opened up to students and families.

You know what they say: If you bring up something be prepared for what happens next. I was asked if I would like to take over the 10-year empty position of the Astronomical Leagues youth coordinator and if I could submit some ideas to the executive board by October 30th. Other members started to jump in with ideas, which was exciting to hear. By the second week of September, I had three pages of ideas and expanded the concept to the whole family. I also added families with special needs or children with disabilities in to the mix. I decided that it would better serve families to be all-inclusive. Since I was given the freedom to rename the office, I decided on S.T.E.A.M. and Accessible Outreach Coordinator. It is so clear that everything I have done and gone through— has not been in vain and actually has been a season of great preparation. Stay tuned for more outreach astronomers and other all coming together to help make the science of astronomy accessible!
The art of astronomy

Astrophotographer: Ginny St. Lawrence

The Jellyfish Nebula is one of my all-time favorite targets to shoot due to its negative space, and the contrast in colors when processed in narrowband. This target was shot in narrowband (Ha, OIII, SII) in Oceanside, Calif., on a small refractor. I really loved how the deep blues and golds brought this image together. The Jellyfish Nebula resides inside the Gemini constellation and is a remnant of a supernova!*

**Jellyfish Nebula**

This nebula is found in the Orion constellation and, like the Andromeda Galaxy, can be seen with the naked eye. Most people actually confuse this nebula with a star because it is so bright. Capturing images of this nebula is always a lot of fun. I find this target compelling because Orion looks like a bird with either the world on its back or a bird with wings on fire — similar to the phoenix — who sets itself ablaze only to rise from its own ashes. The purple and blue amoeba looking object to the left of the Orion Nebula is called the Running Man Nebula. This target was shot on a small refractor and processed in real color.*

**Orion Nebula and Running Man**

“The Horsehead Nebula is one of the most popular targets in the night sky. It is close to the Orion Nebula which is in the Orion constellation (one of my favorites)! It is a dark nebula, and is called the Horsehead because well... The big burst of what looks like a flaming tree to the left of the Horsehead Nebula is called the Flame Nebula. This photo was shot in narrowband.”

**Horsehead Nebula**

“If you are in a dark enough location, you can see the Andromeda Galaxy with your naked eye. It sits close to my all-time favorite constellation — Cassiopeia — and it looks like a tiny little fuzzy blur. I don’t image a lot of galaxies — but Andromeda is very special. To think that that galaxy is twice the size of our Milky Way, and has billions of suns just like our own is absolutely mind blowing. Eventually our galaxy will be colliding with Andromeda.”

**Andromeda Galaxy**

Both of these photographs were acquired using a small refractor and a CCD camera. St. Lawrence typically images in city locations, which causes her to shoot most of her photos in narrowband (3 nanometer filters). For processing, she uses Nebulosity, PixInsight, and Photoshop as well as some minor edits in Snapseed.
Orion

Orion and Uyuni salt flats
Inspired by M. C. Escher’s lithograph “Phosphorescent Sea”, this photo captures Orion’s brightest stars shining over the Uyuni Salt Flat located in southwest Bolivia. This is Earth’s largest salt flat. "I feel this is the perfect way to express my impression and memory of that night: Lights from Orion and reflections from cracks of salt flats. Just like what Mr. Escher did with the Plough and glowing waves in 1933.”

"Moonrise"
Stephanie Ziyi Ye’s image, titled “Moonrise,” took third place in the Against the Lights category in the 2017 TWAN (The World at Night) International Earth & Sky Photo Contest. The images was taken in Salar de Uyuni, Bolivia.

Aurora
The aurora borealis lights up the night sky in Iceland as a meteor streaks above the colorful scene.
With a universe of options to explore, it can be difficult to track what awe-inspiring treasures are visible in your sky each month. To help guide your explorations throughout the year, Sky’s Up is providing the following collection of seasonal star maps created by noted celestial cartographer Wil Tirion. Based in The Netherlands, Tirion has been crafting stars maps since the 1970s and became a professional uranographer shortly after the publication of his highly regarded Sky Atlas 2000.0 in 1981. To learn more about Tirion and his work, click here.
the key to your sky

CREATED BY Wil Tirion

WINTER SKY
For observers at 10° to 30° northern latitudes

WINTER SKY
For observers at 40° to 60° northern latitudes
the key to your sky

SPRING SKY
For observers at 10° to 30° northern latitudes

SPRING SKY
For observers at 40° to 60° northern latitudes
SUMMER SKY
For observers at 10° to 30° northern latitudes

SUMMER SKY
For observers at 40° to 60° northern latitudes
In 2010, the STS-131 space shuttle mission visited the International Space Station. When the three female mission specialists of STS-131 joined Tracy Caldwell Dyson (lower right) of Expedition 23 on the space station, they set a record for most women in space at the same time. The three STS-131 crew members pictured are, clockwise from bottom left, Dorothy Metcalf-Lindenburger, Naoko Yamazaki and Stephanie Wilson.